

California 2001 vs. ASHRAE 1999

Comparison of ASHRAE/IESNA Standard 90.1-1999 and the 2001 California Nonresidential Energy Efficiency Standard

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Table of Contents

Executive Summary.....	1
Purpose	2
The Nonresidential New Construction (NRNC) Database.....	3
Computer Simulations.....	5
Comparison of Percent Savings.....	6
LEED Equivalency.....	12
Description of California 2001 and ASHRAE 1999.....	13
Lighting	13
Lighting Power Limits.....	13
Use-It-Or-Loose-It Credits.....	14
Lighting Control Credits.....	15
Building Envelope and Fenestration.....	15
California 2001 Fenestration.....	15
California 2001 Building Envelope Requirements	16
ASHRAE 1999.....	17
ASHRAE 1999 Fenestration	19
ASHRAE 1999 Building Envelope Requirements.....	19
HVAC.....	20

List of Figures

Figure 1 – Distribution of Percent Savings Against California 2001 and ASHRAE 1999 Baselines	6
Figure 2 – Scatter Plot of California 2001 and ASHRAE 1999	7
Figure 3 – Scatter Plot of Schools.....	8
Figure 4 – Scatter Plot of Offices	9
Figure 5 – Scatter Plot of Retail and Wholesale	9
Figure 6 – Scatter Plot of Assembly Spaces.....	10
Figure 7 – Comparison of Best-fit Regression Lines, with Data Table.....	11
Figure 8 – ASHRAE Temperature Bins.....	18
Figure 9 – California Temperature Bins with Example Cities.....	18
Figure 10 – Relationship between ASHRAE Temperature Bins and California Climate Regions.....	18

List of Tables

Table 1 – Comparison of Percent Savings between ASHRAE 1999 and California 2001	1
Table 2 – Building Types and Climates Represented in Nonresidential New Construction Database	3
Table 3 – Distribution of Percent Savings Against California 2001 and ASHRAE 1999 Baselines.....	7
Table 4 – Equivalent Savings for LEED Calculations – Energy Credit #1	12
Table 5 – Comparison of Whole Building Lighting Power Allowances (W/ft ²)	13
Table 6 – Comparison of Space-by-Space Lighting Power Allowances for Schools (W/ft ²)	14
Table 7 – Use-it-or-loose-it Lighting Power Added for ASHRAE/IESNA Standard 90.1-1999	15
Table 8 – California 2001 Window Requirements.....	16
Table 9 – California 2001 Skylight Requirements.....	16
Table 10 – California 2001 Roof/Ceiling Requirements.....	16
Table 11 – California 2001 Wall Requirements	17
Table 12 – California 2001 Floor/Soffit Requirements	17
Table 13 – ASHRAE 1999 Window Requirements – Nonresidential.....	19
Table 14 – ASHRAE 1999 Window Requirements – Residential	19
Table 15 – ASHRAE 1999 Building Envelope Requirements – Nonresidential.....	20
Table 16 – ASHRAE 1999 Building Envelope Requirements – Residential.....	20

Executive Summary

This report compares the stringency of two energy standards: ASHRAE/IESNA Standard 90.1-1999 (ASHRAE 1999) and California Title 24-2001 (California 2001). The comparison is based on a sample of 940 buildings from the Nonresidential New Construction (NRNC) database. The sample buildings were constructed between 1994 and 1998 and represent a wide range of building types, locations and energy performance. Each building in the sample was upgraded or downgraded to be in minimum compliance with both standards.

California 2001 is more stringent than ASHRAE 1999. On average, the entire building sample consumes 13.5 percent less energy than the ASHRAE 1999 baseline, but only 1.3 percent less than the California 2001 baseline. Another way to compare the standards is to map percent savings against ASHRAE to equivalent percent savings against California 2001. Table 1 shows this type of comparison. Reading the first two columns, an average building that is 8 percent better than California 2001 is 20 percent better than ASHRAE 1999. Likewise, an average building that is 28 percent better than California 2001 is 40 percent better than ASHRAE 1999.

Table 1 – Comparison of Percent Savings between ASHRAE 1999 and California 2001

Percent Savings Against ASHRAE 99	Percent Savings Against California 2001				
	All Buildings	Assembly	Office	School	Retail/ Wholesale
20%	8%	13%	12%	16%	-4%
30%	18%	22%	22%	26%	8%
40%	28%	31%	32%	37%	19%
50%	37%	41%	42%	47%	30%
60%	49%	50%	52%	58%	41%

The difference in stringency between the two standards can be more accurately explained if the comparison is made for different building types. Reading from the fourth column of Table 1, if an office is 12 percent more efficient than California 2001, it is 20 percent more efficient than ASHRAE 1999. The two standards are most divergent for retail/wholesale stores and are closest for schools.

Purpose

There are a number of energy efficiency programs, policies and initiatives in place or under consideration that use the California building energy efficiency standards or ASHRAE 1999 as a baseline for energy savings. For instance:

- The LEED (Leadership in Energy and Environmental Design) Green Building Rating System offers credits for buildings that are more efficient than ASHRAE 1999.
- The Savings by Design program being run by California investor-owned utilities offers incentives for buildings that are at least 5 percent more efficient than California 2001.
- The state of California is considering legislation (AB 545), which would require state office buildings to be 15 percent more efficient than California 2001.

The purpose of this study is to look at a sample of nonresidential buildings constructed between 1994 and 1998 and to compare their energy performance to both the California 2001¹ and ASHRAE 1999² standards. In comparing the two standards, the following questions are of particular interest:

- Which standard (ASHRAE or California) is more stringent and how do they compare by building type? For instance, if a building is 30 percent more efficient than ASHRAE, is it also more efficient than California and by how much?
- What percentage of newly constructed buildings are 50 percent more efficient than ASHRAE 1999, e.g. how many California buildings might qualify for the possible federal tax credit? What percentage are 40 percent more efficient? 30 percent? 20 percent? This type of information is important to policy makers, program managers and legislators who are considering incentive programs, tax credits and other measures.
- Since many buildings in California use the performance method of compliance and already make a performance comparison against California 2001, is there a way to establish a relationship between ASHRAE 1999 and California 2001 that would avoid the need to make a separate energy analysis for ASHRAE? This type of combined energy analysis would benefit California building designers who want to qualify for LEED and/or the federal tax credit.

¹ The 2001 California standard became effective on June 1, 2001, following an emergency rulemaking triggered by Assembly Bill 970. See www.energy.ca.gov/AB970_standards for more detail on the most recent modifications of the standards.

² ASHRAE/IESNA Standard 90.1-1999 was adopted by the ASHRAE and IESNA board of directors in 1999 and approved as an ANSI standard in 2000. Standard 90.1 is expected to become the standard for federal buildings and is referenced by the IECC (International Energy Code Council). It will likely be adopted by some states as a mandatory code.

The Nonresidential New Construction (NRNC) Database

The Nonresidential New Construction (NRNC) Database³ is used to make the comparison. This database is a collection of 990 buildings statistically selected to represent the majority of statewide NRNC activity. Most of the buildings are located in the SCE and PG&E service territories and were surveyed between 1994 and 1996. This data is supplemented with 30 audits made in 1995 of buildings located in the SDG&E service territory. A subset of 940 buildings is used in this study (the medical/clinical category was excluded). The distribution of the sample between building types and climate zones is shown in Table 2.

Table 2 – Building Types and Climates Represented in Nonresidential New Construction Database

Building Type	Climate Zone																Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
C&I Storage		3	6			4		4	3	3	2	11	8				44
Community Center		1	4	1		1	1	2	5	4	1	5		1			26
Fire/Police/Jails			3	2		1		2	1		2	1					12
General C&I Work		7	28	9	2	7	2	5	9	5	7	11	5				97
Grocery Store	1	1	7	8	2	2		2	3	2	3	7	5			2	45
Gymnasium			1	1			2	2	1			2	2			1	12
Hotels/Motels			1			1						1				1	4
Libraries			2	1				1	1			2		2	1	1	11
Office		4	45	34	3	30	17	21	11	11	8	22	7	7			220
Other	1	2	8	2	3	3			5			1	1	2	4	1	33
Religious. Worship, Auditorium, Convention	2	1	3	1		1	3	7	5	6	2	5	7	6	2		51
Restaurant	1		5	3	2	6		1	4	7		2	4	3	1		39
Retail and Wholesale Store	1	7	18	17	4	15	11	14	16	20	1	21	4	8	5		162
School		6	13	6	2	14	4	8	17	17	7	22	31	17	4	1	169
Theater			1	1		1		2	4	1		4	1				15
Grand Total	6	32	145	86	18	86	40	71	85	76	33	117	75	46	21	3	940

Notes. The medical/clinical building type is excluded since Title 24 does not apply to this building type.

The NRNC data represents the broad range of construction practices, climate zones and occupant behavior expected in a building population as diverse as the NRNC market. For example, the office segment contains a wide variety of buildings ranging from glass and steel skyscrapers to one-story wood frame buildings. Each site in the sample has a statistically-derived sample weight and precision, indicating the relative representation of each building in the NRNC population, thus allowing the results obtained from simulations of each individual building to be projected to the population with a quantifiable level of precision.

Since the NRNC database contains California buildings only, it may not be representative of buildings in other parts of the country. California has had energy efficiency standards enforced in most jurisdictions since the late 1970s. The U. S. population of buildings is likely to be less efficient than California buildings. Therefore, projections based on California will likely over-predict the number of buildings that might qualify for the credit. Furthermore, California climates are not representative of the entire country, which can also affect the predictions.

Office, retail, schools and public assembly buildings represent about 70 percent of the NRNC market. These four building types are described below:

- **Offices.** Private offices, financial services and government administration.

³ RLW Analytics et al, *California Non-residential New Construction Baseline Study*, California Board for Energy Efficiency, 1999.

- **Retail.** Stores, shopping centers and post offices.
- **Schools.** Elementary schools, high schools, vocational schools, colleges and universities.
- **Public Assembly.** Theaters, museums, galleries and other facilities whose primary use is for public gathering.

Trained auditors surveyed each site. The audited data includes lighting equipment types, lighting power densities, types and efficiency of HVAC equipment, insulation levels and glazing. Data also includes behavior characteristics such as occupancy schedules, equipment control strategies and equipment set points. Both the as-built and baseline models assume the equipment types and occupancy schedules identified in the audit, but the HVAC equipment is resized for the baseline simulation.

Computer Simulations

For each building in the sample, three computer simulations are performed, as described below:

- **As-Built.** The simulated energy use of the building as constructed. Insulation, HVAC system type, lighting power and other building characteristics are based on surveyed data.
- **California 2001.** The building is upgraded or downgraded to be in exact compliance with the Title 24 standards, as amended through the AB 970 emergency rulemaking. These standards took effect on June 1, 2001.
- **ASHRAE 1999.** The building is upgraded or downgraded to be in exact compliance with ASHRAE/IESNA Standard 90.1-1999.

See the Description of California 2001 and ASHRAE 1999 section for an explanation of the two standards and a discussion of how they are applied. The same schedules of operation, thermostat settings, occupant density and other modeling assumptions are used for all three simulations. The as-built schedules are used in the simulations, as opposed to the schedules and assumptions prescribed by California 2001 or ASHRAE 1999.

Comparison of Percent Savings

Buildings in the database represent a wide range of energy performance. The performance of the building relative to the code baseline is calculated as the percent savings. Positive values mean that the building is more efficient than the code baseline, while a negative value means that the building performs at a level lower than the code baseline. Percent savings is calculated relative to two baseline conditions: California 2001 and ASHRAE 1999. The percent savings is based on source energy and is calculated as follows:

$$\text{Percent Savings} = \frac{\text{Baseline Energy} - \text{AsBuilt Energy}}{\text{Baseline Energy}} \times 100$$

Figure 1 shows the distribution of percent savings against each baseline. The frequency distributions and cumulative “running totals”⁴ are shown for the percent savings compared to California 2001 and ASHRAE 1999.

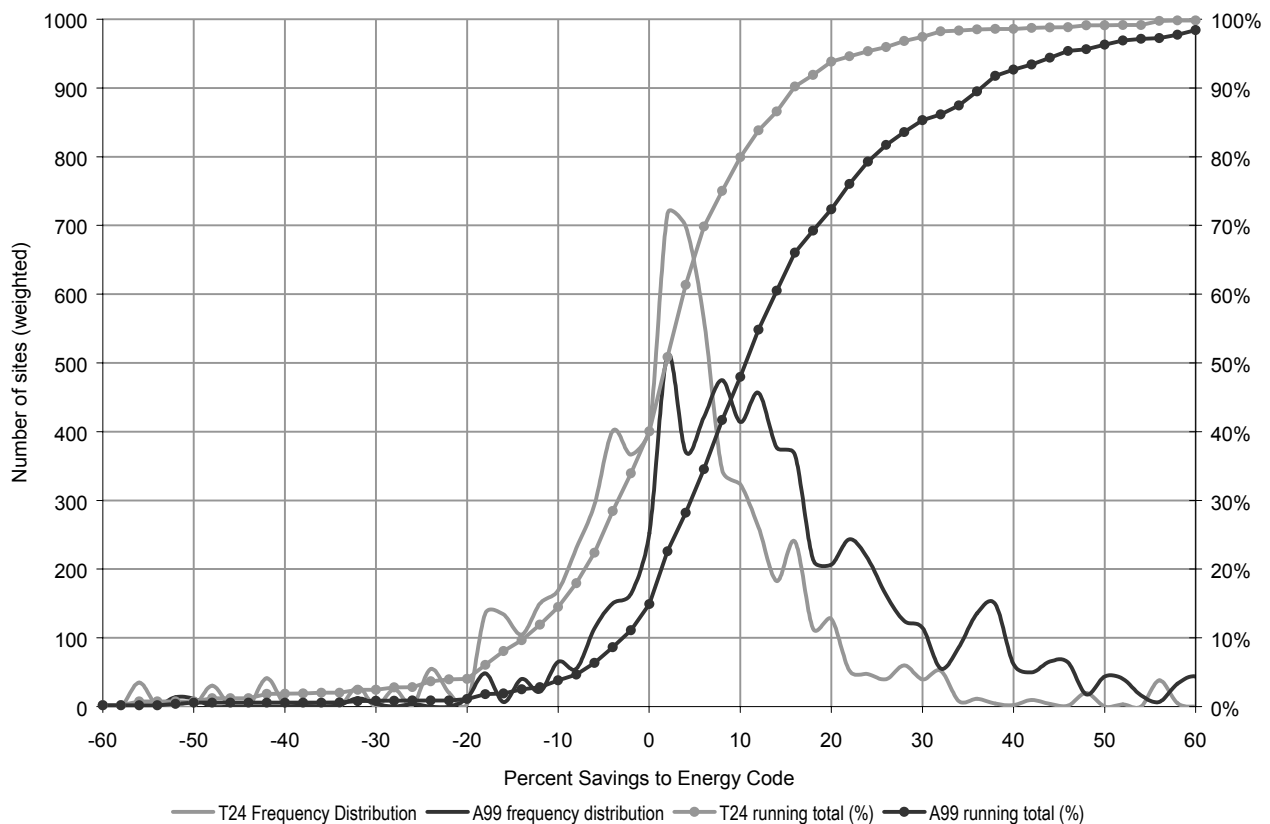


Figure 1 – Distribution of Percent Savings Against California 2001 and ASHRAE 1999 Baselines
(Note T24 is the same as California 2001)

The same data is summarized in Table 3. Note that the distributions and all statistics are based on the weighting factors assigned to each site to ensure the most statistically accurate population. The average

⁴ The “running total (%)” curves in Figure 1 can be used to find the portion of the population that is above or below a certain efficiency level. For example, the “running total” curves intersect the zero gridline of the “Percent Savings to Energy Code” axis at 40 percent and 15 percent for California 2001 and ASHRAE 1999, respectively. This is the amount of the population that does not perform at the minimum code levels.

building exceeds ASHRAE 1999 by 13 percent and California 2001 by 1 percent. The ASHRAE 1999 distribution has a wider spread with a standard deviation of 18 percent, compared to 15 percent for California 2001. The table also shows information about the distribution of percent savings. Of the entire weighted sample, 40 percent fail to perform at the California 2001 minimum level, and 15 percent fail to comply at the ASHRAE 1999 minimum performance level. A few buildings in the database have excessive lighting, clearly violating California energy efficiency codes. A couple of buildings also fall at the opposite extreme, having very low-power lighting systems, while the code permits considerable lighting power.

Table 3 – Distribution of Percent Savings Against California 2001 and ASHRAE 1999 Baselines

	California 2001 Baseline	ASHRAE 1999 Baseline
Mean	1.3%	13.5%
Standard Deviation	14.6%	18%
Negative Percent Savings	40%	15%

The same population of buildings is shown as a scatter plot in Figure 2. Figure 2 clearly shows two important points. First, a simple linear relationship between ASHRAE 1999 and California 2001 does not exist. If such a relationship had existed, most of the data points would be densely grouped around a single line. The best-fit line (using least squares regression), as shown in the figure, represents the line closest to all the data points in the population. Second, California 2001 is clearly a more stringent standard. Only a small minority of buildings (below the gray diagonal gridline) perform worse in relation to California 2001.

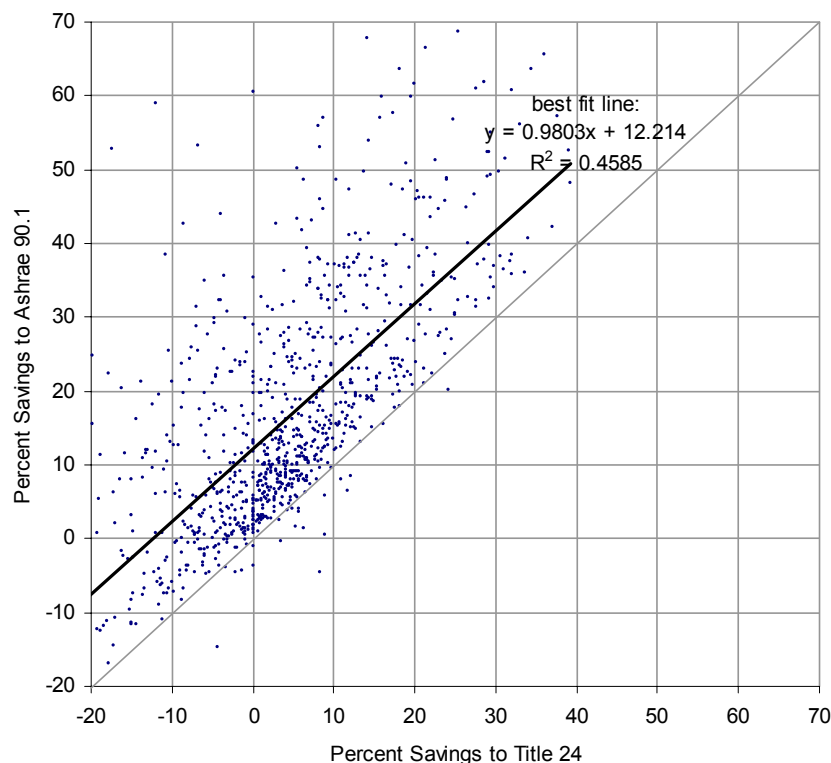


Figure 2 – Scatter Plot of California 2001 and ASHRAE 1999
 (Note T24 is the same as California 2001)

Examining the performance by building type shows that linearity varies throughout the population.

Figure 3, Figure 4, Figure 5, Figure 6 are the scatter plots for schools, offices, retail/wholesale and assembly spaces⁵, respectively. Note that schools have the best linear correlation between California 2001 and

⁵ Assembly spaces include the following building types from Table 2: community centers, gymnasiums, worship spaces, restaurants and theatres.

ASHRAE 1999, while retail/wholesale has the least. However, as expected, the best-fit lines are a better fit for the population of a certain building type than the line shown in Figure 2. This is valuable when one wants to know how the performance of a particular building type differs between the two standards.

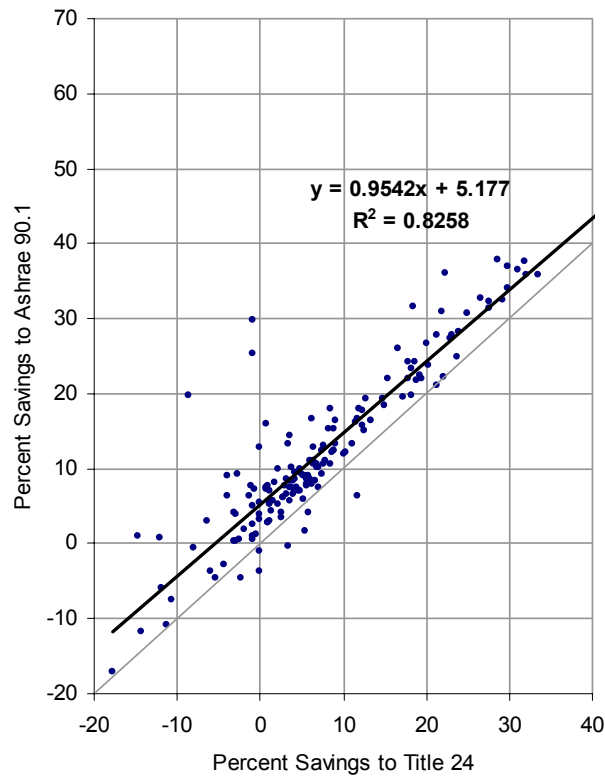


Figure 3 – Scatter Plot of Schools
 (Note T24 is the same as California 2001)

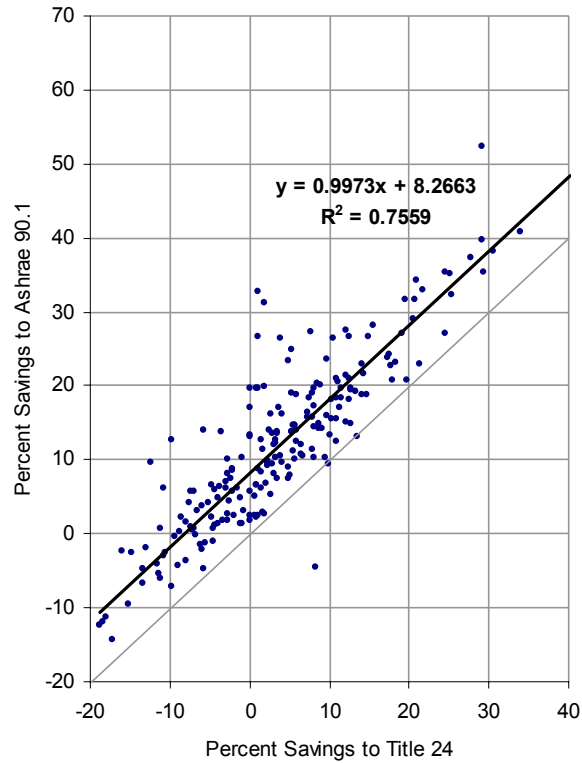


Figure 4 – Scatter Plot of Offices
(Note T24 is the same as California 2001)

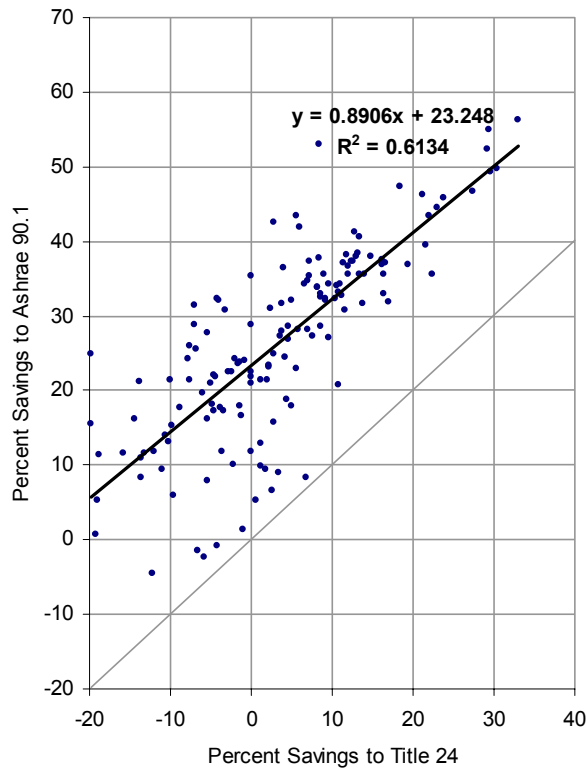


Figure 5 – Scatter Plot of Retail and Wholesale
(Note T24 is the same as California 2001)

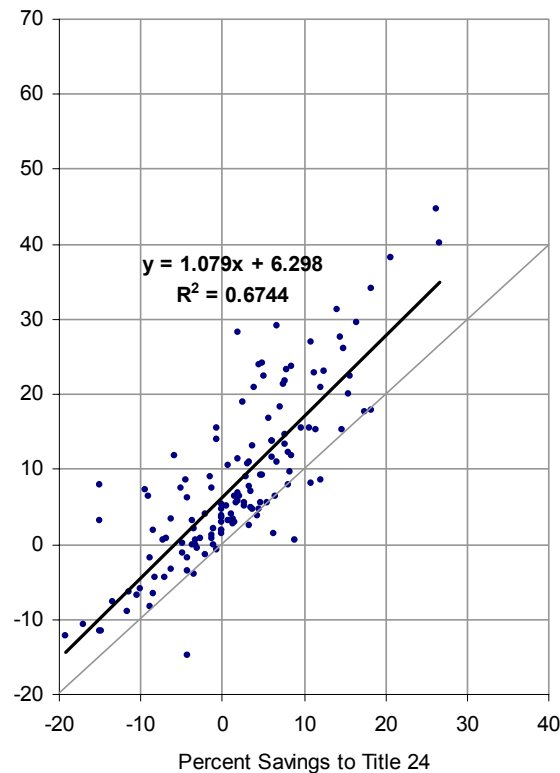


Figure 6 – Scatter Plot of Assembly Spaces
 (Note T24 is the same as California 2001)

Using the equations of the best-fit lines from the scatter plots, it is straightforward to derive relations between the two standards. Remember that these lines indicate the best approximation of the data. The performance of many of these buildings, especially when looking at the population of all building types, does not come very close to the best-fit line. Figure 7 shows the five best-fit lines relative to one another. The equations of the best fit lines are:

Entire population: $A_{1999} = 0.98 (C_{2001}) + 12.21$

Schools: $A_{1999} = 0.95 (C_{2001}) + 5.18$

Offices: $A_{1999} = 0.997 (C_{2001}) + 8.27$

Retail/Wholesale: $A_{1999} = 0.89 (C_{2001}) + 23.25$

Assembly: $A_{1999} = 1.08 (C_{2001}) + 6.30$

where,

A_{1999} = percent savings relative to ASHRAE 1999, and

C_{2001} = percent savings relative to California 2001

For example, a given school is 5 percent better than California 2001. Therefore, that school's performance relative to ASHRAE 1999 =

$$0.95 * 5.0 + 5.18 = 9.9 \text{ percent.}$$

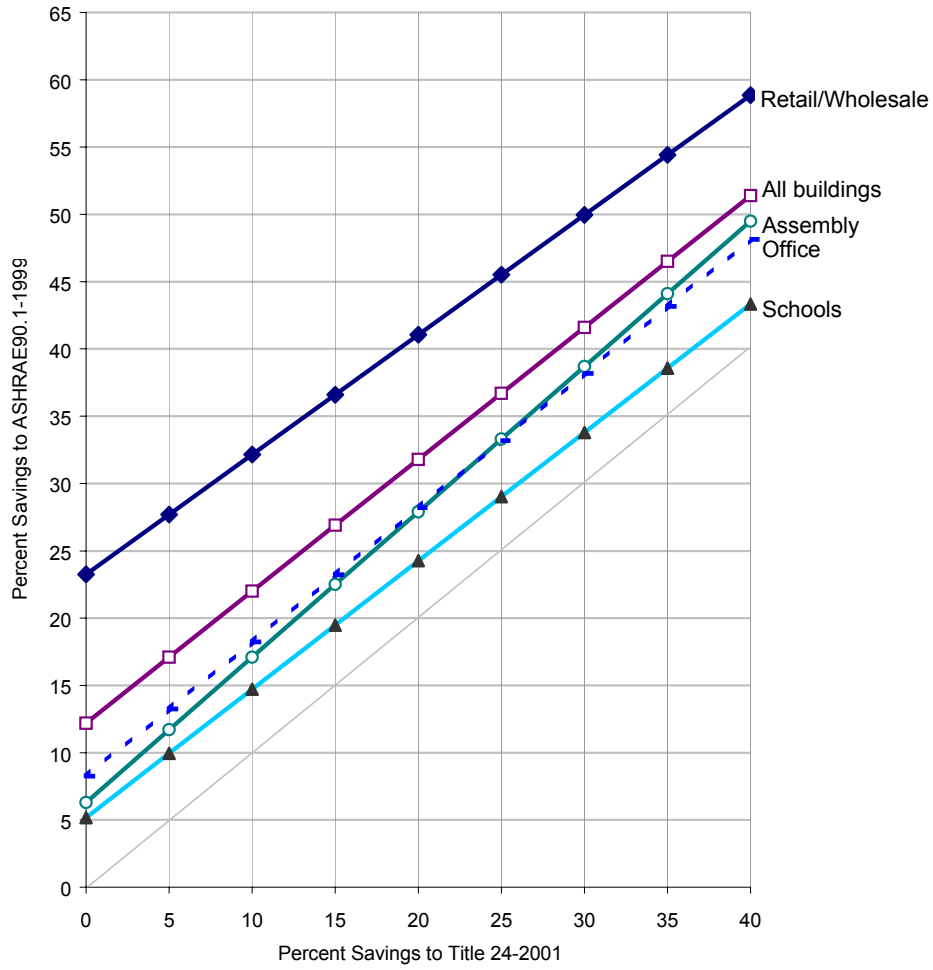


Figure 7 – Comparison of Best-fit Regression Lines, with Data Table.

LEED Equivalency

The LEED Green Building Rating Systems offers credits for building energy efficiency greater than ASHRAE 1999. Two credits are offered for buildings that are 20 percent more efficient, while 10 credits are offered for buildings that are 60 percent more efficient. Table 4 shows the credits offered for each savings percent. The table also shows the equivalent savings for the entire population relative to California 2001. For example, if a building can be shown to be 28 percent better than California 2001, this is equivalent to a 40 percent savings against ASHRAE 1999.

Table 4 – Equivalent Savings for LEED Calculations – Energy Credit #1

LEED Credits	ASHRAE 99	All Buildings	Assembly	Office	School	Retail/ Wholesale
2	20%	8.0%	12.7%	11.8%	15.5%	-3.6%
4	30%	18.2%	21.9%	21.8%	26.0%	7.6%
6	40%	28.4%	31.2%	31.8%	36.5%	18.8%
8	50%	38.6%	40.5%	41.9%	47.0%	30.0%
10	60%	48.8%	49.7%	51.9%	57.5%	41.3%

The LEED philosophy sets the level for certification at approximately one standard deviation, e.g. the top 17 percent or so of buildings would qualify. Using this philosophy and the data from Table 3, the level of certification should be set at about 31.5 percent (sum of the mean and one standard deviation) savings beyond ASHRAE 1999.

Description of California 2001 and ASHRAE 1999

This section of the report compares the specific requirements of California 2001 and ASHRAE 1999. Both standards have requirements for lighting, water heating, building envelope components, heating systems and cooling systems.

Lighting

Lighting Power Limits

Both California 2001 and ASHRAE 1999 have multiple ways of determining the allowed lighting power. Table 5 compares the whole building lighting power allowance of California 2001 and to ASHRAE 1999 for four building types: office, retail, assembly and schools. In general, the California 2001 levels are slightly lower than ASHRAE 1999, except for assembly buildings⁶. The building area method is the simplest way to determine the lighting power allowance, but both ASHRAE 1999 and California 2001 have a more detailed method of determining the lighting power allowance. California 2001 uses the building area method and ASHRAE employs the space-by-space method. The ASHRAE space-by-space method has additional power allowances for display lighting, VDT luminaires and decorative lighting.

Table 5 – Comparison of Whole Building Lighting Power Allowances (W/ft²)

	Office	Retail	Assembly	School
California 2001 (whole building method)	1.20	1.70	1.80	1.40
ASHRAE 1999 (building area method)	1.30	1.90	1.60	1.50
ASHRAE 1999 (space-by-space method w/UIOLI)	1.59	3.21	2.45	1.62

ASHRAE 1999 permits an additional allowance of up to 1.0 W/ft² for decorative lighting, up to 0.35 W/ft² for VDT luminaires, and up to 1.6 W/ft² for display lighting in most retail stores (up to 3.9 W/ft² is permitted for jewelry and fine merchandise stores). These additional allowances can be used with the space-by-space method and are use-it-or-loose-it (UIOLI) allowances, which means that the additional lighting power can only be used for its intended purpose.

Table 6 compares ASHRAE 1999 and California 2001 space-by-space methods for schools. For the most part, the ASHRAE 1999 values are a little higher than California 2001.

⁶ There are a wide variety of assembly buildings ranging from movie theatres to performing arts theatres to hotel meeting rooms to convention centers.

Table 6 – Comparison of Space-by-Space Lighting Power Allowances for Schools (W/ft²)

Space Type	California 2001 Building Area Method	ASHRAE 1999 Space-by-Space Method	Percent ASHRAE 1999 over California 2001
Enclosed Admin/Office	1.3	1.5	15%
Open Admin/Office	1.3	1.3	0%
Art	1.6	1.6	0%
Classroom	1.6	1.6	0%
Commons Cafeteria	1.6	1.4	-13%
Corridor	0.6	0.7	17%
Library – Reading	1.2	1.5	25%
Library – Stacks	1.5	1.9	27%
Kitchen	1.7	2.2	29%
Theatre Auditorium	1.4	1.8	29%
Band and Choir Spaces	1.6	1.6	0%
Gym – Play	1.0	1.9	90%
Gym – Exercise	1.0	1.1	10%
Shower Room	0.9	0.8	-11%
Science Lab	1.6	1.6	0%
Teacher Resource (Prep)	1.3	1.5	15%
Team Resource (Meeting)	1.3	1.5	15%
Technology, Shop	1.5	1.5	0%
Toilets	0.6	1.0	67%
Support/Utility	0.6	1.3	117%

Use-It-Or-Loose-It Credits

Without the use-it-or-loose-it allowances, the ASHRAE 1999 space-by-space method results in a similar lighting power allowance as the building area method. However, the allowance can be increased significantly if the use-it-or-loose-it allowances are applied. The lighting power density for offices could increase about 20 percent, retail by 67 percent, assembly by 53 percent, and schools by 9 percent. Table 7 summarizes the assumptions made about the use-it-or-loose-it credits in ASHRAE 1999 with regard to the building types and space types in the NRNC database. The additional power shown in Table 7 was added to the allowed power for ASHRAE 1999.

Table 7 – Use-it-or-loose-it Lighting Power Added for ASHRAE/IESNA Standard 90.1-1999

Building Type	Space Type	Additional W/ft²	Comment/Justification
Assembly	Courtrooms	0.09	Assume that one-fourth of the spaces have VTDs, which makes the adder equal to 0.35 / 4 or about 0.09.
Offices	Bank/Financial Institution	0.09	Same assumption as above.
Offices	Medical and Clinical Office (doctor)	0.35	Assume that all spaces have VTDs.
Offices	Office – Other	0.17	Assume that half of spaces have VTDs.
Offices	Computer Center	0.35	All the spaces are assumed to have VTDs.
Stores	Grocery	0.40	The additional display power is only allowed where there is display lighting. This tends to be in the produce areas, but not in the general areas. Assume that the display lighting adder applies to one-fourth of the space.
Stores	Retail Sales, Wholesale Showrooms	1.60	The display lighting allowance applies to the entire sales area.
School	Classrooms	0.17	Assume that one-half of the space has VTDs.
School	Library	0.35	Assume that VTDs are present throughout the space.

Lighting Control Credits

The California 2001 standard gives credits for occupant sensors, daylighting controls, lumen maintenance controls and time clocks. The credits are applied as wattage reductions to the installed lighting power. This means that the connected lighting power for California buildings can be larger than the allowed lighting power allowance as long as qualifying automatic controls are installed. ASHRAE 1999 does not have lighting power control credits. The difference in lighting control credits factors into the difficulty of comparing the California 2001 and ASHRAE 1999 standards. Some will argue that the lighting power adjustment factors actually relax the California 2001 standard by essentially raising the lighting power allowance.

Building Envelope and Fenestration

California 2001 Fenestration

The California fenestration requirements were updated in 2001 as part of the AB 970 emergency rulemaking. Prior to the 2001 update, the requirements basically called for single bronze along the coast and double bronze in the Central Valley, desert and mountains. With the 2001 updates, double glass is required throughout the state and double low-e glass in a thermal broken frame is required in the more harsh climates. The fenestration U-factor requirements apply to all window-wall ratio (WWR) ranges below 40 percent and are the same for offices, retail, assembly, schools and other nonresidential building types. Common U-factor criteria apply for all window-wall ratio ranges but the solar heat gain coefficient (SHGC) criteria become more stringent with greater window-wall ratios.

The requirements for windows are summarized in Table 8 and the requirements for skylights are summarized in Table 9.

Table 8 – California 2001 Window Requirements

Space Type	Criterion	Climate Zones									
		1,16		3-5		6-9		2,10-13		14, 15	
Nonresidential	U-factor	0.49		0.81		0.81		0.49		0.49	
	Relative Solar Heat Gain	Non-North	North	Non-North	North	Non-North	North	Non-North	North	Non-North	North
	0-10% WWR	0.49	0.72	0.61	0.61	0.61	0.61	0.47	0.61	0.46	0.61
	11-20% WWR	0.43	0.49	0.55	0.61	0.61	0.61	0.36	0.51	0.36	0.51
	21-30% WWR	0.43	0.47	0.41	0.61	0.39	0.61	0.36	0.47	0.36	0.47
	31-40% WWR	0.43	0.47	0.41	0.61	0.34	0.61	0.31	0.47	0.31	0.40
Residential High-rise	U-factor	0.49		0.49		0.49		0.49		0.49	
	Relative Solar Heat Gain	Non-North	North	Non-North	North	Non-North	North	Non-North	North	Non-North	North
	0-10% WWR	0.46	0.68	0.41	0.61	0.47	0.61	0.36	0.49	0.36	0.47
	11-20% WWR	0.46	0.68	0.40	0.61	0.40	0.61	0.36	0.49	0.31	0.43
	21-30% WWR	0.36	0.47	0.31	0.61	0.36	0.61	0.31	0.40	0.26	0.43
	31-40% WWR	0.30	0.47	0.26	0.55	0.31	0.61	0.26	0.40	0.26	0.31

Table 9 – California 2001 Skylight Requirements

Space Type	Criterion		Climate Zones					
			1,16	3-5	6-9	2,10-13	14, 15	
Nonresidential	U-factor	Glass w/Curb	0.99	1.18	1.18	0.99	0.99	
		Glass w/o Curb	0.57	0.68	0.68	0.57	0.57	
		Plastic w/Curb	0.87	1.30	1.30	1.10	1.10	
	SHGC Glass	0-2% SRR	0.68	0.79	0.79	0.46	0.46	
		2.1-5% SRR	0.46	0.40	0.40	0.36	0.36	
	SHGC Plastic	0-2% SRR	0.77	0.79	0.77	0.77	0.71	
		2.1-5% SRR	0.58	0.65	0.62	0.62	0.58	
	Residential High-rise	U-factor	Glass w/Curb	0.99	1.18	1.18	0.99	0.99
			Glass w/o Curb	0.57	0.68	0.68	0.57	0.57
			Plastic w/Curb	0.87	1.30	1.30	1.10	0.87
SHGC Glass		0-2% SRR	0.46	0.58	0.61	0.46	0.46	
		2.1-5% SRR	0.36	0.32	0.40	0.32	0.31	
SHGC Plastic		0-2% SRR	0.71	0.65	0.65	0.65	0.65	
		2.1-5% SRR	0.55	0.39	0.65	0.34	0.27	

California 2001 Building Envelope Requirements

The California 2001 building envelope requirements vary with climate region and are summarized in Table 10, Table 11 and Table 12.

Table 10 – California 2001 Roof/Ceiling Requirements

Space Type	Criterion	Climate Zones				
		1,16	3-5	6-9	2,10-13	14, 15
Nonresidential	R-value	19	19	11	19	19
	U-factor	0.057	0.057	0.078	0.057	0.057
Residential High-rise	R-value	30	19	19	30	30
	U-factor	0.037	0.051	0.051	0.037	0.037

Table 11 – California 2001 Wall Requirements

Space Type	Criterion	Climate Zones				
		1,16	3-5	6-9	2,10-13	14, 15
Nonresidential	R-value	13	11	11	13	13
	U-factor					
	Wood Frame	0.084	0.092	0.092	0.084	0.084
	Metal Frame	0.182	0.189	0.189	0.182	0.182
	Mass/7.0≤ HC<15.0	0.340	0.430	0.430	0.430	0.430
	Mass/15.0≤HC	0.360	0.650	0.690	0.650	0.400
	Other	0.084	0.092	0.092	0.084	0.084
Residential High-rise	R-value	19	19	11	19	19
	U-factor					
	Wood Frame	0.063	0.092	0.092	0.084	0.084
	Metal Frame	0.140	0.181	0.181	0.175	0.175
	Mass/7.0≤ HC<15.0	0.340	0.430	0.430	0.430	0.430
	Mass/15.0≤HC	0.360	0.650	0.690	0.650	0.400
	Other	0.063	0.092	0.092	0.084	0.084

Table 12 – California 2001 Floor/Soffit Requirements

Space Type	Criterion	Climate Zones				
		1,16	3-5	6-9	2,10-13	14, 15
Nonresidential	R-value	19	11	11	11	11
	U-factor					
	Mass/7.0≤HC	0.097	0.158	0.158	0.097	0.158
	Other	0.05	0.076	0.076	0.076	0.076
Residential High-rise	R-value	19	11	11	11	11
	U-factor					
	Mass/7.0≤HC	0.097	0.158	0.158	0.097	0.158
	Other	0.05	0.076	0.076	0.076	0.076

ASHRAE 1999

In order to make a comparison between the stringency of California 2001 and ASHRAE 1999, the differences in how climate is accounted for must be addressed. California 2001 has separate criteria for five climate regions (see the tables above). However, the building envelope criteria in ASHRAE 1999 are specified separately for 26 different temperature bins. The temperature bins are defined in terms of heating degree-days at base 65°F (HDD65) and cooling degree-days at base 50°F (CDD50). Figure 8 shows the 26 temperature bins used to organize the ASHRAE 1999 criteria for the building envelope. The temperature bins that are shaded in light gray occur in California. These include 5, 6, 7, 8, 9, 11, 12, 14 and 15. Figure 9 shows a close-up of the California 2001 temperature bins with the name of an example city that falls in each bin.

ASHRAE 1999 Fenestration

The ASHRAE 1999 fenestration requirements vary with WWR, e.g. the SHGC criteria becomes more stringent as the WWR becomes larger. The U-factor criterion is the same, however, for all WWR ranges. Like California 2001, ASHRAE 1999 has separate criteria for nonresidential and residential spaces. The fenestration U-factor requirements are less stringent than California 2001, e.g. they permit single glass along the coast and uncoated double glass for the Central Valley, mountains and desert. However, the ASHRAE 1999 SHGC criteria are similar to California 2001. Table 13 and Table 14 show the ASHRAE 1999 window requirements for the temperature bins that occur in California.

Table 13 – ASHRAE 1999 Window Requirements – Nonresidential

Criteria	Bin 6	Bin 7	Bin 9	Bin 12	Bin 5	Bin 8	Bin 11	Bin 14	Bin 15
U-factor, Fixed	1.22	1.22	1.22	1.22	1.22	1.22	0.57	0.57	0.57
U-factor, Operable	1.27	1.27	1.27	1.27	1.27	1.27	0.67	0.67	0.67
SHGC, 10 WWR	0.39	0.61	0.61	0.61	0.25	0.39	0.39	0.49	0.49
SHGC, 20 WWR	0.25	0.61	0.39	0.61	0.25	0.25	0.39	0.39	0.49
SHGC, 30 WWR	0.25	0.44	0.39	0.61	0.25	0.25	0.39	0.39	0.49
SHGC, 40 WWR	0.25	0.44	0.34	0.39	0.25	0.25	0.39	0.39	0.49
SHGC North, 10 WWR	0.61	0.82	0.82	0.82	0.61	0.61	0.49	0.49	0.49
SHGC North, 20 WWR	0.61	0.61	0.61	0.82	0.61	0.61	0.49	0.49	0.49
SHGC North, 30 WWR	0.61	0.61	0.61	0.61	0.61	0.61	0.49	0.49	0.49
SHGC North, 40 WWR	0.61	0.61	0.61	0.61	0.61	0.61	0.39	0.49	0.49

Table 14 – ASHRAE 1999 Window Requirements – Residential

Criteria	Bin 6	Bin 7	Bin 9	Bin 12	Bin 5	Bin 8	Bin 11	Bin 14	Bin 15
U-factor, Fixed	1.22	1.22	1.22	1.22	1.22	1.22	0.57	0.57	0.57
U-factor, Operable	1.27	1.27	1.27	1.27	1.27	1.27	0.67	0.67	0.67
SHGC, 10 WWR	0.61	0.61	0.61	0.61	0.39	0.39	0.39	0.49	0.72
SHGC, 20 WWR	0.44	0.61	0.61	0.61	0.25	0.39	0.39	0.39	0.72
SHGC, 30 WWR	0.44	0.61	0.39	0.61	0.25	0.25	0.39	0.39	0.51
SHGC, 40 WWR	0.40	0.44	0.34	0.61	0.25	0.25	0.39	0.39	0.51
SHGC North, 10 WWR	0.61	0.82	0.82	0.82	0.61	0.49	0.49	0.72	0.49
SHGC North, 20 WWR	0.61	0.61	0.61	0.82	0.61	0.49	0.49	0.72	0.49
SHGC North, 30 WWR	0.61	0.61	0.61	0.82	0.61	0.49	0.49	0.72	0.49
SHGC North, 40 WWR	0.61	0.61	0.61	0.82	0.61	0.49	0.49	0.72	0.49

ASHRAE 1999 Building Envelope Requirements

The insulation requirements for ASHRAE 1999 depend both on climate (temperature bin) and the class of construction. This information is shown in Table 15 for nonresidential buildings and in Table 16 for residential buildings.

Table 15 – ASHRAE 1999 Building Envelope Requirements – Nonresidential

Type	Class	Bin 5	Bin 6	Bin 7	Bin 8	Bin 9	Bin 11	Bin 12	Bin 14	Bin 15
Roof	Insulation Entirely Above Deck	0.0634	0.0634	0.0928	0.0634	0.0634	0.0634	0.0928	0.0634	0.0634
	Metal Building	0.065	0.065	0.072	0.065	0.065	0.065	0.065	0.065	0.065
	Attic and Other	0.0339	0.0339	0.0339	0.0339	0.0339	0.0339	0.0339	0.0339	0.0339
Wall	Mass	0.58	0.58	0.58	0.58	0.58	0.151	0.151	0.151	0.151
	Metal Building	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
	Steel Framed	0.1242	0.1242	0.1242	0.1242	0.1242	0.1242	0.1242	0.1242	0.1242
	Wood Framed and Other	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887
Below Grade Walls		1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Floor	Mass	0.1374	0.1374	0.1374	0.1374	0.1374	0.1067	0.1374	0.1067	0.1067
	Steel Joist	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521
	Wood Framed and Other	0.0508	0.0508	0.0663	0.0508	0.0508	0.0508	0.0508	0.0508	0.0508
Slab-on-Grade	Unheated	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
	Heated	1.02	1.02	1.02	1.02	1.02	1.02	1.02	0.95	0.95
Opaque Doors	Swinging	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Non-Swinging	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45

Table 16 – ASHRAE 1999 Building Envelope Requirements – Residential

Type	Class	Bin 5	Bin 6	Bin 7	Bin 8	Bin 9	Bin 11	Bin 12	Bin 14	Bin 15
Roof	Insulation Entirely Above Deck	0.0634	0.0634	0.0634	0.0634	0.0634	0.0634	0.0634	0.0634	0.0634
	Metal Building	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
	Attic and Other	0.0269	0.0339	0.0339	0.0269	0.0339	0.0339	0.0339	0.0339	0.0339
Wall	Mass	0.151	0.151	0.151	0.1234	0.151	0.1234	0.1234	0.1043	0.1234
	Metal Building	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113	0.113
	Steel Framed	0.1242	0.1242	0.1242	0.0844	0.1242	0.0844	0.1242	0.0844	0.0844
	Wood Framed and Other	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887	0.0887
Below Grade Walls		1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14	1.14
Floor	Mass	0.1067	0.1067	0.1374	0.1067	0.1067	0.0873	0.1067	0.0873	0.0873
	Steel Joist	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521	0.0521
	Wood Framed and Other	0.0508	0.0508	0.0508	0.0508	0.0508	0.0331	0.0508	0.0331	0.0331
Slab-on-Grade	Unheated	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
	Heated	1.02	1.02	1.02	1.02	1.02	0.95	0.95	0.84	0.84
Opaque Doors	Swinging	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
	Non-Swinging	1.45	1.45	1.45	1.45	1.45	1.45	1.45	0.5	1.45

HVAC

The HVAC requirements are similar for the California 2001 and ASHRAE 1999 standards. Most of the ASHRAE 1999 requirements were adopted as part of the recent AB 970 changes to California 2001. The biggest difference between the two standards is that California 2001 restricts electric resistance heat, while ASHRAE 1999 does not.

In applying the standards, it is necessary to make a number of assumptions:

1. The equipment efficiency values that take effect 10/29/2001 are applied for both California 2001 and ASHRAE 1999.

2. There is a requirement in ASHRAE 1999 that systems with more than 5,000 cfm and more than 70 percent outside air have heat recovery in certain climates. This factor is ignored since it generally does not apply to California climates.
3. ASHRAE 1999 also requires that kitchen hoods with more than 5,000 cfm (affects 18 sites) have unconditioned make up air. This requirement is ignored in the comparison. Fan energy for kitchen hoods is not regulated by either California or ASHRAE. The impact would be on heating and cooling loads.
4. ASHRAE 1999 requires that fume hoods with a capacity larger than 15,000 cfm (affects 2 sites) have variable air volume (VAV) control. This requirement is ignored since fume hoods are not included in the energy budget for either standard. The impact would be only on heating and cooling loads.
5. ASHRAE 1999 specifies maximum allowable fan power in terms of hp/cfm. This was converted to W/cfm using standard motor efficiencies (see attached).
6. ASHRAE 1999 has an exception for economizers depending on the number of hours between 8 a.m. and 4 p.m. that the drybulb temperature is greater than 55°F and less than 69°F. The assumption for all California climates is that this climate variable is greater than 1,199.