California Energy Commission

CONSULTANT REPORT

IMPACT ANALYSIS

California's 2013 *Building Energy Efficiency Standards*

CALIFORNIA
ENERGY COMMISSION

Edmund G. Brown Jr., Governor

JULY 2013

CEC-400-2013-008

CALIFORNIA ENERGY COMMISSION

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ACKNOWLEDGEMENTS

Architectural Energy Corporation (AEC) and its subcontractors prepared this impact analysis on the 2013 Title 24, *Building Energy Efficiency Standards,* update project. Ken Nittler, P.E. and Bruce Wilcox, P.E., prepared residential energy savings estimates. Architectural Energy Corporation developed the estimates of nonresidential energy and demand savings. AEC also prepared the report.

ABSTRACT

This report estimates the statewide energy impacts of proposed changes to the California *2013 Building Energy Efficiency Standards* on a regional and statewide basis. The estimates are based on the 15-day draft of the standards as of May 21, 2012.

For each year of construction, in both newly constructed buildings and alterations to existing buildings, the proposed standards are estimated to reduce the growth in electricity by 555.5 gigawatt hours (GWh) and to reduce the growth in peak electrical demand by 148.4 MW. In addition, natural gas use is expected to be reduced by 7.04 million therms. The savings will accumulate as the standards affect each subsequent year of construction.

The savings result from changes to both the residential and nonresidential standards. The standards affect both newly constructed buildings as well as alterations to existing buildings. Alterations are a significant part of the savings. These savings result from retrofit insulation requirements for existing roofs and the energy requirement for renovated lighting systems to meet the new 2013 energy requirements.

Keywords: California Energy Commission, *Building Energy Efficiency Standards*, Architectural Energy Corporation, impact analysis

Hedrick, Roger, Architectural Energy Corporation; , Bruce Wilcox, P.E., Ken Nittler, P.E. 2013. ***Impact Analysis: California's 2013 Building Energy Efficiency Standards.*** California Energy Commission, High Performance Buildings and Standards Development Office, CEC-400-2013-008.

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EXECUTIVE SUMMARY

This report estimates the statewide impacts of proposed changes to the 2013 California *Building Energy Efficiency Standards* regionally and statewide. The estimates are based on the 15-day draft of the standards as of May 21, 2012.

Table 1 shows a summary of the estimated energy savings for the standards. For each year of construction (in both newly constructed buildings and alterations to existing buildings), the proposed standards are estimated to reduce the growth in electricity by 555.5 gigawatt hours (GWh) and to reduce the growth in peak demand by 148.4 megawatts (MW). In addition, natural gas use is expected to be reduced by 7.04 million therms. The savings will accumulate as the standards affect each subsequent year of construction.

The savings result from changes to the requirements affecting both residential and nonresidential buildings. The standards affect both newly constructed buildings as well as alterations to existing buildings. Alterations are a significant part of the savings. These savings result from retrofit insulation requirements for existing roofs and the requirement that renovated lighting systems meet the new requirements.

More detail of the savings is provided in later tables. Electricity energy savings are summarized in Table 2, electric demand savings in Table 3, and gas savings in Table 4.

Table 1: Savings Summary

	Electricity		Demand		Gas	
	Savings (GWh)	Percent of Total	Savings (MW)	Percent of Total	Savings (millions therms)	Percent of Total
Single-Family Newly Constructed Buildings and Alternations	21.9	3.9%	29.0	19.5%	0.76	10.8%
Multifamily Newly Constructed Buildings and Alternations	5.9	1.1%	6.0	4.1%	0.18	2.5%
Nonresidential Newly Constructed Buildings	272.3	49%	50.3	33.9%	3.7	52.6%
Nonresidential Alterations	255.4	46%	63.1	42.5%	2.4	34.1%
Total	**555.5**	**100%**	**148.4**	**100%**	**7.04**	**100%**

Source: Architectural Energy Corporation

Low-Rise Residential Newly Constructed Buildings and Alterations

The first-year savings for single-family homes are 21.9 GWh of electricity, 29.0 MW of demand and 0.76 million therms of gas. For low-rise, multifamily buildings, the first-year electricity savings are 5.9 GWh, 6.0 MW of demand, and 0.18 million therms of gas.

Looking at the entire construction outlook for low-rise single-family detached homes, electricity use is reduced by 36.4 percent compared to the 2008 Standards, peak demand is reduced by 40.4 percent, and gas is reduced by 6.5 percent. These percentage savings are relative to heating, cooling, lighting and water heating only and do not include other appliances, outdoor lighting that is not attached to buildings, plug loads, or other energy uses.

Single-family estimates are based on 22,795 housing starts each year, and multifamily estimates are based on 18,747 housing starts. These data are from the Construction Industries Research

Board (CIRB) and are significantly reduced compared to previous updates to the standards due to the recession in building construction.

Building envelope, heating ventilation and air conditioning (HVAC) and water heating savings for low-rise residential were calculated using the prototype building approach similar to the method used for previous standards updates; however, this analysis included multiple prototype buildings to better approximate the nature of construction activity across the state. The savings for each prototype in each climate were weighted by estimated annual housing starts in each climate to yield an estimate of statewide savings.

Nonresidential Newly Constructed Buildings

The first-year savings for newly constructed nonresidential buildings are 272.3 GWh of electricity, 50.3 MW of demand, and 3.74 million therms of gas, representing reductions from the *2008 Standards* of 22 percent, 18 percent, and 17 percent, respectively. The savings for nonresidential buildings were calculated using the Non-Residential Construction Forecast dataset, which predicts 183.3 million square feet of nonresidential new construction in 2014. Ten building prototypes from the set of U.S. Department of Energy (DOE) "Prototype" EnergyPlus building models were used to predict energy savings. Multiple computer modeling runs were performed on these prototype building models such that changes at modeling run time would result in buildings that complied with the *2008 Standards* for all 16 climate zones, or would include any or all of the measures added to the *2013 Standards*. The efficiency measures pertaining to the building component categories listed in Tables 2-4 were modeled sequentially, such that the energy use calculated for each category also contain the efficiency measures pertaining to all the building component categories listed above. For example, the "Cool Roof" energy use includes the 2013 Standards level of energy use for "Lighting" and "Cool Roof", and the "Glazing" energy use includes the 2013 Standards level of energy use for "Lighting", "Cool Roof" and "Glazing". When all measures are included, the result is a building that complies with the *2013 Standards*. The results of these simulations were then weighted by the forecasted construction based on building type and climate zone to determine statewide energy consumption for new construction.

Alterations to Existing Nonresidential Buildings

Savings for alterations to existing buildings are quite significant, representing almost half of the total nonresidential electricity savings and more than 55 percent of the nonresidential demand savings. First-year electricity savings are expected to be 255.4 GWh, first-year demand reduction is 63.1 MW, and first-year gas savings are 2.4 million therms. Most of the energy savings are related to improvements in interior lighting and increased HVAC equipment efficiency requirements.

Table 2: Summary of First-Year Electricity Savings (GWh)

	2008 Standard	2013 Standard	Savings	Percent Savings	Percent of Total Savings
Single-Family Newly Constructed Buildings and Alternations					
	60.1	38.2	21.9	36.4%	3.9%
Multifamily Newly Constructed Buildings and Alternations					
	25.3	19.4	5.9	23.3%	1.1%
Nonresidential Newly Constructed Buildings					
2008 Standard Baseline	1,249				
Lighting		1,132	117	9.3%	21.1%
Cool Roof		1,126	6	0.5%	1.1%
Glazing		1,110	16	1.3%	2.9%
HVAC		1,073	36	2.9%	6.5%
Process		1,072	2	0.1%	0.3%
Additional Process Savings*		-	93	7.5%	16.7%
Other		1,070	2	0.2%	0.3%
Total			272	21.8%	
Nonresidential Alterations					
Envelope Alterations	3,314	3,298	16	0.5%	2.9%
Lighting Alterations	3,314	3,146	168	5.1%	30.2%
HVAC Alterations	2,485	2,414	72	2.9%	13.0%
Total			255	N/A	
Total			555.5	N/A	100.0%

* These savings were estimated separately in CASE reports and not integrated into the whole building simulations completed for all other savings listed here.

Source: Architectural Energy Corporation

Table 3: Summary of First-Year Electric Demand Savings (MW)

	2008 Standard	2013 Standard	Savings	Percent Savings	Percent of Total Savings
Single-Family Newly Constructed Buildings and Alterations					
	71.7	42.8	29.0	40.4%	19.5%
Multifamily Newly Constructed Buildings and Alterations					
	28.2	22.2	6.0	21.2%	4.0%
Nonresidential Newly Constructed Buildings					
2008 Standard Baseline	273.0				
Lighting		249.4	23.6	8.6%	16.0%
Cool Roof		247.3	2.1	0.8%	1.4%
Glazing		240.0	7.2	2.7%	4.9%
HVAC		226.4	13.6	5.0%	9.2%
Process		226.4	0.0	0.0%	0.0%
Additional Process Savings*		-	3.5	1.3%	2.4%
Other		226.2	0.2	0.1%	0.1%
Total			50.3	18.4%	
Nonresidential Alterations					
Envelope Alterations	707.7	702.2	5.5	0.8%	3.7%
Lighting Alterations	707.7	675.3	32.4	4.6%	21.8%
HVAC Alterations	530.8	505.5	25.2	4.8%	17.0%
Total			63.1	N/A	
Total			148.4	N/A	**100.0%**

* These savings were estimated separately in CASE reports and not integrated into the whole building simulations completed for all other savings listed here.

Source: Architectural Energy Corporation

Table 4: Summary of First-Year Gas Savings (millions Therms)

	2008 Standard	2013 Standard	Savings	Percent Savings	Percent of Total Savings
Single-Family Newly Constructed Buildings and Alternations					
	11.74	10.98	0.76	6.5%	10.7%
Multifamily Newly Constructed Buildings and Alternations					
	4.58	4.41	0.18	3.8%	2.5%
Nonresidential Newly Constructed Buildings					
2008 Standard Baseline	22.27				
Lighting		22.48	-0.20	-0.9%	-2.8%
Cool Roof		22.52	-0.04	-0.2%	-0.6%
Glazing		22.51	0.01	0.0%	0.1%
HVAC		21.26	1.26	5.6%	17.8%
Process		21.26	0.00	0.0%	0.0%
Additional Process Savings*		-	2.74	12.3%	38.8%
Other		21.27	-0.01	0.0%	-0.1%
Total			3.74	16.8%	
Nonresidential Alterations					
Envelope Alterations	57.27	57.36	-0.09	-0.2%	-1.3%
Lighting Alterations	57.27	57.57	-0.30	-0.5%	-4.2%
HVAC Alterations	42.95	40.19	2.77	6.4%	39.2%
Total			2.38	N/A	
Total			7.06	N/A	**100%**

* These savings were estimated separately in CASE reports and not integrated into the whole building simulations completed for all other savings listed here.

Source: Architectural Energy Corporation

Emissions

The *2013 Building Energy Efficiency Standards* are expected to have a significant impact on reducing greenhouse gas and other air emissions. The estimates are shown in Table 5. Carbon dioxide, one of the more significant greenhouse gases, would be reduced by 596,740 tons each year. These estimates are based, when possible, on hourly emission rates for electricity use in California. When savings estimates are made on an annual basis, average emission rates are used.

Table 5: Summary of Air Emissions Reductions

	Emission Reductions				
	NO_X (lb)	**SO_X (lb)**	**CO (lb)**	**CO_2 (tons)**	**PM_{10} (lb)**
Single-Family Newly Constructed Buildings and Alternations	7,901	196	4,483	14,847	1,029
Multifamily Newly Constructed Buildings and Alternations	1,869	52	1,100	3,857	257
Nonresidential Newly Constructed Buildings	47,373	2,120	34,127	152,488	8,698
Electricity	13,888	1,906	19,878	131,114	5,991
Gas	33,486	214	14,249	21,374	2,707
Nonresidential Alterations	34,285	1,923	27,689	136,530	7,337
Electricity	13,024	1,788	18,642	122,959	5,618
Gas	21,261	136	9,047	13,571	1,719
Total	**173,087**	**8,335**	**129,215**	**596,740**	**33,356**

Source: Architectural Energy Corporation

CHAPTER 1:
Low-Rise Residential Newly Constructed Buildings and Alterations

The effect of implementing the residential envelope, HVAC, and water heating measures of the *2008 Standards* was estimated using a prototype building approach. With this approach, three prototype buildings are used, two for single-family homes and one for multifamily homes. Each prototype is configured to minimally comply with the 2008 and 2013 prescriptive requirements, and the results are weighted by anticipated housing starts in each climate zone.

Standards Requirements

The changes to the standards that result in savings are described in the following sections. Compliance alternatives or "credits" are not considered since these are assumed to be energy-neutral. Also, items that were moved from the prescriptive standard to mandatory requirements in all climate zones, such as verified duct sealing, are assumed to be energy-neutral.

Measures Included in Analysis

Key terms used to describe measures below:

- R-value: the measure of the thermal resistance of insulation or any material or building component expressed in ft2-hr-°F/Btu. The higher the R-value the greater the thermal resistance.
- U-factor: the overall coefficient of thermal transmittance of a fenestration, wall, floor, roof or ceiling component, in Btu/(hr. x ft.^{2} x °F), including air film resistance at both surfaces.
- Solar heat gain coefficient (SHGC): the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.
- Radiant barrier: a highly reflective, low emitting material installed at the underside surface of the roof deck and the inside surface of gable ends or other exterior vertical surfaces in attics to reduce solar heat gain.
- Verified airflow and fan watt draw: a measurement of the effectiveness of the air supply system of a building to deliver the air to interior spaces as designed and the measurement of the fan energy use to distribute the air.

Measure	*Modeling Notes*
Wood-Framed Walls. R15 insulation between the framing plus R4 sheathing insulation in all climate zones.	Modeled through the ACM algorithms.
Fenestration. U-factor 0.32 in all climate zones. SHGC 0.25 in cooling climate zones and no requirement in heating climate zones 1, 3 and 5.	Modeled through the ACM algorithms.
Radiant Barrier. Prescriptive requirement expanded to include climate zones 3, 5-7.	Modeled through the ACM algorithms.
Whole House Fan. Prescriptive requirement in zones 8-14.	Modeled through the ACM algorithms.
Verified Airflow and Fan Watt Draw. This feature is now a mandatory measure in all climate zones. Previously a prescriptive requirement in 10-15.	Modeled through the ACM algorithms.
Duct Insulation. Prescriptive requirement for R6 duct insulation expanded to climate zones 6-8.	Modeled through the ACM algorithms.
Water Heating. Revised mandatory and prescriptive requirements in all climate zones.	Modeled through the ACM algorithms.
Lighting. Revised mandatory lighting in all climate zones.	Not modeled through the ACM algorithms as this is a mandatory measure. Calculated separately and added to results of ACM calculations.

Method

Prototype Buildings

The energy and electric demand effect of implementing the 2013 building envelope, HVAC, and water heating requirements is estimated through the use of three prototype buildings: a 2,100 ft^2 one-story home, a 2,700 ft^2 two-story home and a 6,960 ft^2 two-story, eight dwelling, multifamily building. These prototype buildings were also used in developing the *2008 Standards*. Each prototype building is configured to comply minimally with the *2008 and 2013 Standards*. The electric demand values in this report were calculated using an 8,760-hour file of electric demand multipliers and hourly electricity consumption to provide a weighted-average contribution to statewide electricity demand.

Glazing Area

The glazing area in each prototype building is based on a statewide average of 17.3 percent of the floor area for single-family and 14.5 percent for multifamily.

Computer Modeling

Heating, cooling, and water heating energy use is modeled using the MICROPAS v2013.c software. This software includes the use of the new California computer simulation engine (CSE) that is to be used to implement the *2013 Standards*. This computer engine incorporates new capabilities to improve modeling and was used for estimates for both the *2008 and 2013 Standards,* resulting in an equitable comparison of the feature differences of the standards, not software differences.

To separate energy savings due to federal changes in equipment efficiencies, the results presented here have assumed that the new federal efficiency levels apply to both the 2008 and 2013 energy consumption estimates. The new federal equipment efficiencies include furnace annual fuel utilization efficiency (AFUE) of 0.80, air conditioner Seasonal Energy Efficiency Ratio/Energy Efficiency Ratio (SEER/EER) of 14/12.2, and storage water heater energy factor (EF) of 0.60. Note: AFUE, SEER/EER and EF are efficiency rating values prescribed by federal appliance regulations to describe the operation efficiency of equipment under specific testing conditions.

Weighting

The analysis is completed for all 16 California climate zones, and the results are then weighted by the estimated number of housing starts in each climate zone for each prototype building. For single-family, 45 percent of the homes are weighted as being the 2,100 ft^2 prototype building and 55 percent as the 2,700 ft^2 prototype building. For roof types, 80 percent are weighted as having tile and 20 percent as asphalt shingles.

Analysis and Detailed Results

Prototype Building Savings

Table 6, Table 7, and Table 8 show the first-year time dependent valuation (TDV) savings by end use and climate zone for each prototype building. TDV is used by the Energy Commission as the metric to describe building energy use and accounts for the time when energy is used during the day and its effects on the environment from utility supply sources. These data are normalized on a per-square-foot basis. The fan column in these tables includes the added energy use of the new prescriptive requirement for single-family whole house fans in Climate Zones 8-14. This increase in fan energy is offset by substantial savings accrued to the cooling energy.

Table 9 shows the total statewide energy and peak demand impacts for each climate zone of single family buildings. The peak demand impacts are calculated by multiplying the hourly demand impacts by multipliers that represent the importance of each hour's demand to the electricity system demand constraints. Only 250 hours in the year have non-zero multipliers, meaning that only 250 hours of the year are expected to be important when considering California's electricity system demand constraints. Source: Architectural Energy Corporation

Table **10** shows the first-year gas and electricity savings for single-family and multifamily buildings, respectively. These data are presented on a statewide basis and include weighting by housing starts. These tables also show estimates of emissions reductions.

Table 11 shows the estimated housing starts for both single-family and multifamily buildings. It is estimated that 22,795 single-family homes and 18,747 multifamily homes will be constructed each year in California. These are substantially lower housing starts than those used for the impact analysis of the *2008 Standards* because of the downturn of the overall construction industry due to the economic recession experienced during this period.

Table 6: 2,100 ft² Single-Family, First-Year TDV Savings by Climate Zone and End Use (kTDV/ft²)

Climate Zone	Space Heating	Space Cooling	Fan	Water Heating	Lighting	Total
1	0.10	0.00	0.00	0.62	0.36	1.08
2	4.08	4.89	0.00	0.57	0.36	9.90
3	4.14	2.10	0.00	0.58	0.36	7.17
4	3.11	8.61	0.00	0.56	0.36	12.64
5	10.95	0.00	0.00	0.59	0.36	11.90
6	1.93	8.40	0.00	0.54	0.36	11.22
7	0.67	7.59	0.00	0.53	0.36	9.15
8	1.18	16.84	-1.59	0.53	0.36	17.33
9	1.27	20.07	-1.32	0.53	0.36	20.92
10	1.02	19.26	-1.12	0.53	0.36	20.05
11	-0.13	17.71	-0.78	0.53	0.36	17.69
12	-0.01	18.63	-0.96	0.55	0.36	18.57
13	0.21	17.54	-0.90	0.52	0.36	17.73
14	-1.83	14.96	-0.70	0.54	0.36	13.34
15	0.04	11.67	0.00	0.44	0.36	12.51
16	-7.87	19.71	0.00	0.62	0.36	12.82
Average	1.18	11.75	-0.46	0.54	0.36	13.38

Source: Architectural Energy Corporation

Table 7: 2,700 ft² Single-Family, First-Year TDV Savings by Climate Zone and End Use (kTDV/ft²)

Climate Zone	Space Heating	Space Cooling	Fan	Water Heating	Lighting	Total
1	0.42	0.00	0.00	0.54	0.38	1.10
2	4.99	6.30	0.00	0.50	0.38	9.92
3	4.50	3.29	0.00	0.51	0.38	7.20
4	3.88	9.84	0.00	0.49	0.38	12.67
5	10.51	-0.02	0.00	0.51	0.38	11.92
6	2.12	8.88	0.00	0.48	0.38	11.25
7	0.74	7.35	0.00	0.46	0.38	9.17
8	1.52	16.14	-1.45	0.47	0.38	17.35
9	1.82	19.39	-1.25	0.46	0.38	20.94
10	1.77	19.65	-1.06	0.47	0.38	20.08
11	0.50	19.48	-0.75	0.47	0.38	17.72
12	0.68	17.10	-0.93	0.49	0.38	18.60
13	0.79	17.07	-0.87	0.46	0.38	17.75
14	-1.25	14.69	-0.66	0.47	0.38	13.36
15	0.12	11.41	0.00	0.38	0.38	12.53
16	-6.71	23.64	0.00	0.55	0.38	12.85
average	1.65	12.14	-0.43	0.48	0.38	13.40

Source: Architectural Energy Corporation

Table 8: Multifamily, First-Year TDV Savings by Climate Zone and End Use (kTDV/ft²)

Climate Zone	Space Heating	Space Cooling	Fan	Water Heating	Lighting	Total
1	0.50	0.02	0.00	0.67	0.37	1.77
2	3.75	6.99	0.00	0.61	0.37	11.93
3	2.73	4.28	0.00	0.62	0.37	8.21
4	2.77	9.59	0.00	0.60	0.37	13.54
5	5.48	-1.51	0.00	0.62	0.37	5.17
6	0.77	9.61	0.00	0.58	0.37	11.53
7	0.01	8.05	0.00	0.56	0.37	9.20
8	0.62	10.69	0.00	0.56	0.37	12.45
9	1.01	13.97	0.00	0.56	0.37	16.12
10	1.15	11.32	0.00	0.56	0.37	13.61
11	0.81	10.94	0.00	0.56	0.37	12.89
12	0.92	9.06	0.00	0.58	0.37	11.15
13	0.93	10.73	0.00	0.55	0.37	12.79
14	-0.41	9.51	0.00	0.57	0.37	10.25
15	0.00	9.32	0.00	0.43	0.37	10.33
16	-4.49	21.83	0.00	0.67	0.37	18.59
Average	1.03	9.03	0.00	0.58	0.37	11.22

Source: Architectural Energy Corporation

Table 9: Statewide Impact – Single-Family

	Energy and Demand			Emissions				
Climate Zone	Gas Savings (MBtu)	Electricity (MWh)	Demand (MW)	NOX (tons)	SOX (tons)	CO (tons)	CO_2 (tons)	PM2.5 (tons)
1	-32	20	0.00	0.00	0.00	0.00	8	0.00
2	4419	334	0.29	0.21	0.00	0.10	413	0.02
3	12657	611	0.44	0.58	0.01	0.26	1017	0.05
4	9322	1143	1.51	0.45	0.01	0.22	1083	0.05
5	5781	130	0.00	0.26	0.00	0.11	393	0.02
6	8479	1348	1.93	0.41	0.01	0.21	1133	0.05
7	4514	990	1.48	0.23	0.00	0.12	734	0.03
8	8677	2723	4.49	0.46	0.01	0.26	1807	0.06
9	11111	4168	5.92	0.60	0.02	0.36	2642	0.09
10	8917	3204	4.31	0.48	0.01	0.29	2052	0.07
11	838	809	0.95	0.06	0.00	0.05	437	0.01
12	4570	2831	4.03	0.28	0.01	0.19	1624	0.05
13	2743	1843	1.80	0.17	0.01	0.12	1044	0.03
14	-797	546	0.56	-0.02	0.00	0.00	218	0.00
15	470	608	0.38	0.04	0.00	0.03	320	0.01
16	-5833	530	0.88	-0.25	0.00	-0.09	-78	-0.02
Total	75838	21838	28.98	3.95	0.10	2.24	14847	0.51

Source: Architectural Energy Corporation

Table 10: Statewide Impact – Multifamily

	Energy and Demand			Emissions				
Climate Zone	Gas Savings (MBtu)	Electricity (MWh)	Demand (MW)	NOX (tons)	SOX (tons)	CO (tons)	CO_2 (tons)	PM2.5 (tons)
1	50	9	0.00	0.00	0.00	0.00	7	0.00
2	1753	161	0.16	0.08	0.00	0.04	178	0.01
3	1777	128	0.12	0.08	0.00	0.04	163	0.01
4	1246	174	0.20	0.06	0.00	0.03	155	0.01
5	1030	26	-0.01	0.05	0.00	0.02	72	0.00
6	1101	354	0.42	0.06	0.00	0.03	233	0.01
7	820	433	0.52	0.05	0.00	0.03	255	0.01
8	1310	534	0.59	0.07	0.00	0.04	332	0.01
9	2031	755	0.90	0.11	0.00	0.07	479	0.02
10	3016	897	0.94	0.16	0.00	0.09	604	0.02
11	759	304	0.25	0.04	0.00	0.03	190	0.01
12	2190	627	0.59	0.11	0.00	0.06	427	0.01
13	1776	666	0.52	0.10	0.00	0.06	422	0.01
14	114	244	0.19	0.01	0.00	0.01	124	0.00
15	254	307	0.16	0.02	0.00	0.02	162	0.00
16	-1728	315	0.42	-0.07	0.00	-0.02	53	0.00
Total	17501	5933	5.97	0.93	0.03	0.55	3857	0.13

Source: Architectural Energy Corporation

Table 11: Estimated Housing Starts by Climate Zone

Climate Zone	Single-Family	Multi-Family
1	65	94
2	579	684
3	1636	863
4	1541	616
5	299	269
6	2034	1252
7	2062	1912
8	2765	1629
9	3280	1986
10	2484	2645
11	621	820
12	2665	2165
13	1380	1755
14	493	726
15	494	748
16	398	583
Total	22795	18747

Source: Architectural Energy Corporation

Alterations and Renovations

The projected savings for newly constructed homes are increased by 43 percent to account for additions and alterations to existing homes. This multiplier is based on the dollar value of 2011 CIRB new single-family construction compared to addition/alteration construction dollars.

CHAPTER 2:
Nonresidential Newly Constructed Buildings

Standards Requirements

The following sections describe the significant changes to the nonresidential standards, organized by building envelope, lighting, HVAC, process and other uses. Most requirements apply to new construction, but some requirements have been evaluated for their effect as alterations to existing buildings. The analysis was based on the standards as issued in the 15-day rulemaking language on May 21, 2012.

Lighting

Measure	*Modeling Notes*
Lighting Controls §130.1 – The *2013 Standards* requires occupancy controls for lighting in open office areas and manual lighting controls in primary sidelit daylighting areas.	Occupancy controls used the original prototype model schedules adjusted by the difference between 2008 ACM lighting schedule and the CASE[1] report schedule. Manual lighting controls simulated by decreasing the daylighting control setpoint.
Daylighting §140.3(c) – Spaces > 5,000 ft² directly under the roof with a ceiling height > 15 ft. shall have at least 75 percent of the floor area in either a primary sidelit or skylit daylighting area. Determination of the primary and secondary sidelit areas is changed slightly.	Modeled by adding skylights to high-bay spaces and adding daylighting controls to secondary sidelit daylit areas.
Lighting Power Density Table 140.6-C – *2013 Standards* have revised lighting power density values.	Modeled using area category values including an estimate of subspace areas for use of allowances from the Table 140.6-C footnotes.

1 The Codes and Standards Enhancement (CASE) Initiative addresses energy efficiency opportunities through development of new and updated measures affecting Title 24 (buildings) and Title 20 (appliance) standards. With representatives from state utilities, CASE teams provide individual technical reports that document information and data helpful to the California Energy Commission and other stakeholders in updating the standards. The objective of CASE reports is to provide comprehensive technical, economic, market, and infrastructure information on measures with potential benefit for the building energy and appliance standards.

Envelope

Measure	*Modeling Notes*
Roof Reflectance §140.3(a) 1A – Minimum roof reflectance is increased to 0.63 for low-sloped roofs and 0.20 for steep-sloped roofs. The reflectance and thermal emittance requirements now apply to all climate zones. No change to high-rise residential buildings	Simulated using: solar absorptance = 1/reflectance thermal absorptance = 1/emittance.
Windows §140.3(a)5B – The *2013 Standards* have requirements for vertical and skylight glazing that are consistent across all climate zones, and add requirements for visible transmittance. The requirements vary only be glazing type (fixed, operable, and so forth.).	Glazing modeled using EnergyPlus WindowMaterial: SimpleGlazingSystem objects

HVAC

Measure	*Modeling Notes*
Equipment Efficiency Updates Tables 110.2-A-110.2-G – *2013 Standard* have revised equipment efficiency requirements.	Modeled by adjusting HVAC efficiency to match prescriptive requirements.
Occupancy Controls §120.2(e)3 – Buildings (except retail, restaurant, grocery, church, and theater buildings) must include automatic shutoff controls that reset heating and cooling setpoints by 2°F when spaces are unoccupied. Multipurpose rooms, classrooms, conference rooms, conventions, auditoriums and meeting center rooms must also reset minimum ventilation rates.	Modeled with revised occupancy, thermostat and ventilation schedules for offices and schools. Baseline models used revised occupancy schedules.
Economizer Fault Detection and Diagnostics §120.2(i) – DX systems with economizer and capacity > 4.5 tons must include FDD systems.	Modeled by derating baseline system performance by decreasing economizer maximum temperature by 10 percent of the difference between the 2013 value and 55°F, for example, 73°F vs. 75°F.
Building Commissioning §120.8 – All new nonresidential buildings must receive commissioning.	Applied CASE report savings estimate. Used average TDV factors to convert electric and gas savings to TDV Btus.
Commercial Boilers §120.9 – The *2013 Standards* include three mandatory measures for commercial boilers: combustion air positive shutoff, combustion fan VFD motors, and parallel	Modeled by increasing boiler efficiency, reducing boiler combustion motor power and

position control.	applying a revised normalized boiler efficiency curve.
Variable Air Volume (VAV) System Zone Controls §140.4(d) – The *2013 Standards* require controls on VAV boxes to reduce reheating or recooling of primary air. The controls limit the airflow to 50 percent of maximum before reheat is used, airflow is limited to 20 percent of maximum in the deadband, the first stage of heating is to increase supply temperature at deadband airflow, and heating airflow is increased only at supply temperature > 95°F.	Modeled by changing heating control damper action from "normal" to "reverse," decreasing maximum supply air temperature from 122°F to 95°F, and decreasing the maximum zone flow fraction in heating from 0.5 to 0.3.
Economizers §140.4(e) – Cooling capacity threshold where economizers are required is decreased from 6.25 tons to 4.5 tons.	Modeled by identifying units from the base buildings with capacities in this range based on CZ12. Cases for 2013 have multiple stages, while 2008 cases are single-speed.
Fan Controls §140.4(m), Table 140.4D – DX systems with cooling capacity of 65 kBtuh or more must have fans with at least two speeds.	Modeled by changing single-speed DX systems to VAV.

Process

Measure	***Modeling Notes***
Refrigerated Warehouses §120.6(a) – The *2013 Standards* include a number of requirements for refrigerated spaces.	Applied CASE report savings estimate. Used average TDV factors to convert electric and gas savings to TDV Btus.
Commercial Refrigeration §120.6(b) – Retail food stores greater than 8,000 ft² with refrigerated display cases or walk-in coolers have a number of new requirements: variable-speed condenser fans; condenser variable setpoint control logic in response to ambient conditions; condenser efficiency requirements; floating suction pressure control logic for compressors; and liquid subcooling for large, low-temperature compressors. Refrigerated display cases must have time-switch or motion sensor controlled lighting. Heat recovery must be installed to use rejected heat for space heating except in Climate Zone 15.	Applied CASE report savings estimate. Used average TDV factors to convert electric and gas savings to TDV Btus.
Parking Garages §120.6(c) – Systems that exhaust more than 10,000 cfm must detect contaminant levels and modulate flow to 50 percent or less to maintain contaminant levels. CO	Applied CASE report savings estimate. Used average TDV factors to convert electric and

levels must be maintained below 25 ppm, and the exhaust must be 0.15 cfm/ft² during occupancy.	gas savings to TDV Btus.
Process Boilers §120.6(d) – Process boilers must include combustion air positive shutoff, variable-speed combustion air fans, and flue gas oxygen controls.	Applied CASE report savings estimate. Used average TDV factors to convert electric and gas savings to TDV Btus.
Compressed Air Systems §120.6(e) – Compressed air systems must include trim compressors or variable speed compressors to provide trim capacity across the range of operating capacity.	Applied CASE report savings estimate. Used average TDV factors to convert electric and gas savings to TDV Btus.
Computer Rooms §140.9(a) – Rooms served by systems more than 5 tons must have either an integrated economizer that meets entire cooling load at an outside operating temperature of 55°F or less or an integrated water economizer that meets the entire load at 40°F DBT/35°F WBT or less. Reheat and nonadiabatic humidification are not allowed. Fans must consume 27 W/Btuh of sensible cooling capacity or less and be variable-speed. Finally, air-cooled computers must have containment to separate the hot and cold sides.	Applied CASE report savings estimate. Used average TDV factors to convert electric and gas savings to TDV Btus.
Commercial Kitchens §140.9(b) – Restricts use of makeup air introduced directly into exhaust hoods, limits exhaust hood-flow rates, requires use of any available transfer air for exhaust makeup, and requires demand-controlled exhaust for certain systems.	Modeled by applying a modified exhaust schedule to restaurants and food service spaces in the hotel and schools.
Laboratory Exhaust §140.9(c) – Laboratory exhaust systems that are required to provide 10 ACH or less must have variable-flow capability for both supply and exhaust fans to maintain proper pressurization while modulating flow.	Savings for this measure were not included in the impact analysis because data needed to project statewide savings are not available.
Building Commissioning §120.8 – New requirements for building commissioning are included in the *2013 Standards.* These requirements include development of the owner's or owner representative's project requirements (OPR) and a basis-of-design document, completion of a design phase review, inclusion of commissioning requirements on construction documents, development of a commissioning plan, performance of functional requirements testing, and completion of documentation and training.	Applied 25 percent of CASE report savings estimates. The CASE report savings were described as an upper bound, and were derated based on professional judgment with the concurrence of Energy Commission staff. Used average TDV factors to convert electric and gas savings to TDV Btus.

Other

Measure	*Modeling Notes*
Hot Water Pipe Insulation §120.3(a) – Hot water pipe insulation thickness is increased as per Table 120.3-A	Modeled by estimating pipe size and length for DHW system and using the EnergyPlus Pipe: Indoor object.
Hotel/Motel Guest Room Controls §120.2(e)4, §130.1(c)8, §130.5(d)5 – Guest rooms must be equipped with controls that turn off all lights, turn off at least 50 percent of receptacles, and reset temperature setpoints by 5°F within no more than 30 minutes of the room being vacated.	Modeled with modified lighting, equipment, and temperature setpoint schedules.

Method

EnergyPlus, Version 6, was used to simulate buildings that comply with the 2008 and 2013 versions of the standards, with the differences in energy consumption showing the effect of the changes to the standards. The analysis used some of the DOE "Prototype" building models (https://www.energycodes.gov/development/commercial/90.1_models), which were originally compliant with American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2010. Prototype building versions are also available that comply with ASHRAE Standard 90.1-2007 and 90.1-2004. These prototype buildings were modified to include parameters that would allow them to be made compliant with the *2008 or 2013 Standards*. The prototype buildings used were:

- Hotel-Large.
- Office-Large.
- Office-Medium.
- Restaurant-Full Service.
- Restaurant-Quick Service.
- Retail-Stand Alone.
- Retail-Stripmall.
- School-Primary.
- School-Secondary.
- arehouse.

Each of these prototype building models was equated to some portion of the buildings in the Non-Residential Construction Forecast dataset developed by Heschong Mahone Group (Sep. 26, 2011). Table 12 shows the correspondence between the modeled buildings and the building types from the construction forecast. When two building prototype building are used to

calculate the energy consumption for a building type from the forecast, the energy consumption of each model is weighted by the percentage shown in the table to compute the total energy consumption of that building type. The small office prototype building was dropped from the analysis because it represents a small percentage (<4%) of the statewide nonresidential energy consumption. Other buildings were not modeled because uncertainty exists about building characteristics (College, Miscellaneous), because their energy consumption is dominated by refrigeration equipment for which a well-defined baseline is not available, or because they were not included in the set of DOE prototypes

All simulations were performed using updated weather files for the 16 California climate zones. These files were developed by Whitebox Technologies and called out in this analysis as the CZ2010 weather files. The CZ2010 weather files include 86 state locations but do not include "climate zone" files. The analysis used the weather files for the "reference" locations of the 16 climate zones as identified by Whitebox.

TDV energy was computed using TDV factors that correspond to the new weather files. The TDV factors are annual hourly multipliers applied to site energy consumption that account for the time and priced of fuel for electric and gas. Values used for this analysis are based on the Electric (Non-Res) 15-year TDV factors. Electric demand values were calculated in a similar manner by using annual hourly multipliers for electric consumption, resulting in a weighted-average contribution to statewide electric demand.

Table 12: 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)	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	
Non-refrigerated Warehouse	Warehouse	100%
Refrigerated Warehouse	Not modeled	
School	Primary School	34%
School	Secondary School	66%
College	Not modeled	
Hospital	Not covered by the standard	
Hotel	Small Hotel (not modeled)	
Hotel	Large Hotel	100%
Miscellaneous	Not modeled	100%

Source: Architectural Energy Corporation

Statewide energy consumption by new construction nonresidential buildings is then calculated by multiplying the 2014 forecasted construction (expressed in millions of square feet) by the energy use per square foot of each modeled building in each climate zone. Table 13 shows the 2014 values from the Non-Residential Construction Forecast dataset.

Table 13: Projected 2014 Construction by Building Types and Climate Zone From the Non-Residential Construction Forecast (10^6 ft²)

	California Climate Zone																Grand Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
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

Analysis and Detailed Results

The efficiency measures listed above were applied to the *2008 Standards* baseline building models in the order listed. Measures were added cumulatively. Tables 14 through 20 show the energy and demand savings for various measures or groups of measures. The peak demand impacts are calculated by multiplying the hourly demand impacts by multipliers that represent the importance of each hour's demand to the electricity system demand constraints. Only 250 hours in the year have non-zero multipliers, meaning that only 250 hours of the year are expected to be important when considering California's electricity system demand constraints. Table 18 shows process measure savings. It also includes measures where the savings were not included in the modeling simulations themselves but are instead based on the CASE report estimates. Table 20 shows the overall savings when all new construction measures are included in the prototype buildings.

Table 14: Nonresidential Statewide First-Year Savings for New Construction Lighting Measures

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	4.6	0.5	0.2	0.00	0.04
2	57.4	7.6	2.4	-0.01	0.50
3	225.2	30.5	9.5	-0.02	1.88
4	147.8	20.2	6.3	-0.01	1.25
5	28.2	3.8	1.2	0.00	0.23
6	255.2	34.7	10.5	-0.01	2.10
7	296.0	40.0	12.0	-0.01	2.43
8	303.7	41.7	12.5	-0.01	2.48
9	598.4	81.4	24.8	-0.03	5.05
10	148.6	20.1	6.2	-0.01	1.25
11	71.7	9.3	3.0	-0.01	0.63
12	397.8	53.3	16.8	-0.04	3.47
13	172.3	22.6	7.3	-0.02	1.54
14	34.6	4.6	1.5	0.00	0.30
15	15.8	2.2	0.7	0.00	0.13
16	39.1	4.7	1.7	-0.01	0.34
Total	2,796.5	377.3	116.5	-0.20	23.60

Source: Architectural Energy Corporation

Table 15*:* Nonresidential Statewide First-Year Savings for New Construction Cool Roofs (Roof Reflectance)

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	0.8	0.0	0.0	0.00	0.01
2	2.6	0.2	0.1	0.00	0.04
3	7.4	0.6	0.3	0.00	0.10
4	6.4	0.6	0.2	0.00	0.08
5	1.0	0.1	0.0	0.00	0.01
6	21.9	2.4	0.8	0.00	0.25
7	21.8	2.4	0.8	0.00	0.25
8	24.6	2.8	0.9	0.00	0.28
9	27.3	3.0	1.0	0.00	0.33
10	8.5	0.8	0.3	0.00	0.10
11	4.0	0.3	0.1	0.00	0.06
12	18.4	1.6	0.7	-0.01	0.26
13	9.2	0.9	0.3	0.00	0.12
14	1.9	0.2	0.1	0.00	0.02
15	0.9	0.1	0.0	0.00	0.01
16	7.3	-0.1	0.3	-0.01	0.12
Total	163.9	16.0	6.0	-0.04	2.07

Source: Architectural Energy Corporation

Table 16: Nonresidential Statewide First-Year Savings for New Construction Glazing

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	-0.3	-0.1	0.0	0.00	0.00
2	5.7	0.8	0.2	0.00	0.07
3	49.4	5.8	1.3	0.01	0.69
4	43.2	5.3	1.2	0.01	0.66
5	4.4	0.4	0.1	0.00	0.06
6	47.7	4.7	1.6	-0.01	0.56
7	38.9	2.8	1.4	-0.02	0.50
8	70.1	7.5	2.2	0.00	0.90
9	163.6	16.1	4.8	0.00	2.38
10	20.0	2.4	0.7	0.00	0.24
11	9.9	1.3	0.3	0.00	0.12
12	50.1	6.4	1.6	0.01	0.64
13	23.4	2.9	0.8	0.00	0.31
14	4.3	0.5	0.1	0.00	0.05
15	2.7	0.3	0.1	0.00	0.03
16	-0.3	-0.5	0.0	0.00	0.03
Total	532.8	56.8	16.4	0.01	7.25

Source: Architectural Energy Corporation

Table 17: Nonresidential Statewide First-Year Savings for New Construction HVAC Measures

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	1.4	0.4	0.0	0.00	0.01
2	17.8	3.2	0.5	0.02	0.21
3	53.7	11.3	1.5	0.06	0.56
4	42.9	7.6	1.3	0.03	0.49
5	6.7	1.3	0.2	0.01	0.07
6	126.1	25.6	3.6	0.13	1.21
7	148.1	33.7	4.0	0.20	1.30
8	148.2	28.3	4.4	0.13	1.56
9	308.0	57.8	8.7	0.28	3.36
10	98.9	19.0	2.8	0.09	1.07
11	24.0	3.7	0.8	0.01	0.27
12	163.7	30.4	4.6	0.15	1.91
13	94.4	16.7	2.7	0.07	1.12
14	19.7	3.8	0.6	0.02	0.21
15	10.8	1.7	0.4	0.00	0.12
16	20.5	5.5	0.5	0.04	0.17
Total	1,285.2	250.1	36.5	1.26	13.63

Source: Architectural Energy Corporation

Table 18: Nonresidential Statewide First-Year Savings for New Construction Process Measures and Commissioning

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	0.1	0.0	0.0	0.00	0.00
2	0.4	0.1	0.0	0.00	0.00
3	1.7	0.3	0.1	0.00	0.00
4	1.0	0.2	0.1	0.00	0.00
5	0.2	0.0	0.0	0.00	0.00
6	3.0	0.6	0.2	0.00	0.00
7	4.4	0.9	0.3	0.00	-0.01
8	3.2	0.6	0.2	0.00	0.00
9	6.7	1.3	0.4	0.00	0.00
10	2.5	0.5	0.1	0.00	0.01
11	0.5	0.1	0.0	0.00	0.00
12	3.9	0.6	0.2	0.00	0.01
13	2.4	0.4	0.1	0.00	0.01
14	0.5	0.1	0.0	0.00	0.00
15	0.2	0.0	0.0	0.00	0.00
16	0.7	0.2	0.0	0.00	0.00
Total Simulated	31.4	5.8	1.7	0.00	0.03
CASE Report Total	2,385.5	591.4	93.1	2.74	3.48
Overall Total	2,416.9	597.2	94.9	2.73	3.51

Source: Architectural Energy Corporation

Table 19: Nonresidential Statewide First-Year Savings for Other New Construction Measures

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	0.1	0.0	0.0	0.00	0.00
2	1.2	0.2	0.1	0.00	0.01
3	3.3	0.5	0.2	0.00	0.02
4	3.2	0.5	0.2	0.00	0.02
5	0.6	0.1	0.0	0.00	0.00
6	2.2	0.3	0.1	0.00	0.01
7	3.2	0.5	0.2	0.00	0.01
8	4.3	0.7	0.2	0.00	0.02
9	9.8	1.5	0.5	0.00	0.05
10	1.4	0.2	0.1	0.00	0.01
11	0.7	0.1	0.0	0.00	0.00
12	5.9	0.9	0.3	0.00	0.03
13	2.2	0.3	0.1	0.00	0.01
14	0.8	0.1	0.0	0.00	0.00
15	0.2	0.0	0.0	0.00	0.00
16	0.8	0.1	0.0	0.00	0.00
Total	40.2	6.0	2.0	-0.01	0.21

Source: Architectural Energy Corporation

Table 20: Total Nonresidential New Construction Statewide First-Year Savings

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	6.8	0.8	0.3	0.00	0.07
2	85.0	12.1	3.2	0.01	0.82
3	340.8	48.9	12.9	0.05	3.25
4	244.5	34.4	9.2	0.03	2.50
5	41.2	5.7	1.6	0.00	0.38
6	456.2	68.4	16.8	0.11	4.13
7	512.4	80.3	18.6	0.17	4.49
8	554.2	81.7	20.5	0.12	5.24
9	1,113.8	161.1	40.1	0.24	11.17
10	279.9	43.0	10.2	0.08	2.67
11	110.9	14.9	4.3	0.00	1.08
12	639.7	93.2	24.2	0.11	6.32
13	303.9	43.8	11.3	0.05	3.10
14	61.8	9.4	2.3	0.01	0.59
15	30.6	4.4	1.2	0.00	0.30
16	68.1	9.8	2.5	0.01	0.67
Total Simulated	4,849.9	711.9	179.2	1.01	46.78
CASE Report Total	2,385.5	591.4	93.1	2.74	3.48
Overall Total	7,235.3	1,303.3	272.3	3.74	50.25

Source: Architectural Energy Corporation

CHAPTER 3:
Nonresidential Interior Lighting Alterations

Standards Requirement

New lighting systems in existing buildings and modifications to existing lighting systems must meet the control and lighting power requirements of §130.1, §140.3(c) and Table 140.6-C of the *2013 Standards*.

Method

The effect of new lighting systems in existing buildings is a result of the difference between the 2008 and 2013 standards. Although the lighting systems being replaced are expected to have significantly higher energy consumption than those that comply with the *2008 Standards*, the savings claimed here are only the additional savings for improvements beyond those already required by the *2008 Standards*. The analysis was performed by comparing 2008 compliant buildings to the same buildings with 2013 compliant lighting systems. The results were weighted by the existing floor area in each climate zone, and buildings were classified as shown in Table 12. The research team assumed that lighting systems are replaced every 15 years, meaning that 1/15th of the existing floor area was included in the analysis. Existing floor area data came from the Non-Residential Construction Forecast dataset, shown in Table 21.

Table 21: Existing Building Floor Area by Building Types and Climate Zone From the Non-Residential Construction Forecast (10^6 ft²)

	California Climate Zone																Grand Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Office-Small	8.9	16.0	35.0	48.0	30.9	25.5	7.3	66.3	15.7	40.0	21.3	14.8	55.5	3.0	6.8	1.5	396.5
Office-Large	5.5	21.8	36.1	166.8	207.6	61.5	4.9	269.7	92.3	54.1	133.2	79.5	114.7	22.7	4.1	11.9	1,286.4
Restaurant	2.8	4.3	10.9	17.9	15.1	6.0	2.4	45.8	12.1	29.8	13.9	9.9	15.9	1.9	1.2	1.0	190.8
Retail	13.2	36.4	80.0	147.0	121.9	47.9	16.6	254.6	69.2	138.5	67.2	48.4	106.6	11.9	11.0	6.1	1,176.4
Food	4.7	12.7	27.2	38.2	28.0	9.3	5.3	61.7	17.0	38.2	16.2	12.0	32.2	2.8	4.4	1.5	311.4
Warehouse	6.6	54.8	78.3	100.4	109.7	40.9	9.8	226.3	57.1	160.3	67.2	48.1	73.1	6.5	14.0	3.3	1,056.6
Refr. Wrhse.	0.4	5.4	11.1	7.9	7.5	1.3	3.4	9.9	2.4	3.9	2.5	1.7	0.7	0.1	0.5	0.1	58.8
School	11.4	21.5	50.4	74.9	58.5	18.9	11.3	111.0	29.3	61.4	28.7	20.3	48.0	2.3	5.0	1.2	553.9
College	5.8	10.1	27.3	49.1	40.0	9.4	3.3	68.3	17.8	30.5	27.5	18.6	32.4	4.6	1.9	2.4	348.9
Hospital	5.9	12.9	32.7	50.4	37.1	15.3	3.9	62.8	23.1	26.1	24.3	17.5	33.3	3.5	2.1	1.8	352.8
Hotel	5.4	6.7	17.4	50.6	48.1	11.4	2.7	59.4	16.6	25.2	22.4	13.5	44.6	2.1	3.6	1.1	330.9
Misc.	15.8	33.8	78.7	177.3	152.6	39.3	18.1	295.9	85.4	146.2	65.6	44.2	89.6	13.3	10.0	6.8	1,272.4
Grand Total	86.3	236.3	485.2	928.6	856.9	286.7	89.0	1,531.8	438.0	754.3	490.1	328.3	646.7	74.8	64.4	38.5	7,335.9

Source: Architectural Energy Corporation

Analysis and Detailed Results

The changes to the lighting requirements were analyzed as described above. The results are shown below in Table 22.

Table 22: Nonresidential Statewide First-Year Savings for New Lighting Systems in Existing Buildings

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	31.8	2.9	1.5	-0.02	0.28
2	109.5	14.1	4.6	-0.02	0.95
3	208.9	27.7	8.9	-0.03	1.76
4	484.0	66.3	20.7	-0.04	3.95
5	441.6	61.8	18.8	-0.02	3.47
6	166.8	23.4	7.0	-0.01	1.31
7	44.7	6.1	1.8	0.00	0.37
8	850.2	119.0	35.7	-0.03	6.76
9	248.2	34.7	10.5	-0.01	1.99
10	403.4	55.1	16.9	-0.03	3.41
11	289.5	39.3	12.4	-0.03	2.36
12	191.1	26.0	8.1	-0.02	1.59
13	380.5	50.7	16.2	-0.04	3.25
14	50.5	6.9	2.2	0.00	0.42
15	34.6	4.8	1.4	0.00	0.30
16	23.4	2.9	1.0	-0.01	0.20
Total	3,958.6	541.8	167.6	-0.30	32.38

Source: Architectural Energy Corporation

CHAPTER 4:
Cool Roof for Nonresidential Roofing Alterations

Standards Requirement

The standards require that when low-sloped roofs are replaced, they are to be replaced as "cool roofs" with an aged reflectance of 0.63 or more, and an emittance of 0.75 or more. A cool roof is a roofing material with high thermal emittance and high solar reflectance, or low thermal emittance and exceptionally high solar reflectance as specified in standards that reduces heat gain through the roof. Insulation requirements are not changing, nor are requirements for steep-sloped roofs.

Method

The effect of cool roofs on existing buildings is the result of the difference between the *2008 and 2013 Standards*. Although the roofs being replaced are expected to have a lower reflectance than those compliant with the *2008 Standards*, the savings claimed here are only the additional savings for improvements beyond those already required by the *2008 Standards*. This was analyzed by comparing the 2008 compliant buildings against the same buildings with 2013 compliant roofing. The results were weighted by the existing floor area in each climate zone, with buildings classified as shown in Table 12. The research team assumed that roofing is replaced every 15 years, meaning that 1/15th of the existing floor area was included in the analysis. Existing floor area data came from the Non-Residential Construction Forecast dataset, shown in Table 21.

Both of the restaurant buildings modeled for this analysis have steep-sloped roofs. The requirements for these roofs do not change, and they show no savings.

Analysis and Detailed Results

The cool roof requirements were analyzed as described above. The results are shown below in Table 23.

Table 23: Nonresidential Statewide First-Year Savings for Cool Roofs on Existing Buildings

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	11.3	0.5	0.4	-0.01	0.18
2	10.0	0.8	0.3	0.00	0.15
3	18.0	1.7	0.6	0.00	0.24
4	39.5	3.9	1.4	-0.01	0.52
5	38.8	3.6	1.4	-0.01	0.50
6	26.3	3.0	1.0	0.00	0.30
7	8.4	1.0	0.3	0.00	0.10
8	135.0	15.6	5.0	-0.01	1.53
9	21.6	2.3	0.8	0.00	0.26
10	42.1	4.4	1.5	-0.01	0.50
11	21.8	2.1	0.7	0.00	0.30
12	15.9	1.5	0.6	0.00	0.22
13	38.1	3.8	1.3	-0.01	0.54
14	3.4	0.3	0.1	0.00	0.05
15	4.1	0.5	0.1	0.00	0.05
16	6.0	0.2	0.2	-0.01	0.09
Total	440.3	45.1	15.8	-0.09	5.52

Source: Architectural Energy Corporation

CHAPTER 5:
Nonresidential HVAC Alterations

Standards Requirement

The standards require that when HVAC equipment is replaced, the new units must meet the requirements of the standard for equivalent equipment being installed in new construction.

Method

The effect of HVAC equipment replacements in existing buildings is the result of the difference between the 2008 and 2013 standards. Although the HVAC systems being replaced are expected to have significantly higher energy consumption than those that comply with the 2008 standard, the savings claimed here are only the additional savings for improvements beyond those already required by the *2008 Standards*. This was analyzed by comparing the 2008 compliant buildings that use cooling equipment against the same buildings with cooling equipment efficiencies that comply with the *2013 Standards*. Other measures that apply to the central HVAC unit, such as economizer requirements, were also applied. Note, an economizer is a system by which the supply air of a cooling system is cooled directly or indirectly by evaporation of water, or other appropriate fluid, in order to reduce or eliminate the need for mechanical cooling.

Changes to zone-level equipment were not applied, as these units are not necessarily changed with the central HVAC unit. Central plant equipment changes were also not included in the analysis as boilers and chillers are typically replaced less frequently than packaged units. The results were weighted by the existing floor area in each climate zone, with buildings classified as shown in Table 12. The research team assumed that packaged units are replaced every 20 years, meaning that modeling runs used 1/20th of the existing floor area in the analysis. Existing floor area data came from the Non-Residential Construction Forecast dataset, shown in Table 21.

Analysis and Detailed Results

The HVAC alteration requirements were analyzed as described above. The results are shown below in Table 24.

Table 24: Nonresidential Statewide First-Year Savings for DX HVAC Replacements on Existing Buildings

CZ	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
1	22.4	7.2	0.4	0.06	0.20
2	57.0	13.1	1.4	0.08	0.57
3	125.8	29.3	3.4	0.18	1.26
4	248.0	52.6	7.1	0.28	2.43
5	198.5	45.7	5.5	0.27	1.98
6	95.8	18.3	3.2	0.08	0.81
7	32.6	6.4	1.1	0.03	0.27
8	606.4	120.3	19.0	0.55	5.61
9	171.7	32.6	5.0	0.16	1.77
10	364.5	74.6	9.9	0.41	3.81
11	181.9	38.0	4.8	0.22	1.93
12	119.8	26.9	3.0	0.17	1.28
13	232.4	44.7	6.4	0.23	2.68
14	26.8	5.4	0.7	0.03	0.29
15	25.1	3.8	0.8	0.01	0.28
16	11.0	3.0	0.3	0.02	0.08
Total	2,519.8	521.9	71.9	2.77	25.24

Source: Architectural Energy Corporation

CHAPTER 6:
Overall Energy Savings

Total Savings

The energy savings for each measure or groups of measures in Tables 14 through 20 and 22 through 24 are listed in Table 25, which shows the overall statewide energy effects on nonresidential buildings for the *2013 Building Energy Efficiency Standards*.

Table 25: Nonresidential Statewide First-Year Savings for the *2013 Energy Standard*

Measure or Group of Measures	TDV Energy (GBtu)	Site Energy (GBtu)	Electricity (GWh)	Gas (10^6 therm)	Coincident Demand (MW)
Lighting	2,796	377.3	116.5	-0.20	23.6
Cool Roof	164	16.0	6.0	-0.04	2.1
Glazing	533	56.8	16.4	0.01	7.2
HVAC	1,285	250.1	36.5	1.26	13.6
Process	31	5.8	1.7	0.00	0.0
Process (not-simulated)	2,385	591.4	93.1	2.74	3.5
Other	40	6.0	2.0	-0.01	0.2
Envelope Alterations	440	45.1	15.8	-0.09	5.5
Lighting Alterations	3,959	541.8	167.6	-0.30	32.4
HVAC Alterations	2,520	521.9	71.9	2.77	25.2
TOTAL	14,154	2,412.2	527.7	6.12	113.4

Source: Architectural Energy Corporation

CHAPTER 7:
Pollutant Emissions

Emission Factors

The energy savings listed in Table 25 will result in reduced emissions of pollutants into the atmosphere. These emissions reductions are based on reduced combustion of fossil fuels, primarily natural gas, in power plants, and reduced combustion of natural gas on site. Table 26 lists emissions factors for four criteria pollutants (oxides of nitrogen, oxides of sulfur, carbon monoxide, and particulate matter smaller than 2.5 nM), and carbon dioxide (CO_2) equivalents as provided by the California Energy Commission for use with the *2013 Standards*.

Table 26: Emissions Factors for Electricity and Natural Gas

Source	Unit	NO_X	SO_X	CO	PM2.5	CO_2e
Electricity	Tons/GWh	0.0255	0.0035	0.0365	0.011	481.5
Natural Gas	Tons/Mtherm	4.4751	0.02856	1.904	0.3618	5712.92

Source: Architectural Energy Corporation

Emission Impacts

The emission factors from Table 26 were applied to the statewide energy savings listed above in Table 25. Table 27 lists the pollutant emissions that the *2013 Building Energy Efficiency Standards* will avoid.

Table 27: Statewide First-Year Emissions Reductions for the *2013 Energy Standards* (tons)

Measure or Group of Measures	NO_X	SO_X	CO	PM2.5	CO_2e
Lighting	2.06	0.40	3.87	1.21	54,953
Cool Roof	-0.05	0.02	0.13	0.05	2,628
Glazing	0.46	0.06	0.61	0.18	7,942
HVAC	6.55	0.16	3.72	0.86	24,740
Process	0.04	0.01	0.06	0.02	826
Process (not-simulated)	14.62	0.40	8.61	2.01	60,470
Other	0.01	0.01	0.06	0.02	928
Envelope Alterations	0.01	0.05	0.41	0.14	7,115
Lighting Alterations	2.93	0.58	5.54	1.73	78,982
HVAC Alterations	14.21	0.33	7.89	1.79	50,433
TOTAL	40.83	2.02	30.91	8.02	289,018

Source: Architectural Energy Corporation

CHAPTER 8:
Conclusion

This report estimates the statewide energy effects of proposed changes to California's *2013 Building Energy Efficiency Standards* on a regional and statewide basis. The proposed *2013 Building Energy Efficiency Standards* are estimated to reduce electricity consumption by 555.5 GWh and to reduce the growth in peak electric demand by 148.4 MW. In addition, natural gas use is expected to be reduced by 7.04 million therms. Over time, the energy savings will accumulate as the standards affect each subsequent year of construction.

Energy savings result from changes to the standards affecting newly constructed residential and nonresidential buildings and to alterations to existing residential and nonresidential buildings.