California Energy Commission

CONSULTANT REPORT

ENERGY EFFICIENCY COMPARISON

California's *Building Energy Efficiency Standards and ASHRAE/IESNA Standard 90.1-2010*

CALIFORNIA
ENERGY COMMISSION

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ABSTRACT

The Energy Policy Act of 1992 requires each state to certify that it has reviewed and considered adopting the national model energy code or standard. All states must determine if its energy code meets or exceeds the current federal reference code and to certify to the Secretary of the Department of Energy of its determination. The federal reference energy code for residential buildings is the International Energy Conservation Code and for commercial buildings the reference standard is ASHRAE/IESNA Standard 90.1.

Whenever the national reference energy codes are updated and the Department of Energy determines that the newer national model code will improve energy efficiency compared to the previous edition of the corresponding code or standard states must reevaluate the efficiency requirements of their code against those of the new federal building efficiency reference codes. This report documents the California Energy Commission's response to this federal law by providing a comparison of the energy savings impacts for nonresidential buildings between California's Title 24, Part 6, *Building Energy Efficiency Standards* to the energy requirements of the American Society of Heating, Refrigerating and Air-Conditioning Engineers and Illuminating Engineering Society of North America Standard 90.1-2010 (*ASHRAE/IESNA Standard 90.1-2010*).

This report concludes that the estimated energy use for nonresidential buildings of California's *2013 Building Energy Efficiency Standards* exceed the energy savings expected from the commercial building requirements of *ASHRAE/IESNA Standard 90.1-2010.* California's nonresidential energy standards contain building measures and building performance operation impacts that are more rigorous, resulting in higher efficiency levels for new nonresidential construction than expected to occur from efficiency requirements of the federal reference energy code.

Keywords: California Energy Commission, *Building Energy Efficiency Standards*, Architectural Energy Corporation, ASHRAE/IESNA Standard 90.1-2010, energy comparison.

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CHAPTER 1: Introduction

States are required by federal law to adopt an energy code that is at least as energy efficient as the federal reference model energy code. When a new national model energy code is adopted, the Department of Energy (DOE) is required to make a determination whether the newly adopted code is more stringent than its predecessor. States have two years after the publication of this determination to certify that it has reviewed the provisions of its residential and nonresidential building code regarding energy efficiency and to report its findings as to whether it is appropriate for that state to revise its energy code requirements to meet or exceed the newly adopted reference national model energy code. The federal reference energy code for residential buildings is the 2009 and 2012 International Energy Conservation Code (IECC); and for nonresidential buildings the federal reference energy code is the American Society of Heating, Refrigerating and Air-Conditioning Engineers and Illuminating Engineering Society of North America (ASHRAE/IESNA) Standard 90.1-2007 and 2010.

This report compares the stringency of California's 2013 energy code (Title 24, Part 6, *Building Energy Efficiency Standards*) for nonresidential buildings to that of ASHRAE/IESNA Standard 90.1-2010. The comparison is based on energy computer simulation results using selected prototype buildings from the set of "Prototype Building Models" specified by the DOE (https://www.energycodes.gov/development/commercial/90.1_models). These prototype buildings are used as the baseline for estimating energy use using the EnergyPlus version 6 computer simulation program. The prototype building models represent buildings compliant with *ASHRAE/IESNA Standard 90.1*. Overall, there are 17 different prototype building models, each representing a different ASHRAE climate zone or subzone (Climate Zones 1-8 with sub-climates of A, B or C in some climate zones). The prototype building models used for this analysis were:

1. Hotel-Large
2. Office-Large
3. Office-Medium
4. Restaurant-Full Service
5. Restaurant-Quick Service
6. Retail-Stand Alone
7. Retail-Stripmall
8. School-Primary
9. School-Secondary
10. Warehouse

Building Energy Efficiency Standards

California's energy standards are separated into two parts, low-rise residential buildings of three stories or less, and nonresidential buildings which also includes high-rise residential buildings four stories or higher and hotel/motel occupancies. The standards prescribe minimum mandatory energy efficiency measures which must be met regardless of building type and there are two methods of demonstrating compliance: prescriptive and performance. In all, the standards set the minimum energy threshold, expressed in terms of energy consumption per square foot of floor area per year, which cannot be exceeded.

With the prescriptive method of compliance every measure listed in the nonresidential component package must be met or exceeded in order for the building to be in compliance:

- Nonresidential buildings must meet the prescriptive requirements prescribed in Tables 143-A and B of the *2008 Building Energy Efficiency Standards*; and Tables 140.3-B and C of the *2013 Building Energy Efficiency Standards*.

When the performance approach is used, the energy effects of building features are analyzed to determine their overall affect on the building's total energy use. Individual energy measures of the building can be less than measures listed in the prescriptive tables so long as other more energy efficient measures are used and the resulting building energy use exceeds the minimum energy compliance level established by the standards.

Reference Model Energy Codes

The DOE is required by law (the Energy Conservation and Production Act, as amended (ECPA)) to issue a determination as to whether the latest version of the International Energy Conservation Code (for low-rise residential buildings) and the latest edition of ASHRAE/IESNA Standard 90.1 (for commercial and multi-family high-rise residential buildings) will improve energy efficiency compared to the previous edition of the corresponding code or standard. The DOE has one year to publish a determination in the Federal Register after each new edition of the code or standard is published, and states have two years from the determination date to respond to the DOE regarding the equivalency of their own energy code.

ASHRAE/IESNA Standard 90.1 is developed under the auspices of the American Society of Heating, Refrigerating and Air Conditioning Engineers and the Illuminating Engineering Society of North America using the consensus process of the American National Standards Institute (ANSI) which requires a balance of interests.

CHAPTER 2:
Energy Comparison Analysis

Statewide energy consumption for new nonresidential buildings was calculated by multiplying the 2014 forecasted construction (expressed in millions of square feet) by the energy use per square foot of each prototype building modeled by EnergyPlus in each climate zone.

Each prototype building was equated to some portion of all buildings representing the Nonresidential Construction Forecast dataset developed by Heschong Mahone Group (Sep. 26, 2011). Table 1 shows the correspondence between the prototype building models and the building types from California's construction forecast. In some cases, two prototype buildings are used to calculate the energy consumption for a single building type to represent the forecast dataset. The estimated energy consumption of each prototype building was weighted by the percentage shown in the Table 1 to compute the total energy consumption of that building type in a given climate zone.

ASHRAE/IESNA Climate Zone 3C (San Francisco) was used as the starting comparison point using the prototype building models previously listed for the *2013 Standards* energy consumption estimate. The methodology used included multiple series of parametric analysis for each prototype building in each climate zone, where fixed input values were replaced with variables that were set at runtime in order to have the prototype building be exactly compliant with the *2013 Standards* based on California's specific climate zone and building characteristics prescribed by the standards. The prototype building was simulated using each of the sixteen California climate zone weather files.

For estimates of ASHRAE/IESNA 90.1-2010 energy consumption, EnergyPlus simulations were performed for ASHRAE/IESNA Climate Zones 2B (Phoenix), 3C (San Francisco), 4B (Albuquerque), and 5B (Boise). Prototype buildings in these climate zones were selected because these ASHRAE/IESNA climate zones cover most of California. Automated routines were set up within the computer simulation program that allowed for "autosizing" HVAC equipment based on the specified prototype building and climate zone.

The national climate regions are drawn based on county lines, whereas California's sixteen climate zones are drawn based on the results of climate data analysis where some climate lines may coincide with boundaries of individual cities or counties . California counties were identified for each run analysis from *ASHRAE/IESNA 90.1*. This provided a list of ASHRAE and California climate zone pairs, along with construction data for each. This resulted in a set of 23 unique climate pairs. Energy modeling results for each climate pair was then weighted by population and construction to yield results for each California climate zone. Construction forecast floor areas were then used to weight climate zone results to derive statewide results.

The ASHRAE/IESNA prototype buildings were slightly modified in some cases to better simulate energy measures included specifically to California standards. For example, the standards require occupancy sensors to control lights and thermostat setpoints in a number of space types, and to also control minimum ventilation rates in others. In order to evaluate the estimated energy savings for these measure, occupancy schedules had to be defined that allowed the building to be "occupied" part of the day. For California's standards, occupancy, lighting, thermostat and minimum ventilation rate schedules were modified accordingly. The same occupancy schedules were applied to the same zones of the ASHRAE/IESNA prototype building models in order to accurately compare the two sets of standards.

Table 1: Correspondence between the California Forecasted Construction and the DOE Prototype Buildings

California Forecasted Construction Building Type	DOE Prototype Building Type	DOE Prototype Building Share of California Forecasted Construction
Small Office	**Small Office (dropped from analysis)**	100%
Large Office	Large Office	50%
Large Office	Medium Office	50%
Restaurant	Full-Service Restaurant	40%
Restaurant	Quick-Service Restaurant	60%
Retail	Stand-alone Retail	50%
Retail	Strip Mall	50%
Food	**Not modeled**	100%
Non-refrigerated Warehouse	Warehouse	100%
Refrigerated Warehouse	**Not modeled**	100%
School	Primary School	34%
School	Secondary School	66%
College	**Not modeled**	100%
Hospital	**Not covered by the standard**	100%
Hotel	**Small Hotel (not modeled)**	50%
Hotel	Large Hotel	50%
Miscellaneous	**Not modeled**	100%

Source: Architectural Energy Corporation

CHAPTER 3: Summary of Findings

Results of this analysis show that California's *2013 Building Energy Efficiency Standards* for nonresidential buildings to be more stringent than *ASHRAE/IESNA Standard 90.1-2010*. Nonresidential buildings that will be built in California after 2014 are estimated to use a total of 27,804 GBtu of TDV energy compared to 31,486 GBtu of TDV energy for buildings constructed under the ASHRAE/IESNA Standard 90.1-2010. This is a reduction of approximately 12% energy use compared to commercial buildings of ASHRAE/IESNA Standard 90.1-2010. Comparisons of energy use are presented in Table 2.

It should be noted that the *2013 Standards* also includes a number of requirements that are not included in the simulations and are not included in the reference national energy code. Some of these measures and requirements apply to such things as: process boilers, commercial refrigeration, parking garages, laboratories, computer rooms and compressed air systems. It can be assumed that if California requirements for these measures were included in the analysis savings results compared to the national reference code would increase even further.

Table 2: Comparison of New Building Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	31,486	1,168	19.3	5,915
Title 24-2013	27,804	1,012	18.0	5,253
Savings	3,682	156	1.3	662
Savings	12%	13%	7%	11%

Source: Architectural Energy Corporation

Comparison by Building Type

Tables 3-8 shows the comparison of energy savings between these two energy codes based on building type. California's largest energy savings compared to ASHRAE/IESNA requirements are estimated for restaurants. This is most likely related to California's process requirements such as demand controlled exhaust systems. On the other hand, the smallest energy savings shown for California's standards compared to the requirements of ASHRAE/IESNA Standards 90.1 are for schools and large offices. For a number of building types, natural gas consumption is larger for California's standards the for the national energy reference code (negative savings). One reason for this is that energy efficiency measures of California's standards are aimed at reducing cooling loads (peak load savings) which can in some cases result in increased heating loads. Electricity savings, however, more than offset the increases in gas use.

Table 3: Comparison of New Large Office Building Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	5,417	227	0.71	844
Title 24-2013	5,196	210	1.27	843
Savings	221	17	-0.6	1
Savings	4%	7%	-79%	0%

Source: Architectural Energy Corporation

Table 4: Comparison of New Restaurant Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	9,415	307	11.95	2,242
Title 24-2013	7,643	250	9.52	1,806
Savings	1,771	57	2.4	436
Savings	19%	18%	20%	19%

Source: Architectural Energy Corporation

Table 5: Comparison of New Retail Building Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	9,788	369	1.50	1,407
Title 24-2013	8,722	316	1.70	1,250
Savings	1,066	52	-0.2	158
Savings	12%	14%	-13%	11%

Source: Architectural Energy Corporation

Table 6: Comparison of New Warehouse Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	2,314	96	1.50	478
Title 24-2013	2,051	79	1.81	451
Savings	263	17	-0.3	27
Savings	11%	18%	-21%	6%

Source: Architectural Energy Corporation

Table 7: Comparison of New School Building Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	2,419	102	0.48	395
Title 24-2013	2,350	100	0.43	383
Savings	69	2	0.05	12
Savings	3%	2%	10%	3%

Source: Architectural Energy Corporation

Table 8: Comparison of New Large Hotel Energy Consumption under Title 24-1023 and 90.1-2010, (2014 forecasted construction)

Code	TDV Energy (GBtu)	Electricity (GWh)	Natural Gas (Mtherm)	Site Energy (GBtu)
90.1-2010	2,134	69	3.15	550
Title 24-2013	1,841	57	3.26	521
Savings	292	12	-0.11	29
Savings	14%	17%	-3%	5%

Source: Architectural Energy Corporation

Nonresidential Construction Forecast Data

The Nonresidential Construction Forecast dataset is used to help make this energy comparison. This database projects new construction based on building type and California climate zone for the years 2010 through 2020. The 2014 forecast values were used for this analysis and are shown in Table 9 below.

Table 9: Projected 2014 Construction by Building Types and Climate Zone from the Non-Residential Construction Forecast (106 ft^2)

	California Climate Zone																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Grand Total
Small Office	0.04	0.24	0.82	0.57	0.11	0.78	0.83	0.93	1.71	0.46	0.29	1.30	0.69	0.12	0.04	0.16	9.09
Large Office	0.03	0.84	4.11	2.16	0.42	2.01	1.25	2.81	5.36	0.63	0.53	5.39	1.29	0.29	0.19	0.40	27.69
Restaurant	0.01	0.06	0.26	0.13	0.03	0.53	0.81	0.56	1.14	0.39	0.07	0.58	0.33	0.07	0.03	0.09	5.08
Retail	0.07	0.62	2.20	1.57	0.30	3.08	3.71	3.50	6.94	1.97	0.87	4.34	2.13	0.43	0.17	0.53	32.44
Food	0.03	0.16	0.51	0.41	0.08	0.69	0.95	0.84	1.80	0.52	0.31	1.21	0.67	0.13	0.05	0.15	8.51
Warehouse	0.04	0.48	2.46	1.13	0.22	2.36	4.79	2.69	5.29	2.35	1.33	5.35	2.57	0.38	0.15	0.49	32.07
Refrig. Wrhse.	0.00	0.04	0.19	0.10	0.02	0.06	0.08	0.06	0.14	0.16	0.15	0.42	0.26	0.03	0.02	0.03	1.75
School	0.05	0.25	0.86	0.56	0.11	0.76	0.93	0.90	1.62	0.66	0.44	1.60	0.88	0.15	0.05	0.18	9.98
College	0.02	0.18	0.69	0.46	0.09	0.64	0.53	0.77	1.64	0.32	0.19	1.01	0.56	0.10	0.04	0.14	7.38
Hospital	0.03	0.22	0.78	0.53	0.10	0.75	0.55	0.85	1.58	0.31	0.30	1.48	0.81	0.09	0.04	0.16	8.59
Hotel	0.03	0.29	0.79	0.77	0.15	0.50	0.67	0.94	2.19	0.33	0.17	1.34	0.49	0.19	0.04	0.20	9.10
Miscellaneous	0.08	0.65	2.28	1.61	0.31	2.85	4.52	3.26	6.75	2.36	0.68	3.52	1.70	0.43	0.17	0.47	31.65
Grand Total	0.44	4.03	16.0	10.0	1.94	15.0	19.6	18.1	36.2	10.5	5.31	27.5	12.4	2.40	0.99	2.99	183.33

Source: Architectural Energy Corporation

CHAPTER 4: Conclusion

This report concludes that the estimated energy use for nonresidential buildings of California's *2013 Building Energy Efficiency Standards* exceed the energy savings expected from the commercial building requirements of *ASHRAE/IESNA Standard 90.1-2010.* California's nonresidential energy standards contain building measures and building performance operation impacts that are more rigorous, resulting in higher efficiency levels for new nonresidential construction than expected to occur from efficiency requirements of the federal reference energy code.