NORESCO

IMPACT ANALYSIS

2019 Update to the California Energy Efficiency Standards for Residential and Non-Residential Buildings

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Prepared for:

California Energy Commission
1516 9th Street
Sacramento, CA 95814

Prepared by:

Non-Residential

NORESCO
475 Sansome Street, Suite 500
San Francisco, CA 94111

Residential

Ken Nittler, P.E.
Enercomp

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Primary Author(s):

NORESCO (Non-residential)

Dimitri Contoyannis, Skye Lei, Chitra Nambiar, John Arent, Silas Taylor, Nikhil Kapur

Enercomp (Residential)

Ken Nittler

Contributing Agencies and Consultants:

Energy Solutions

Heidi Hauenstein, Rahul Athalye

Frontier Energy

Alea German

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1 EXECUTIVE SUMMARY

This report estimates the statewide impacts of 2019 changes to the California Energy Efficiency Standards on a regional and statewide basis. This impact analysis draws from changes approved in the 2019 Standards 15-day code language published by the California Energy Commission (Energy Commission) on April 20, 2018 with subsequent changes adopted on May 18, 2018.

The total estimated impact of the 2019 updates incorporates both the residential and non-residential building sectors. Within each sector, the Standards affect both newly constructed buildings as well as alterations to existing buildings. Table 1 summarizes the first-year electricity, peak demand and natural gas savings by building sector and construction activity. Based on this analysis, the 2019 updates to the Standards are estimated to result in approximately 1,419 GWh in electricity savings and 353.1 MW in peak demand reduction. In addition, this analysis reveals that natural gas consumption may be reduced by 0.02 million therms. The savings will accumulate as the Standards affect each subsequent year of construction.

More detail on energy savings is provided in the following tables. Electricity energy savings are summarized in Table 2, electric demand savings in Table 3, and natural gas savings in Table 3.

Table 1 – Total Energy Savings Summary

	Electricity		Demand		Gas
	Savings (GWh)	Percent of Total	Savings (MW)	Percent of Total	Savings (millions therms)
Single-Family Newly Constructed Buildings and Alterations	596	42%	50.4	14%	4.42
Multi-Family Newly Constructed Buildings and Alterations	91	6%	4.1	1%	0.25
Nonresidential Newly Constructed Buildings	197	14%	76.6	22%	0.27
Nonresidential Alterations	536	38%	222.0	63%	-4.92
Grand Total	**1,419**	**100%**	**353.1**	**100%**	**0.02**

1.1 Low-rise Residential Newly Constructed Buildings and Alterations

The first-year savings for single-family homes are 596 GWh of electricity, 50.4 MW of demand and 4.42 million therms of gas. For low-rise multi-family buildings, the first-year electricity savings are 91 GWh, 4.1 MW of demand, and 0.25 million therms of gas.

On a percent savings basis compared to the 2016 standards, the single-family savings are 79% of electricity, 17% of demand and 9% of gas. For low-rise multi-family, savings are 79% of electricity, 11% of demand and 5% of gas.

These savings include the impact of photovoltaic systems on new construction homes. For the impact of energy efficiency measures only on new construction homes, please refer to Section 2.4 Analysis and Detailed Results under Low-rise Residential.

Low-rise single-family estimates are based on 117,069 housing starts each year, and low-rise multi-family estimates are based on 30,067 dwelling units. Energy savings for low-rise residential were calculated using the prototype approach similar to the method used for previous standards updates. 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.

1.2 Non-residential Newly Constructed Buildings

The first-year savings for newly constructed non-residential buildings are 197 GWh of electricity, 76.6 MW of demand, and 0.27 million therms of gas, representing reductions from the 2016 Standard of 10.7%, 9%, and 1%, respectively. The savings for non-residential buildings were calculated using the Non-Residential Construction Forecast dataset, which predicts 176 million square feet of non-residential new construction in 2020 and multifamily residential forecast for High Rise Residential Multi-Family which predicts 17 million square feet of new construction in 2020. The total square footage for all non-residential construction buildings is predicted to be 193 million square feet. Sixteen building prototypes were used to predict energy savings. The EnergyPlus models generated from CBECC-Com were parameterized such that changes at run time would result in buildings that were compliant with the 2016 standards by all 16 climate zones, or would include any or all of the measures added to the 2019 standard. When all measures are included, the result is a building which is compliant with the 2019 standard. The results of these simulations were then weighted by forecast construction of building type and climate zone to determine statewide energy consumption for new construction.

1.3 Alterations to Existing Non-residential Buildings

Savings for alterations to existing buildings are significantly greater than the savings for new construction in both electricity savings and demand reduction. First-year electricity savings are expected to be 536 GWh, first-year demand reduction is 222 MW and first-year gas savings are –4.92 million therms for alterations. Nearly all of the energy savings for alterations can be attributed to improvements in lighting, with less than 1% resulting from increased HVAC equipment efficiency requirements. The negative savings in natural gas result primarily from the interactive effects with reduced lighting load.

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

	2016	2019	Savings	Percent Savings	Percent of Total Savings
Single-Family Newly Constructed & Alterations	754	158	595.7	79.0%	42.0%
Low-rise Multi-Family Newly Constructed & Alterations	115	25	90.6	78.7%	6.4%
Indoor Lighting Power Densities	1,839	1,709	130.6	7.1%	9.2%
Indoor Lighting Manual ON Time-Switch		1,839	0.4	0.0%	0.0%
Indoor Occupant Sensing Light Controls in Restrooms		1,838	1.2	0.1%	0.1%
Outdoor Lighting Controls - Scheduling Controls		1,837	2.3	0.1%	0.2%
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold		1,836	3.0	0.2%	0.2%
Fan System Power		1,830	9.8	0.5%	0.7%
Equipment Efficiency		1,839	0.4	0.0%	0.0%
Waterside Economizers		1,839	0.2	0.0%	0.0%
Transfer Air for Exhaust Air Makeup		1,839	0.4	0.0%	0.0%
Demand Controlled Ventilation for Classrooms		1,836	3.0	0.2%	0.2%
Occupant Sensor Ventilation Requirements		1,819	21.0	1.1%	1.5%
Cooling Tower Minimum Efficiency		1,839	0.1	0.0%	0.0%
Economizer Fault Detection Diagnostics		1,839	0.9	0.0%	0.1%
Variable Exhaust Flow Control and High Efficiency Fume Hoods		1,832	7.8	0.4%	0.5%
Adiabatic Condensers (Option B)		1,839	0.7	0.0%	0.0%
Outdoor Lighting Power Allowance		1,824	15.8	0.9%	1.1%
2019 Total New Construction		1,642	197	10.7%	13.9%
Lighting Alterations	12,046	11,529	518	4.3%	36.5%
Indoor Lighting Manual ON Time-Switch			1	N/A	0.1%
Outdoor Lighting Controls - Scheduling Controls			7	N/A	0.5%
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold			9	N/A	0.6%
HVAC Alterations	4,517	4,516	1	0.0%	0.1%
2019 Alterations Total			536	N/A	37.7%
2019 Total			**1,419**	**N/A**	**100.0%**

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

	2016	2019	Savings	Percent Savings	Percent of Total Savings
Single-Family Newly Constructed & Alterations	297.2	247	50.44	17.0%	14.3%
Low-rise Multi-Family Newly Constructed & Alterations	37.6	34	4.07	10.8%	1.2%
Indoor Lighting Power Densities	847.6	802.4	45.2	5.3%	12.8%
Indoor Lighting Manual ON Time-Switch		847.6	0.0	0.0%	0.0%
Indoor Occupant Sensing Light Controls in Restrooms		847.1	0.4	0.1%	0.1%
Outdoor Lighting Controls - Scheduling Controls		847.6	0.0	0.0%	0.0%
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold		847.4	0.2	0.0%	0.0%
Fan System Power		844.3	3.3	0.4%	0.9%
Equipment Efficiency		847.2	0.4	0.0%	0.1%
Waterside Economizers		847.6	0.0	0.0%	0.0%
Transfer Air for Exhaust Air Makeup		846.7	0.9	0.1%	0.2%
Demand Controlled Ventilation for Classrooms		836.8	10.8	1.3%	3.1%
Occupant Sensor Ventilation Requirements		839.0	8.6	1.0%	2.4%
Cooling Tower Minimum Efficiency		847.4	0.1	0.0%	0.0%
Economizer Fault Detection Diagnostics		846.5	1.1	0.1%	0.3%
Variable Exhaust Flow Control and High Efficiency Fume Hoods		845.9	1.7	0.2%	0.5%
Adiabatic Condensers (Option B)		847.5	0.1	0.0%	0.0%
Outdoor Lighting Power Allowance		843.6	4.0	0.5%	1.1%
2019 Total New Construction		770.9	76.6	9.0%	21.7%
Lighting Alterations	5,547	5,326	220.8	4.0%	62.5%
Indoor Lighting Manual ON Time-Switch			0.0	N/A	0.0%
Outdoor Lighting Controls - Scheduling Controls			0.0	N/A	0.0%
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold			0.0	N/A	0.0%
HVAC Alterations	2,080	2,079	1	0.1%	0.3%
2019 Alterations Total			222.0	N/A	62.9%
2019 Total			**353.1**	**N/A**	**100.0%**

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

	2016	2019	Savings	Percent Savings
Single-Family Newly Constructed & Alterations	46.97	43	4.42	9.4%
Low-rise Multi-Family Newly Constructed & Alterations	5.29	5	0.25	4.7%
Indoor Lighting Power Densities	27.88	28.15	-0.27	-
Indoor Lighting Manual ON Time-Switch		27.88	0.00	-
Indoor Occupant Sensing Light Controls in Restrooms		27.88	0.00	-
Outdoor Lighting Controls - Scheduling Controls		27.88	0.00	-
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold		27.88	0.00	-
Fan System Power		27.89	-0.01	-
Equipment Efficiency		27.88	0.00	-
Waterside Economizers		27.88	0.00	-
Transfer Air for Exhaust Air Makeup		27.85	0.03	-
Demand Controlled Ventilation for Classrooms		27.63	0.25	-
Occupant Sensor Ventilation Requirements		27.61	0.27	-
Cooling Tower Minimum Efficiency		27.88	0.00	-
Economizer Fault Detection Diagnostics		27.87	0.01	-
Variable Exhaust Flow Control and High Efficiency Fume Hoods		27.88	0.00	-
Adiabatic Condensers (Option B)		27.88	0.00	-
Outdoor Lighting Power Allowance		27.88	0.00	-
2019 Total New Construction		27.61	0.27	-
Lighting Alterations	180	185	-4.92	-
Indoor Lighting Manual ON Time-Switch			0.00	-
Outdoor Lighting Controls - Scheduling Controls			0.00	-
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold			0.00	-
HVAC Alterations	67	67	0.00	-
2019 Alterations Total			-4.92	N/A
2019 Total			**0.02**	**N/A**

1.4 Emissions

The standard is 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 683,506 tons each year. The emissions reductions are estimated based on the statewide emission factors provided by the Energy Commission.

Table 5 – Summary of Air Emissions Reductions

	Emission Reductions				
	NO_X (lb)	SO_X (lb)	CO (lb)	CO_2 (tons)	$PM_{2.5}$ (lb)
Single-Family Newly Constructed Buildings and Alterations	69,919	4,422	60,308	312,062	16,302
Multi-Family Newly Constructed Buildings and Alterations	6,846	648	7,558	45,024	2,172
Nonresidential Newly Constructed Buildings Total	**12,514**	**1,398**	**15,456**	**96,653**	**4,542**
Electricity	10,072	1,382	14,417	95,094	4,345
Gas	2,442	16	1,039	1,558	197
Nonresidential Alterations Total	**-16,717**	**3,468**	**20,359**	**229,767**	**8,222**
Electricity	27,314	3,749	39,096	257,872	11,782
Gas	-44,031	-281	-18,736	-28,105	-3,560
Grand Total	**72,562**	**9,936**	**103,682**	**683,506**	**31,239**

2 LOW-RISE RESIDENTIAL NEWLY CONSTRUCTED BUILDINGS AND ALTERATIONS

The following sections describe the significant 2019 changes made to the residential standards, the methods used to evaluate the energy and demand impacts, and the results of the analysis.

2.1 Standards Requirements

The changes to the Standards that result in savings are described in the following sections. Compliance options or "credits" are not considered since these are assumed to be energy neutral. The changes to ventilation and indoor air quality and the modeling of high solar heat gain climate zones as well as any updates to background assumptions in CBECC-Res are treated as modeling assumptions with the same values applied for all modeling in this analysis.

2.2 Measures Included in Analysis

The following measures that can be modeled with Alternative Calculation Method (ACM) algorithms are included in this analysis.

Table 6 – Low-Rise Residential Measure List

Measure	Single-Family	Multi-Family
High Performance Walls	R21 insulation between the framing plus R5 sheathing insulation in climate zones 1-5 and 8-16	No change to U-factor
High Performance Attics	R38 ceiling insulation with R19 below roof deck insulation in climate zones 4, 8, 9 and 10-16	R38 ceiling insulation with R19 below roof deck insulation for tile roofs in climate zones 4, 8, 9 and 11-15
High Performance Windows	0.30 U-factor in all climate zones. 0.23 SHGC in climate zones 2, 4 and 6-15. 0.35 SHGC assumed in climate zones 1, 3, 5 and 16[1]	Same as Single-Family
High Performance Doors	0.20 U-factor in all climate zones	Same as Single-Family
Quality Insulation Installation	Improved in all climate zones	Improved in climate zones 1-6 and 8-16
Air-handling Unit Fan Efficacy	0.45 W/CFM for gas furnace air-handling units in all climate zones	Same as Single-Family
Photovoltaic (PV) Requirements	PV sized in accordance with ACM requirements to offset total kWh energy use.	Same as Single-Family

2.3 Methodology

2.3.1 Prototype Buildings

The energy and electric demand impact of implementing the 2019 building heating, cooling 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 8 dwelling multifamily building. These prototypes were also used in the development of the 2016 standards. Each prototype building is made to minimally comply with the 2016 and the 2019 Standards. The prototypes are described in Appendix A of the Alternative Calculation Method Approval Manual.

2.3.2 Glazing Area

The prototype glazing area is 20% of the floor area for single-family and 15% for multifamily. The glazing is distributed equally on the north, east, south and west orientations.

2.3.3 Computer Modeling

Heating, cooling, and water heating energy use is modeled using the Commission's 2019 CBECC-Res research software. This software is used on estimates for both the 2016 and 2019 standards to establish the savings so there is a valid comparison of the prescriptive feature differences, not software differences. 2019 TDV values are used in all calculations.

2.3.4 Energy Design Ratings (EDR)

Compliance with the 2019 standards for newly constructed buildings will be determined using Energy Design Rating (EDR) values that are based on TDV energy. The Energy Design Rating (EDR) has two components, the Energy Efficiency Design Rating, and the Solar Electric Generation and Demand Flexibility Design Rating. The Solar Electric Generation and Demand Flexibility Design Rating shall be subtracted from the Energy Efficiency Design Rating to determine the Total Energy Design Rating. The Proposed Building shall separately comply with the Energy Efficiency Design Rating and the Total Energy Design Rating. While the energy savings in this analysis are presented in traditional quantities like kTDV/ft2, kWh and therms, EDR values are included in the tables below where appropriate.

2.3.5 Photovoltaic (PV) Energy

Compliance with the 2019 standards for newly constructed buildings also requires the installation of solar photovoltaic systems. Where appropriate, the size of the PV system in kWdc is included in the tables below.

2.3.6 Housing Starts

Table 7 shows the estimated housing starts for both low-rise single-family and low-rise multi-family buildings in 2020.The multi-family values are the number of dwelling units in each climate zone.

Table 7 – Estimated Low-Rise Housing Starts by Climate Zone

Climate Zone	Single-Family	Multi-Family
1	465	111
2	3,090	1,318
3	11,496	2,831
4	7,435	1,089
5	1,444	747
6	6,450	1,400
7	5,779	3,939
8	9,948	1,899
9	12,293	4,419
10	18,399	2,897
11	3,947	522
12	19,414	4,935
13	7,034	1,309
14	3,484	756
15	3,203	454
16	3,188	1,441
Total	117,069	30,067

2.3.7 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 zone for each prototype. For single-family, 45% of the homes are weighted as the 2100 ft^2 prototype and 55% as the 2700 ft^2 prototype. When Statewide results are shown, they are weighted by the building starts in each climate zone to give a more representative statewide result than a simple average.

2.3.8 Additions and Alterations

The projected savings for newly constructed homes are increased by 28% to account for additions and alterations to existing homes except for savings due to PV that do not apply for additions and alterations. The adjustment is equal to the dollar value of residential addition and alterations construction divided by total new construction for 2016 as reported by the Construction Industry Research Board (CIRB).

2.4 Analysis and Detailed Results

2.4.1 Prototype TDV Savings

Tables 8 through 10 show the first-year kTDV/ft^2 savings by end use and climate zone for each of the prototype buildings. End uses not shown were not affected by changes in the 2019 standards.

Table 8 – 2,100 ft² Single-Family First- Year TDV Savings by Climate Zone and End Use (kTDV/ ft²)

Climate Zone	Space Heating	Space Cooling	Efficiency Total	Photovoltaics	Total With PV
1	9.90	0.00	9.90	43.65	53.55
2	4.67	1.19	5.86	43.45	49.33
3	5.22	0.00	5.22	42.20	47.41
4	3.65	0.30	3.95	43.10	47.09
5	5.38	0.00	5.38	42.18	47.55
6	2.04	1.30	3.34	41.56	44.91
7	1.11	0.39	1.50	41.42	42.93
8	1.50	5.01	6.51	44.18	50.71
9	1.98	6.61	8.59	45.69	54.30
10	2.32	6.51	8.83	45.30	54.14
11	4.76	9.82	14.58	56.76	71.35
12	4.73	6.89	11.62	46.90	58.54
13	4.19	10.64	14.83	56.86	71.70
14	4.57	8.93	13.50	53.90	67.40
15	0.68	19.78	20.46	83.89	104.34
16	10.41	0.73	11.14	43.17	54.32
Statewide	3.48	5.22	8.70	46.91	55.62

Table 9 – 2,700 ft² Single-Family First -Year TDV Savings by Climate Zone and End Use (kTDV/ft²)

Climate Zone	Space Heating	Space Cooling	Efficiency Total	PV	Total With PV
1	8.49	0.00	8.49	38.79	47.28
2	4.11	2.11	6.22	39.18	45.42
3	4.55	0.00	4.55	37.81	42.35
4	3.29	3.08	6.37	39.05	45.45
5	4.63	0.00	4.63	37.79	42.40
6	1.68	1.29	2.97	37.64	40.62
7	0.89	0.52	1.41	37.36	38.77
8	1.35	4.61	5.96	40.61	46.58
9	1.77	5.92	7.69	42.29	49.99
10	2.04	6.02	8.06	42.15	50.21
11	4.20	9.22	13.42	53.30	66.73
12	4.14	6.36	10.50	43.42	53.94
13	3.73	9.73	13.46	53.40	66.87
14	4.06	8.24	12.30	50.73	63.03
15	0.76	17.34	18.10	76.93	95.02
16	9.28	0.65	9.93	39.82	49.75
Statewide	3.06	5.00	8.05	43.19	51.25

Table 10 – 6,960 ft² Multi-Family TDV Savings by Climate Zone and End Use (kTDV/ft²)

Climate Zone	Space Heating	Space Cooling	Efficiency Total	PV	Total With PV
1	5.81	0.00	5.81	70.22	75.91
2	3.05	1.77	4.82	72.44	77.22
3	2.70	0.05	2.75	69.73	72.37
4	2.21	3.12	5.33	72.69	78.01
5	2.53	-0.43	2.10	69.89	71.83
6	0.84	1.46	2.30	70.58	72.82
7	0.05	1.08	1.13	70.28	71.41
8	0.47	3.88	4.35	75.88	80.18
9	0.81	5.35	6.16	77.31	83.43
10	1.02	5.09	6.11	76.64	82.70
11	3.03	7.82	10.85	90.14	100.96
12	2.98	5.67	8.65	79.70	88.33
13	2.66	8.53	11.19	89.58	100.74
14	2.93	7.10	10.03	85.78	95.78
15	0.09	14.64	14.73	114.10	128.78
16	6.94	0.63	7.57	72.35	79.85
Statewide	1.91	3.78	5.69	76.30	81.95

2.4.2 Prototype Energy Savings

Tables 11 through 13 show the first-year Therm, kWh and demand savings by climate zone for each of the prototype buildings. The kWh and demand values to the right include the contribution by PV.

Table 11 – 2,100 ft² Single-Family Energy Savings

Climate Zone	Gas (Therms)	Electricity (kWh)	Demand (kW)	Electricity With PV (kWh)	Demand with PV (kW)
1	81	150	0.00	4,190	0.11
2	36	85	0.06	4,066	0.13
3	42	70	0.00	3,990	0.08
4	28	65	0.02	4,013	0.09
5	44	68	0.00	3,979	0.05
6	16	44	0.06	3,970	0.11
7	9	17	0.04	3,895	0.07
8	12	101	0.26	4,197	0.30
9	16	165	0.35	4,469	0.39
10	19	205	0.36	4,624	0.39
11	37	400	0.41	5,492	0.50
12	37	191	0.40	4,393	0.47
13	33	436	0.45	5,671	0.53
14	36	370	0.40	5,405	0.44
15	6	884	0.73	9,016	0.79
16	81	177	0.08	4,323	0.15
Statewide	27	187	0.26	4,563	0.32

Table 12 – 2,700 ft² Single-Family Energy Savings

Climate Zone	Gas (Therms)	Electricity (kWh)	Demand (kW)	Electricity With PV (kWh)	Demand with PV (kW)
1	91	152	0.00	4,769	0.12
2	41	109	0.09	4,725	0.18
3	48	72	0.00	4,589	0.09
4	33	101	0.18	4,703	0.26
5	50	69	0.00	4,573	0.06
6	17	51	0.08	4,624	0.13
7	10	22	0.04	4,522	0.07
8	14	122	0.26	4,965	0.30
9	18	207	0.40	5,332	0.45
10	21	253	0.40	5,545	0.44
11	42	474	0.50	6,628	0.60
12	41	248	0.44	5,255	0.52
13	37	506	0.55	6,834	0.64
14	41	441	0.47	6,542	0.52
15	8	1,046	0.83	10,640	0.89
16	93	201	0.09	5,122	0.17
Statewide	31	228	0.31	5,411	0.38

Table 13 – 6,960 ft² Multi-Family Energy Savings

Climate Zone	Gas (Therms)	Electricity (kWh)	Demand (kW)	Electricity With PV (kWh)	Demand with PV (kW)
1	163	201	-0.01	21,705	0.58
2	82	212	0.28	22,185	0.69
3	74	55	0.02	21,495	0.44
4	60	278	0.64	22,332	1.02
5	71	20	-0.11	21,461	0.17
6	23	99	0.23	22,181	0.48
7	1	52	0.22	21,856	0.39
8	13	355	0.59	23,691	0.79
9	23	522	0.90	24,662	1.15
10	28	533	0.87	25,305	1.06
11	81	1,031	1.08	27,773	1.53
12	80	613	0.90	24,292	1.30
13	71	1,119	1.24	28,391	1.62
14	79	959	1.04	27,448	1.25
15	3	2,287	1.71	38,731	1.96
16	183	352	0.24	23,355	0.61
Statewide	52	431	0.61	23,973	0.91

2.4.3 Prototype Compliance Results

Tables 14 through 16 show the TDV Percent Savings, Energy Design Ratings and PV system sizes for the prototypes. The percent savings show the percent savings over the 2016 standards and are calculated by taking the 2019 kTDV/ft^2 energy savings divided by the 2016 values. The efficiency percent savings are based on regulated loads only while the Total with PV is based on all home energy loads.

Table 14 – 2,100 ft² Single-Family Percent Savings, Energy Design Ratings and PV Sizes

Climate Zone	Efficiency TDV Percent Savings	Total TDV Percent Savings	Efficiency EDR	Final EDR	PV Size (kWdc)
1	15%	44%	56.4	34.3	3.0
2	13%	49%	47.3	25.5	2.5
3	14%	52%	47.9	24.6	2.5
4	11%	52%	44.4	22.1	2.5
5	15%	52%	45.7	23.1	2.3
6	12%	56%	50.3	23.1	2.5
7	9%	60%	49.5	20.1	2.4
8	20%	59%	47.2	20.9	2.6
9	18%	54%	48.0	24.2	2.6
10	18%	53%	46.9	24.3	2.7
11	17%	52%	45.9	24.8	3.2
12	18%	49%	46.1	26.0	2.7
13	17%	51%	47.3	25.9	3.4
14	17%	51%	47.2	25.7	2.8
15	17%	61%	50.2	22.5	4.9
16	16%	43%	49.7	30.9	2.4
Statewide	16%	53%	47.4	24.2	2.7

Table 15 – 2,700 ft² Single-Family Percent Savings, Energy Design Ratings and PV Sizes

Climate Zone	Efficiency TDV Percent Savings	Total TDV Percent Savings	Efficiency EDR	Final EDR	PV Size (kWdc)
1	16%	47%	51.7	29.8	3.5
2	15%	51%	44.1	23.4	2.9
3	15%	54%	44.7	21.9	2.9
4	17%	53%	43.1	22.0	2.9
5	16%	55%	42.4	20.2	2.7
6	12%	56%	48.6	22.2	2.9
7	9%	61%	47.8	19.1	2.7
8	18%	59%	45.9	20.5	3.1
9	17%	54%	46.1	23.3	3.1
10	16%	52%	45.1	23.4	3.2
11	17%	52%	43.3	23.2	3.9
12	17%	49%	43.6	24.6	3.2
13	16%	51%	44.7	24.3	4.1
14	16%	51%	44.9	24.2	3.4
15	16%	60%	47.2	21.2	5.7
16	15%	44%	47.3	29.1	2.9
Statewide	16%	53%	45.2	23.0	3.2

Table 16 – 6,960 ft² Multi-Family Percent Savings, Energy Design Ratings and PV Sizes

Climate Zone	Efficiency TDV Percent Savings	Total TDV Percent Savings	Efficiency EDR	Final EDR	PV Size (kWdc)
1	12%	54%	58.5	27.9	16.1
2	10%	55%	55.3	25.6	14.0
3	8%	57%	56.0	24.3	13.6
4	11%	56%	55.2	25.1	13.7
5	7%	58%	56.0	24.1	12.7
6	6%	58%	61.8	26.6	14.0
7	4%	58%	63.0	26.6	13.3
8	9%	59%	60.3	25.4	14.7
9	11%	57%	58.8	26.2	14.8
10	10%	56%	57.6	26.5	15.2
11	13%	57%	53.7	24.6	16.8
12	12%	55%	54.6	26.2	15.1
13	13%	56%	54.2	25.5	17.6
14	12%	57%	55.2	25.5	14.7
15	12%	60%	58.8	25.0	21.8
16	12%	51%	56.2	29.1	13.5
Statewide	10%	56%	57.7	26.0	14.6

2.4.4 Statewide Results

Tables 17 through 20 show the first-year energy, demand and emission savings for single-family and multi-family buildings, with and without PV. This data is calculated by taking the weighted prototype savings, applying the adjustment for additions and alterations for all values except PV, then multiplying times the housing starts. The electric demand values in this report were calculated using an 8760 hour file of multipliers and hourly electricity consumption to provide a weighted average contribution to statewide electricity demand. Emissions are calculated from the energy savings using the emission factors shown in Section 8.1.

The percent at the bottom of the tables is the 2019 savings divided by the 2016 values.

Table 17 – Statewide Impact – Single-Family Without PV

Climate Zone	Energy and Demand				Emissions				
	TDV (GTDV)	Gas (Mtherms)	Electricity (GWh)	Demand (MW)	NOx (tons)	SOx (tons)	CO(tons)	PM2.5 (tons)	CO2e (tons)
1	13	0.05	0.09	0.00	0.23	0.00	0.10	0.02	337
2	58	0.15	0.39	0.31	0.70	0.01	0.31	0.06	1,062
3	173	0.67	1.04	0.00	3.00	0.02	1.30	0.25	4,302
4	123	0.29	0.80	1.03	1.34	0.01	0.59	0.12	2,066
5	22	0.09	0.13	0.00	0.39	0.00	0.17	0.03	561
6	63	0.14	0.40	0.57	0.62	0.01	0.28	0.05	973
7	26	0.07	0.14	0.27	0.32	0.00	0.14	0.03	471
8	193	0.17	1.43	3.31	0.79	0.01	0.37	0.08	1,646
9	310	0.27	2.96	5.94	1.28	0.02	0.62	0.13	2,964
10	481	0.47	5.45	9.00	2.25	0.03	1.10	0.23	5,321
11	171	0.20	2.23	2.32	0.96	0.01	0.47	0.10	2,227
12	666	0.97	5.52	10.44	4.50	0.05	2.05	0.41	8,219
13	308	0.32	4.27	4.59	1.52	0.02	0.76	0.16	3,863
14	139	0.17	1.82	1.95	0.82	0.01	0.39	0.08	1,861
15	191	0.03	3.99	3.21	0.23	0.01	0.20	0.05	2,084
16	104	0.36	0.78	0.35	1.62	0.01	0.71	0.14	2,420
Total	3,042	4.42	31.44	43.31	20.57	0.24	9.56	1.94	40,377
Percent	8%	9%	4%	15%	9%	6%	8%	8%	6%

Table 18 – Statewide Impact – Single-Family With PV

Climate Zone	Energy and Demand				Emissions				
	TDV (GTDV)	Gas (Mtherms)	Electricity (GWh)	Demand (MW)	NOx (tons)	SOx (tons)	CO(tons)	PM2.5 (tons)	CO2e (tons)
1	60	0.05	2.12	0.05	0.28	0.01	0.18	0.04	1,313
2	367	0.15	13.77	0.56	1.04	0.05	0.79	0.21	7,505
3	1,285	0.67	49.89	0.94	4.25	0.19	3.09	0.79	27,819
4	861	0.29	32.83	1.59	2.15	0.12	1.76	0.47	17,488
5	162	0.09	6.24	0.08	0.55	0.02	0.39	0.10	3,506
6	681	0.14	28.02	0.89	1.33	0.10	1.28	0.36	14,272
7	576	0.07	24.53	0.47	0.94	0.09	1.03	0.30	12,215
8	1,213	0.17	46.27	3.68	1.93	0.17	2.01	0.57	23,234
9	1,619	0.27	61.41	6.54	2.77	0.22	2.75	0.77	31,109
10	2,429	0.47	95.59	9.70	4.55	0.35	4.39	1.22	48,723
11	697	0.20	24.63	2.69	1.53	0.09	1.28	0.34	13,015
12	2,788	0.97	95.70	11.98	6.80	0.36	5.35	1.40	51,640
13	1,248	0.32	45.33	5.16	2.57	0.17	2.26	0.61	23,630
14	581	0.17	21.41	2.11	1.32	0.08	1.11	0.30	11,290
15	814	0.03	32.61	3.41	0.96	0.11	1.24	0.37	15,864
16	424	0.36	15.35	0.58	1.99	0.06	1.24	0.30	9,438
Total	15,804	4.42	595.69	50.44	34.96	2.21	30.15	8.15	312,062
Percent	43%	9%	79%	17%	15%	56%	26%	32%	49%

Table 19 – Statewide Impact – Multi-Family Without PV

Climate Zone	Energy and Demand				Emissions				
	TDV (GTDV)	Gas (Mtherms)	Electricity (GWh)	Demand (MW)	NOx (tons)	SOx (tons)	CO(tons)	PM2.5 (tons)	CO2e (tons)
1	1	0.00	0.00	0.00	0.01	0.00	0.01	0.00	18
2	7	0.02	0.04	0.06	0.08	0.00	0.03	0.01	120
3	8	0.03	0.02	0.01	0.15	0.00	0.07	0.01	204
4	6	0.01	0.05	0.11	0.05	0.00	0.02	0.00	83
5	2	0.01	0.00	-0.01	0.04	0.00	0.02	0.00	50
6	3	0.01	0.02	0.05	0.02	0.00	0.01	0.00	40
7	5	0.00	0.03	0.14	0.00	0.00	0.00	0.00	20
8	9	0.00	0.11	0.18	0.02	0.00	0.01	0.00	74
9	30	0.02	0.37	0.64	0.08	0.00	0.04	0.01	271
10	20	0.01	0.25	0.40	0.07	0.00	0.03	0.01	194
11	6	0.01	0.09	0.09	0.03	0.00	0.02	0.00	80
12	47	0.06	0.48	0.71	0.30	0.00	0.14	0.03	594
13	16	0.01	0.23	0.26	0.07	0.00	0.04	0.01	198
14	8	0.01	0.12	0.13	0.05	0.00	0.02	0.00	110
15	7	0.00	0.17	0.12	0.01	0.00	0.01	0.00	81
16	12	0.04	0.08	0.06	0.19	0.00	0.08	0.02	280
Total	189	0.25	2.07	2.94	1.17	0.01	0.55	0.11	2,419
Percent	4%	5%	2%	8%	4%	3%	4%	4%	3%

Table 20 – Statewide Impact – Multi-Family With PV

Climate Zone	Energy and Demand				Emissions				
	TDV (GTDV)	Gas (Mtherms)	Electricity (GWh)	Demand (MW)	NOx (tons)	SOx (tons)	CO(tons)	PM2.5 (tons)	CO2e (tons)
1	7	0.00	0.30	0.01	0.02	0.00	0.02	0.00	162
2	90	0.02	3.66	0.13	0.17	0.01	0.17	0.05	1,864
3	180	0.03	7.61	0.16	0.34	0.03	0.34	0.10	3,858
4	75	0.01	3.05	0.16	0.12	0.01	0.13	0.04	1,529
5	47	0.01	2.00	0.01	0.09	0.01	0.09	0.03	1,014
6	89	0.01	3.89	0.10	0.12	0.01	0.15	0.04	1,901
7	246	0.00	10.77	0.22	0.28	0.04	0.39	0.12	5,188
8	134	0.00	5.65	0.23	0.16	0.02	0.21	0.06	2,741
9	327	0.02	13.70	0.78	0.42	0.05	0.53	0.16	6,692
10	213	0.01	9.22	0.47	0.29	0.03	0.36	0.11	4,513
11	47	0.01	1.83	0.12	0.08	0.01	0.08	0.02	920
12	390	0.06	15.09	0.96	0.67	0.05	0.67	0.19	7,627
13	118	0.01	4.70	0.32	0.19	0.02	0.20	0.06	2,347
14	65	0.01	2.62	0.15	0.11	0.01	0.11	0.03	1,316
15	52	0.00	2.23	0.14	0.06	0.01	0.08	0.02	1,077
16	103	0.04	4.22	0.12	0.30	0.02	0.23	0.06	2,275
Total	2,185	0.25	90.55	4.07	3.42	0.32	3.78	1.09	45,024
Percent	45%	5%	79%	11%	13%	58%	26%	34%	52%

3 NON-RESIDENTIAL NEWLY CONSTRUCTED BUILDINGS

3.1 Statewide Building Data Projections

The projection of energy savings for individually modeled buildings to a statewide impact was based on building floor area data and forecasts from the CEC. The Non-Residential Construction Forecast dataset, developed by the Energy Commission's Demand Analysis office, provides floor areas for new construction. Energy Solutions translated the projections from forecast climate zone to Title 24 climate zones. These data are shown in Table 21.

The high-rise apartment data in Table 21 are based on 2020 residential multifamily starts data from Energy Solutions, shown in Table 22. Energy Solutions provided data which gave fractions of the total starts which are high-rise by climate zone. However, the proportion of high-rise residential for the 2019 impact study will be consistent with the 2016 impact study, where it was recommended that the statewide average of 26% be used for all climate zones, due to low confidence in the climate zone specific values. Based on the high-rise apartment prototype, the total average conditioned floor area per dwelling unit is 1,248 ft^2. This includes common area floor space, allocated to the dwelling units. This square footage per unit, in combination with the projected high-rise multifamily starts, is used to project the total square footage for high-rise residential projects.

Table 21 – Projected 2020 Construction by Building Types and Climate Zone from the Non-Residential Construction Forecast (10^6 ft^2)

	California Climate Zone																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
Small Office	0.062	0.263	0.859	0.587	0.114	0.788	1.055	1.097	1.076	1.233	0.349	1.871	0.757	0.201	0.270	0.278	10.860
Restaurant	0.021	0.116	0.485	0.264	0.051	0.577	0.317	0.830	0.918	0.802	0.108	0.538	0.250	0.153	0.106	0.170	5.706
Retail	0.108	0.890	3.951	2.138	0.415	3.311	2.042	4.779	5.048	3.831	0.807	4.394	1.789	0.757	0.665	0.957	35.882
Food	0.036	0.234	0.918	0.555	0.108	0.828	0.628	1.189	1.225	1.075	0.275	1.158	0.603	0.204	0.226	0.258	9.519
Warehouse	0.046	0.596	3.573	1.353	0.263	2.717	1.143	3.860	4.133	3.283	0.800	3.759	1.533	0.641	0.718	0.670	29.088
Ref. Warehouse	0.003	0.048	0.231	0.119	0.023	0.118	0.011	0.164	0.138	0.075	0.095	0.279	0.246	0.023	0.021	0.042	1.635
School	0.083	0.412	1.513	0.931	0.181	1.000	1.076	1.459	1.480	2.066	0.538	2.197	1.191	0.376	0.380	0.406	15.288
College	0.035	0.205	0.913	0.461	0.089	0.572	0.471	0.802	0.943	0.689	0.173	0.845	0.346	0.122	0.092	0.209	6.968
Hospital	0.039	0.265	1.047	0.636	0.123	0.632	0.668	0.963	1.369	0.815	0.260	1.237	0.564	0.161	0.113	0.237	9.128
Hotel	0.032	0.296	1.664	0.661	0.128	0.771	0.674	1.108	1.275	0.738	0.179	1.104	0.402	0.139	0.167	0.189	9.527
Large Office	0.069	1.044	6.928	2.343	0.455	4.366	2.200	6.392	8.623	2.170	0.412	4.504	0.790	0.544	0.272	1.247	42.359
Hi-Rise Res.	0.036	0.515	2.747	1.254	0.243	1.101	1.283	1.679	3.372	1.366	0.243	1.962	0.448	0.246	0.148	0.470	17.115
TOTAL	0.571	4.883	24.83	11.30	2.194	16.78	11.56	24.32	29.59	18.14	4.240	23.84	8.918	3.567	3.177	5.131	193.07

Table 22 – Multifamily Data by Climate Zone

CZ	Existing Multifamily Household Units	Existing High-Rise Multifamily Household Units	New Construction Multifamily Housing Units	New Construction High-Rise Multifamily Housing Units
1	3,395,774	2,721	111	29
2	33,513,642	26,854	1,582	413
3	194,606,029	155,934	8,432	2201
4	75,897,612	60,815	3,848	1005
5	14,736,527	11,808	747	195
6	104,592,265	83,808	3,379	882
7	104,317,267	83,588	3,939	1028
8	163,406,088	130,934	5,153	1345
9	303,179,906	242,933	10,350	2702
10	100,854,046	80,813	4,191	1094
11	22,927,180	18,371	747	195
12	141,972,176	113,760	6,023	1572
13	47,800,853	38,302	1,375	359
14	21,199,316	16,987	756	197
15	14,413,958	11,550	454	119
16	39,961,117	32,020	1,441	376
TOTAL	1,386,773,757	1,111,197	52,528	13,714

The Non-Residential Construction Forecast dataset also includes estimates of existing building floor area by building type and climate zone. These data were used to extrapolate savings for alteration projects to statewide savings. These data are shown in Table 23.

The high-rise apartment data in Table 23 are based on 2020 residential multifamily housing units data from Energy Solutions, shown in Table 22. The number of households was converted to floor area using the same procedure that was used for the new housing starts data, described above.

Table 23 – Existing Building Floor Area in 2020 by Building Types and Climate Zone from the Non-Residential Construction Forecast (10^6 ft²)

	California Climate Zone																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
Small Office	3	12	39	28	5	39	45	53	48	57	15	75	32	9	12	12	484
Restaurant	1	5	18	10	2	26	13	37	39	37	4	21	10	7	5	7	241
Retail	5	36	151	88	17	152	92	216	209	181	32	179	69	35	28	42	1532
Food	2	10	35	23	4	38	28	54	51	50	11	47	23	9	9	11	406
Warehouse	2	25	132	60	12	141	61	198	188	194	35	160	59	36	35	33	1372
Ref. Warehouse	0	2	9	5	1	6	1	8	6	4	4	12	10	1	1	2	72
School	4	20	77	45	9	67	44	94	84	87	22	92	49	16	14	18	741
College	2	11	45	25	5	38	24	52	55	36	9	42	18	6	4	11	382
Hospital	2	13	53	32	6	40	33	59	71	42	13	63	27	8	6	12	482
Hotel	2	13	61	29	6	42	39	60	59	41	7	47	15	7	7	9	443
Large Office	3	42	254	99	19	186	101	270	325	97	16	176	28	23	11	47	1695
Hi-Rise Res.	3	34	195	76	15	105	104	163	303	101	23	142	48	21	14	40	1387
TOTAL	28	223	1068	520	101	877	585	1265	1438	927	191	1056	389	180	146	243	9237

Not all of the building types included in the Non-Residential Construction Forecast were used for this analysis:

- Hospital was excluded from this impact analysis because the 2019 Standards is the first code cycle to include measures that impact the Hospital building type. Since there is no baseline to compare the measures against, this study did not include the Hospital building type.
- Refrigerated Warehouse was excluded because the energy consumption is dominated by refrigeration equipment for which a well-defined baseline is not available.
- Food was also excluded because of the significance of refrigeration equipment in building energy consumption, although refrigeration is not as dominant as in refrigerated warehouses. While the prototypes do not support refrigeration modeling, NORESCO has included savings based on the CASE report estimates for adiabatic condensers. Please refer to Section 3.8 for more details on the savings for adiabatic condensers.

3.2 Prototype Building Models

The remaining building types were then mapped to a series of prototype building models. The prototypes used are briefly described in Table 24, with additional details included in Appendix 1: Prototype Model Descriptions included with this report.

Table 24 – Summary of Prototype Descriptions Mapped to Construction Forecast Building Type

Construction Forecast Building Type	Description	Prototype	Floor Area (ft^2)	Stories	Notes
Small office	Offices less than 30,000 square feet	Small Office	5,503	1	Five zone office model with unconditioned attic and pitched roof.
Restaurant	Any facility that serves food	Small Restaurant	2,501	1	Similar to a fast food restaurant with a small kitchen and dining areas.
Retail	Retail stores and shopping centers	Stand-Alone Retail	24,566	1	Stand Alone store, such as convenience and pharmacy stores.
		Large Retail	240,023	1	Big box retail building, such as national consumer electronic stores.
		Strip Mall	9,376	1	Four unit strip mall retail building. West end unit is twice as large as other three.
		Mixed-Use Retail	9,376	1	Four unit retail representing the ground floor units in a mixed use building. Same as the strip mall with adiabatic ceilings.
Food	Any service facility that sells food and or liquor	Not included			
Non-refrigerated warehouse	Non-refrigerated warehouses	Warehouse	52,050	1	High ceiling warehouse space with small office area.
Refrigerated warehouse	Refrigerated Warehouses	Not included			
Schools	Schools K-12, not including	Small School	24,415	1	Similar to an elementary school with classrooms, support spaces and small dining area.

	colleges	Large School	210,907	2	Similar to high school with classrooms, commercial kitchen, auditorium, gymnasium and support spaces.
College	Colleges, universities, community colleges	Small Office	5,503	1	Five zone office model with unconditioned attic and pitched roof.
		Medium Office	53,633	3	Five zones per floor office building with plenums on each floor.
		Medium Office/Lab	53,633	3	Five zones per floor building with a combination of 27% office and 73% lab spaces.
		Large School	210,907	2	Similar to high school with classrooms, commercial kitchen, auditorium, gymnasium and support spaces.
		High Rise Apartment	94,097	10	75 residential units along with common spaces and a penthouse. Multipliers are used to represent typical floors.
Hospital	Hospitals and other health-related facilities	Not included			
Hotel/motel	Hotels and motels	Hotel	43,206	4	Hotel building with common spaces and 77 guest rooms.
Large offices	Offices larger than 30,000 square feet	Medium Office	53,633	3	Five zones per floor office building with plenums on each floor.
		Large Office	498,637	12	Five zones per floor office building with plenums on each floor. Middle floors represented using multipliers.
High Rise Apartment	High-rise multifamily residential building	HR Apartment	94,097	10	75 residential units along with common spaces and a penthouse. Multipliers are used to represent typical floors.

In addition to the existing prototypes, this analysis involved the creation of new variants of existing CBECC-Com prototypes in order to address the specific building or system needs not currently available in the existing prototypes. The following prototype variants were developed for modeling some of the proposed 2019 Title 24 measures.

Construction Forecast Building Type	Description	Prototype	Floor Area (ft^2)	Stories	Notes
Schools	Schools K-12, not including colleges	Small School SPVAC	24,415	1	Similar to an elementary school with classrooms, support spaces and small dining area with packaged vertical air conditioners.
		Small School SPVHP	24,415	1	Similar to an elementary school with classrooms, support spaces and small dining area with packaged vertical heat pumps.

The following table shows the mapping of the existing prototypes to the construction forecast building types. Where multiple building prototypes map to single construction forecast building type, a weighting fraction will be applied as shown in the Table 25.

Table 25 – Correspondence between the California Forecasted Construction and Prototype Buildings

California Forecasted Construction Building Type	Prototype Building Type	Prototype Building Share of CA Forecasted Construction
Small Office	Small Office	100%
Large Office	Large Office	50%
	Medium Office	50%
Restaurant	Small Restaurant	100%
Retail	Stand-Alone Retail	10%
	Large Retail	75%
	Strip Mall	5%
	Mixed-Use Retail	10%
Food	Not included	
Non-refrigerated Warehouse	Warehouse	100%
Refrigerated Warehouse	Not included	
College	Small Office	6%
	Medium Office	16%
	Medium Office/Lab	21%
	Large School	31%
	High Rise Apartment	26%
Hospital	Not included	
Hotel	Small Hotel	100%
High Rise Residential	Large Apartment	100%

Where variants to existing prototypes are required, the weighting fractions for the prototype variants will be based on the CASE reports of applicable measures, while the weighting of the existing prototypes will be proportionately adjusted as shown in Table 26.

Table 26 - Prototype Weighting Adjustments

California Forecasted Construction Building Type	Prototype Building Type	Prototype Building Share of CA Forecasted Construction
School	Small School	18%
	Small School with Single Packaged Vertical Heat Pump (variant)	30%
	Small School with Single Packaged Vertical Air Conditioner (variant)	12%
	Large School	40%

3.3 New Construction Energy Savings Methodology

EnergyPlus, version 8.5, was used to simulate buildings that are compliant with the 2016 and 2019 versions of the Standards, with the differences in energy consumption showing the impact of the changes to the Standards. These models were originally built in CBECC-Com as minimally compliant with Title 24 2016. The EnergyPlus files generated from CBECC-Com were modified to include parameters that would allow them to be made compliant with Title 24-2019, or to represent any of the specific measures added to the 2019 Standards.

Energy consumption by prototype building and climate zone were divided by conditioned floor area to provide energy use intensities (EUIs). These were then multiplied by the 2020 construction forecasts (in millions of square feet) to determine annual energy consumption for new construction in each climate zone under the 2016 or 2019 Standards. Statewide total energy consumption was then found by summing the climate zone specific consumption. The savings attributed to the 2019 Standards is then the difference in consumption between the 2016 and 2019 cases. Energy consumption was calculated as site kWh, site therms, site Btus, and TDV Btus. TDV calculations were done in EnergyPlus, using the 15 year, Non-Res hourly TDV factors for electricity and natural gas for each climate zone.
Calculation of energy use intensity is shown in Equation 1:

$$EUI_{16zp} = E_{16zp} \div CFA_p \quad (1)$$

where: EUI_{16zp} = Energy Use Intensity of prototype *p*, in climate zone *z* under 2016 Standards,
E_{16zp} = Energy Use of prototype *p*, in climate zone *z* under 2016 Standards, and
CFA_p = Conditioned Floor Area of prototype *p*

EUI_{19zp} would be calculated in the same way using E_{19zp}, the energy use under the 2019 standards.

Calculation of statewide energy consumption for newly constructed buildings of a specific type is shown in Equation 2:

$$ET_{16b} = \sum_{p=1}^{16} \sum_{z=1}^{16} EUI_{16zp} \cdot FA_{zb} \cdot WF_{bp} \quad (2)$$

where: ET_{16b} = Statewide total energy for building type b under the 2016 Standards,
FA_{zb} = Projected new construction floor area of building type *b*, in climate zone *z*, and
WF_{bp} = Weighting factor for prototype *p* used to represent building type *b* (from Table 16)

ET_{19b} would be calculated in the same way using EUI_{19zp}, the energy use intensity under the 2019 standards.

Total statewide energy savings for new construction is found using Equation 3:

$$Sav_{NC} = \sum_{b=1}^{8} ET_{16b} - \sum_{b=1}^{8} ET_{19b} \quad (3)$$

where: Sav_{NC} = Total statewide total energy savings for new construction.

Statewide demand reductions were also calculated using climate zone specific hourly demand factors. The hourly energy consumption was multiplied by these factors to calculate a demand impact for the hour. These were summed over the 8,760 hours of the analysis to determine the total demand impact. These demand values were again divided by floor area, and then accumulated in the same manner as the energy consumption to get statewide demand impact under the 2016 and 2019 Standards, with the difference being the demand savings attributed to the 2019 Standards.

All simulations were performed using weather files for representative cities for each of the 16 California climate zones as per 2016 Reference Joint Appendix JA2. The different climate zones were represented by specific weather files, shown in Table 27. These weather files were used in EnergyPlus for the analysis.

Table 27 – California Climate Zone Mapping

Climate Zone (CZ)	Representative City and Weather Station ID
CZ 01	ARCATA_725945
CZ 02	SANTA-ROSA_724957
CZ 03	OAKLAND_724930
CZ 04	SAN-JOSE-REID_724946
CZ 05	SANTA-MARIA_723940
CZ 06	TORRANCE_722955
CZ 07	SAN-DIEGO-LINDBERGH
CZ 08	FULLERTON_722976
CZ 09	BURBANK-GLENDALE_722880
CZ 10	RIVERSIDE_722869
CZ 11	RED-BLUFF_725910
CZ 12	SACRAMENTO-EXECUTIVE_724830
CZ 13	FRESNO_723890
CZ 14	PALMDALE_723820
CZ 15	PALM-SPRINGS-INTL
CZ 16	BLUE-CANYON_725845

3.4 Alterations Energy Savings Methodology

The impact of new systems in existing building undergoing alterations is due to the difference between the 2016 and 2019 standards. Although the systems being replaced are expected to have significantly higher energy consumption than those which are compliant with the 2016 standard, the savings claimed are only the additional savings for improvements beyond those already required by the 2016 standard. The analysis was performed by comparing 2016 compliant buildings to the same buildings with 2019 compliant systems. The results were weighted by the existing floor area in each climate zone, shown in Table 16, and buildings were classified as shown in Table 17.

For lighting, the analysis assumes minimal compliance with the standards. Section 141.0, specifically Table 141.0-E, provides exceptions to certain control requirements if the lighting power is less than 85% of the lighting power allowance specified in Section 140.6(c)2, Area Category Method. However, the assumption of this study is that minimal compliance is interpreted to mean that the lighting power is equal to the Area Category Method lighting power allowance, and so none of the exceptions apply. Also, the assumption is that lighting alterations meet the requirements of Section 141.0(b)2Ji (meet the lighting power allowance in Section 140.6 and comply with the control requirements in Table 141.0-E).Section 141.0(b)2Jii compliance is not assumed as no information is available as to the characteristics of the existing luminaires being replaced.

It was assumed that lighting systems are replaced every 15 years, meaning that 1/15th of the existing floor area included in the analysis. Similarly, HVAC system alterations were analyzed by comparing the 2016 compliant buildings that use small packaged vertical air conditioners and small packaged vertical heat pumps against the same buildings with efficiencies that are compliant with the 2019 standard. It was assumed that packaged units are replaced every 20 years, meaning that 1/20th of the existing floor area were used in the analysis.

Calculation of alterations savings follows the process described with the exception that EUI_{16zp} and ET_{16b} are replaced with EUI_{mzp} and ET_{mb}, where m is the specific measure, either the lighting or HVAC. These are calculated in Equations 4 and 5:

$$EUI_{mzp} = E_{mzp} \div CFA_p \quad (4)$$

where: EUI_{mzp} = Energy Use Intensity of prototype *p*, in climate zone *z* under 2016 Standards plus the measure *m*,
E_{mzp} = Energy Use of prototype *p*, in climate zone *z* under 2016 Standards plus measure m, and
CFA_p = Conditioned Floor Area of prototype *p*

EUI_{19zp} would be calculated in the same way using E_{19zp}, the energy use under the 2019 standards.

Calculation of statewide energy consumption for existing building alterations of a specific type is shown in Equation 5:

$$ET_{mb} = \sum_{p=1}^{16} \sum_{z=1}^{16} EUI_{mzp} \cdot EFA_{zb} \cdot {}^{1}/_{MF_m} \quad (5)$$

where: ET_{mb} = Statewide total energy for building type b under the 2019 Standards plus measure *m*,
EFA_{zb} = Existing floor area of building type *b*, in climate zone *z*,
MFm = the frequency measure *m* is applied (yrs)

Total statewide energy savings for alterations is found using Equation 6:

$$Sav_{Alt} = \sum_{m-1}^{2} (\sum_{b=1}^{8} ET_{16b} - \sum_{b=1}^{8} ET_{mb}) \quad (6)$$

where: Sav_{Alt} = Total statewide total energy savings for alterations.

Total statewide energy savings is found using Equation 7:

$$TotalSavings = Sav_{NC} + Sav_{Alt} \quad (7)$$

3.5 CASE Measure List

The following sections describe the CASE measures conducted for the 2019 Standards that recommend changes to the non-residential 2019 Standards. The measures are categorized by interior lighting, exterior lighting, HVAC and process loads. Most requirements apply to new construction, but some are evaluated for their impact as alterations to existing buildings. The 15-day language published by the Energy Commission was used as the source of the measures, and later verified against the final adoption of the code. For the purpose of Impact Analysis, some of these measures were modeled using appropriate building prototypes, while some relied on methodologies and assumptions specified in the CASE reports. The list of measures included in the non-residential portion of the analysis is presented in Table 28.

Table 28 - Non-residential Measures *Included* in the 2019 Impact Analysis

Category	CASE Measure ID	Measure Title	Title 24 Section	Modeling
Interior Lighting	2019-NR-LIGHT2-F	Lighting Power Densities	§140.6	✓
	2019-NR-LIGHT4-F	Lighting Controls: Manual ON Time-Switch	§130.1	
		Lighting Controls: Occupant Sensors in Restrooms	§130.1, §140.6	✓
Exterior Lighting	2019-NR-LIGHT1-F	Lighting Power Allowances	§100.1, §130.2, §140.7	✓
	2019-NR-LIGHT3-F	Lighting Controls: 50% Reduction After-Hours	§130.2	
		Lighting Controls: Remove 75 Watt Threshold for Bi-Level Motion Controlled Lighting	§130.2	
HVAC	2019-NR-ASHRAE90.1F	Fan System Power	§140.4	✓
		Equipment Efficiency	§110.2	✓
		Waterside Economizers	§140.4	
		Transfer Air for Exhaust Air Makeup	§140.4	
		Demand Controlled Ventilation for Classrooms	§120.1	✓
		Occupant Sensor Ventilation Requirements	§120.1, §120.2	✓
HVAC	2019-NR-MECH1-F	Cooling Tower Minimum Efficiency	§140.4	✓
	2019-NR-MECH2-F	Economizer Fault Detection Diagnostics	§120.2	
Process	2019-NR-MECH3-F	Variable Exhaust Flow Control	§140.9. 141.1	✓
	2019-NR-MECH4-F	High Efficiency Fume Hoods	§140.9	✓
	2019-NR-MECH6-F	Adiabatic Condensers	§120.6	

Some of the other CASE measures were excluded from this analysis for various reasons: (1) if they were not adopted into the final version of 2019 Standards, (2) if they were only adopted as compliance options in the 2019 Standards, (3) if they are not expected to generate code savings. The list of excluded measures was reviewed and approved by the Energy Commission during the course of this analysis.

Specifically, measures that were not covered in the scope of this analysis are listed in

Table 29 with corresponding reasons for exclusion.

Table 29 - Non-residential Measures *NOT Included* from the 2019 Impact Analysis

Category	CASE Measure ID	Measure Title	Reason for Exclusion
Interior Lighting	2019-NR-LIGHT4-F	Lighting Controls: Mandatory Automatic Daylight Dimming Plus OFF Controls	No savings expected as this is a compliance option
Exterior Lighting	2019-NR-LIGHT3-F	Lighting Controls: Bi-level Motion Controlled Lighting: 75% Reduced Wattage When Vacant After-Hours	Not adopted in the 2019 Standards
Advanced Daylighting	2019-NR-LIGHT5-F	Power Adjustment Factors and Performance Compliance Options	No savings expected as this is a compliance option
		Min VT Interpretation for Tubular Daylighting Devices	No savings reported as a result of changes made in the 2019 Standards
		Update to Daylit Zones Definitions	No savings reported as a result of changes in the 2019 Standards
HVAC	2019-NR-ASHRAE90.1-F	Exhaust Air Heat Recovery	Not adopted in the 2019 Standards
Envelope	2019-RES-ENV5-F	Loading Dock Seals in Warehouses	Not adopted in the 2019 Standards
Air Quality	2019-NR-ASHRAE62.1-F	Non-residential Indoor Air Quality	No savings expected due to minimal changes to ventilation rates

3.6 Simulation Order

The individual measures selected for modeling in this analysis, according to Table 28, were sequentially added to the 2016 minimally-compliant baseline prototypes in the order listed in Table 30. 2019 compliant version runs were also created by adding all the measures. Energy consumption for the baseline and each added measure run was converted to Energy Use Intensity (EUI) values for each energy type and unit. The measure EUI was then projected to a statewide consumption by multiplying the EUI with the statewide construction forecast building area for each prototype and each California climate zone. Savings were calculated by taking the difference in statewide energy consumption for each additional measure category.

Table 30 - Order of Modeling Simulation

Category	Measure Title
Lighting	Indoor Lighting Power Density
	Lighting Controls: Occupant Sensors in Restrooms
Process	Variable Exhaust Flow Control
	High Efficiency Fume Hoods
HVAC	Equipment Efficiency
	Fan System Power
	Demand Controlled Ventilation for Classrooms
	Occupant Sensor Ventilation Requirements
	Cooling Tower Minimum Efficiency
Exterior Lighting	Outdoor Lighting Power Allowances

3.7 Measure Simulation Details

The scope of the non-residential and high-rise residential impact analysis covers the following energy efficiency measures from the 2019 Standards. For the purpose of this analysis, some of the measures were modeled using appropriate building prototypes, while other measures had savings extracted from the CASE reports. The following sections by measure category describe the measures and modeling methodologies conducted in this analysis.

3.7.1 Lighting

1. Indoor Lighting Power Density – §140.6

CASE Measure ID: 2019-NR-LIGHT2-F

The 2019 Standards have revised lighting power density values in Table 140.6-C. Indoor lighting power reductions were modeled based on the updated lighting power density values (LPDs) in the area category method. The prototype models do not cover all of the space types that are impacted by the changes to the area category method. All simulation models use a certain amount of abstraction when converting from the real building to the simulation model. Since the prototypes are not models of particular buildings but are representation of "typical" buildings, this abstraction presents a particular issue with the models. An example of this is that the office building models are made up of spaces which are all (or nearly all) assigned the space function of "Office (Greater than 250 square feet in floor area)."In reality, an office building will have some fraction of space which is small private offices, conference rooms, corridors, restrooms, lobbies, kitchenettes, mechanical rooms, janitors' closets, and other space types. Rather than try to include physical representations of all of the detailed space uses of the real building in the simulation model, this analysis took an area weighting approach to overcome the space type limitation. The area weighting approach involves calculating averaged characteristics from multiple space types, but simulating them by applying the averaged value to a particular space. This approach was recommended to the CASE Team at the inception of the 2019 CASE measure analysis efforts for consistency.

For this impact study, the area weightings of space categories for the prototypes were determined based on information provided in the 2019-T24-CASE Report-Indoor Light Sources, while the area category LPD values came from Table 140.6-C of the 2019 Standards. Please review Appendix 2: Area Weighted Lighting Power Density Calculation included with this report for details of space types included to calculate the area weighted lighting power density of each prototype and the weightings. Based on the area weightings, the calculated weighted LPD's for each prototype for 2016 and 2019 Standards are listed for comparison in Table 31.

Table 31 – Area-weighted Lighting Power Densities

Building Type	Prototype	2016 LPD (W/ft^2)	2019 LPD (W/ft^2)
Small Office	Small Office	0.84	0.68
Large Office	Large Office	0.85	0.67
	Medium Office	0.84	0.67
Restaurant	Small Restaurant	0.98	0.57
Retail	Stand-Alone Retail	1.09	0.9
	Large Retail	1.05	0.86
	Strip Mall	1.09	0.9
	Mixed-Use Retail	1.09	0.9
Non-refrigerated Warehouse	Warehouse	0.96	0.64
School	Small School	0.99	0.64
	Small School SPVAC	0.99	0.64
	Small School SPVHP	0.99	0.64
	Large School	0.94	0.63
College	Small Office	0.84	0.68
	Medium Office	0.84	0.67
	Medium Office/Lab	1.26	0.91
	Large School	0.94	0.63
	High Rise Apartment	0.57	0.44
Hotel	Small Hotel	1.15	0.77
High Rise Residential	Large Apartment	0.57	0.44

2. Lighting Controls, Occupant Sensing Controls in Restrooms – §130.1

CASE Measure ID: 2019-NR-LIGHT4-F

The 2019 Standards have added a mandatory requirement for occupant sensing full OFF controls in non-residential restrooms for new construction and lighting alterations. This measure was modeled by applying modified occupancy and lighting schedules to building prototypes that have restroom spaces. The impact of this measure was evaluated in both new construction and alterations. Per the CASE report restroom lighting controls result in a 30% reduction in full load hours (FLH). Based on this assumption, the restroom lighting schedule was adjusted from 34 FLH to 26 FLH in the school prototypes and from 38 FLH to 29 FLH in all other prototypes that have restroom spaces.

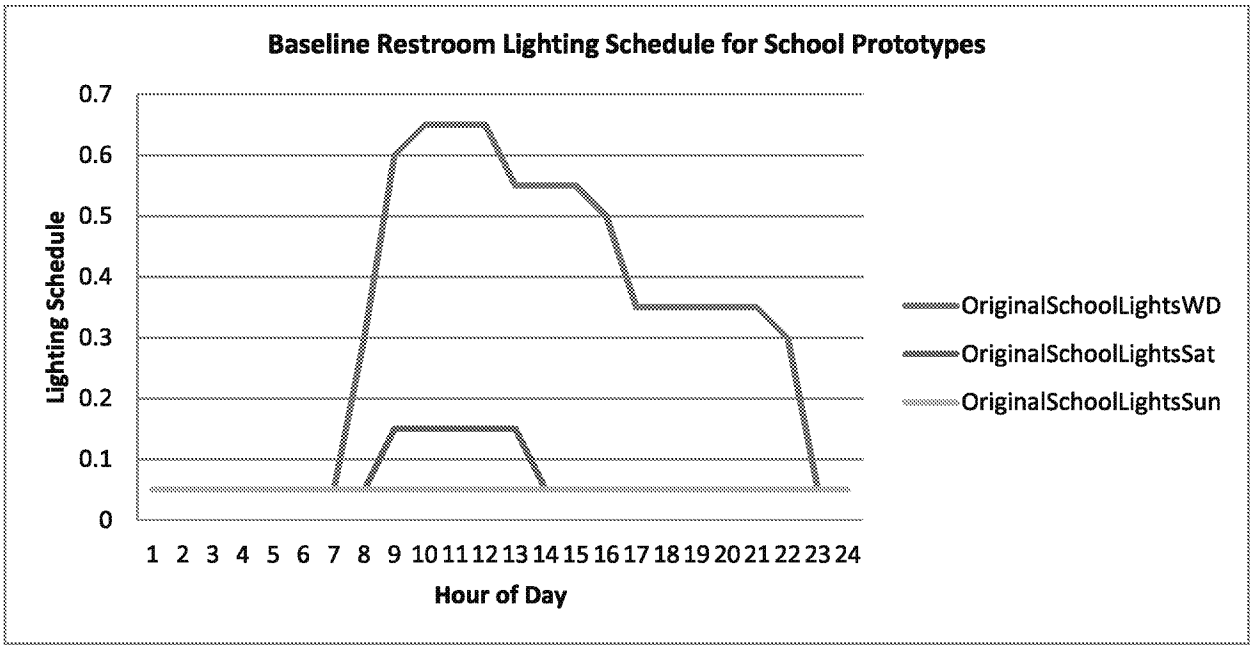

Figure 1 – Baseline School Restroom Lighting Schedule

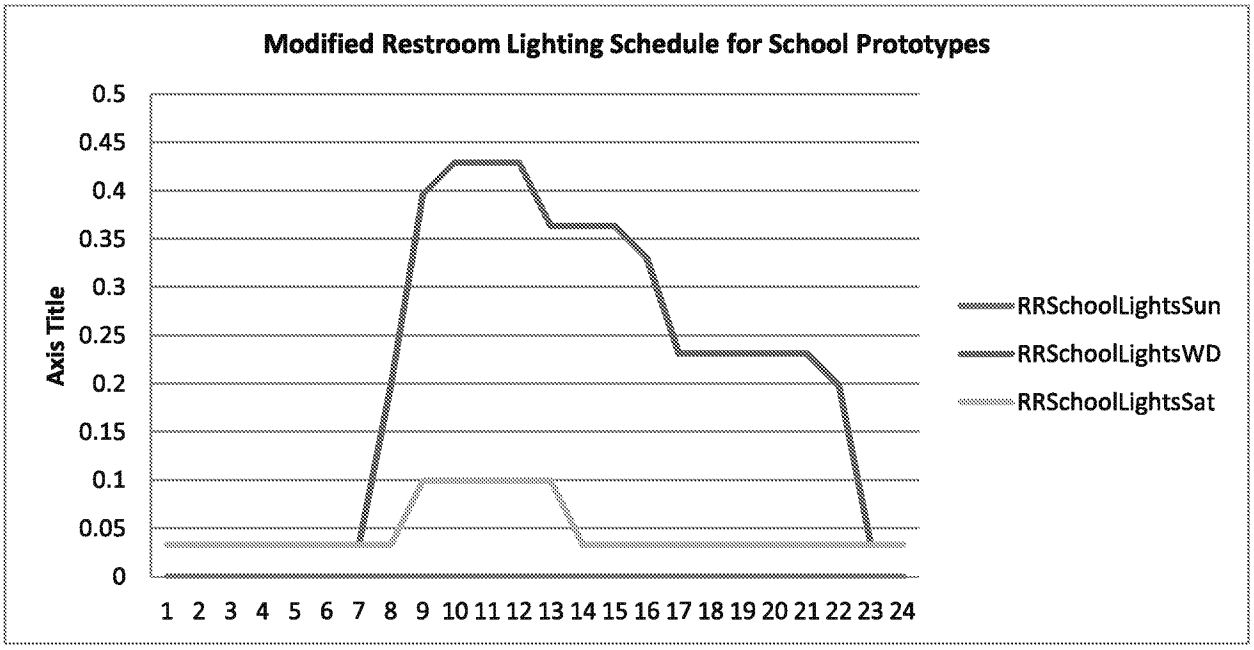

Figure 2 - Modified School Restroom Lighting Schedule

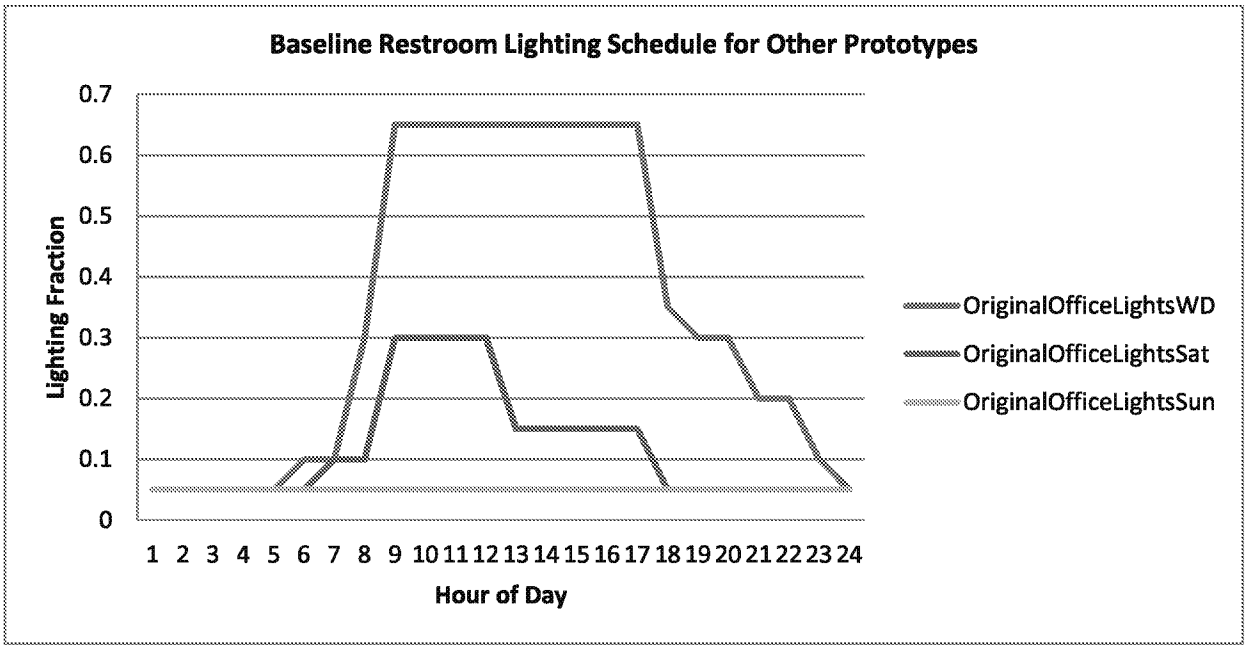

Figure 3 - Baseline Restroom Lighting Schedule for Other Prototypes

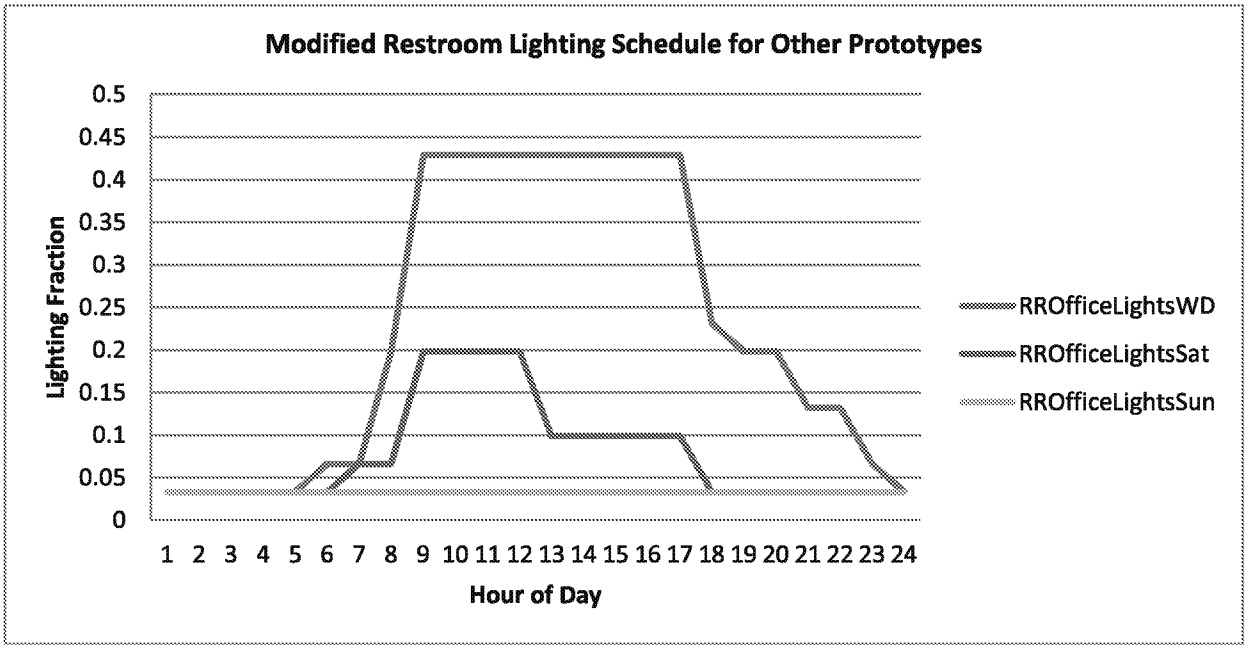

Figure 4 - Modified Restroom Lighting Schedule for Other Prototypes

3.7.2 Exterior Lighting

3. Outdoor Lighting Power Allowance – §100.1, §130.2, §140.7

CASE Measure ID: 2019-NR-LIGHT1-F

The 2019 Standards have revised lighting power allowance (LPA) values in Table 140.7-A. This measure was modeled using the EnergyPlus exterior light objects for lighting zones 2 and 3 (LZ2 and LZ3), lighting power allowance factors listed in Tables 140.7-A in the 2019 Standards, and weighting factors proposed by the CASE Team. This analysis focused on LZ2 and LZ3 since these two zones account for more than 90% of the total, as shown in Table 32. Please review Appendix 3: Outdoor LPA Calculation included with this report for details on total LPA's calculated for specific applications of exterior lighting.

Table 32 – Percent Construction by Lighting Zone

Lighting Zone	Percent of Land Mass (Source: 2010 US Census)	Percent of Construction Activity (Estimate)
LZ0	9%	0%
LZ1	1%	0.10%
LZ2	85%	9.90%
LZ3	5%	90%
LZ4	0%	0%

Outdoor lighting area assumptions for each prototype were based on Table 36 of the CASE report. Lighting power for each area category was based on Table 140.7-A and B of the Standards. Please refer to Appendix 3 for more details. The total outdoor lighting wattages are shown in Table 30. Based on the LPA factors, the calculated weighted LPA's for each prototype for 2016 Standards and 2019 Standards are listed for comparison in Table 33:

Table 33 – Outdoor Lighting Power by Building Prototype

	LZ2 Allowance		LZ3 Allowance	
	2016 (W)	**2019 (W)**	**2016 (W)**	**2019 (W)**
Small School	1,016	618	1,377	850
Small Office	622	366	740	489
Medium Office	1,738	1,146	2,121	1,410
Large Office	11,744	8,168	14,457	9,689
Medium Retail	2,579	1,752	3,425	2,298
Large Retail	20,280	14,340	27,543	18,646
Small Restaurant	748	384	987	542
Small Hotel	1,424	910	1,916	1,253
Warehouse	1,099	656	1,415	859
Large Apartment	1,255	764	1,620	990
Strip Mall	651	384	781	512
Large School	4,511	2,931	6,760	4,041
Small School SPVAC	1,016	618	1,377	850
Small School SPVHP	1,016	618	1,377	850

3.7.3 HVAC

4. Fan System Power – §140.4(c)

CASE Measure ID: 2019-NR-ASHRAE90.1F

The 2019 Standards have added new prescriptive requirements for fan power for systems with a total fan motor (nameplate) horsepower of 5 HP or more according to Tables 140.4-A, 140.4-B. This measure only applies to buildings that follow the prescriptive path since the baseline fan power per the 2016 performance approach rules were already at the same levels as the new changes in the 2019 prescriptive requirement. This measure was modeled by adjusting HVAC fan power in all prototypes with fan motor (nameplate) horsepower of 5 HP or more. The 2016 baseline fan power was set to 1.25 W/cfm for variable air volume (VAV) system types, and 0.80 W/cfm for constant air volume (CV) system types. The measure case was modeled with 1.03 W/cfm for VAV fans and 0.78 W/cfm for CV fans. The fan bhp is calculated per the 2019 Nonresidential ACM (NACM) rules as Equations 8 and 9:

For CAV:

$$\begin{aligned} \text{BHP} &= 0.00094 \times \text{CFM} + \text{A} \\ &= 0.00094 \times \text{CFM} + (0.9 \times \text{CFM} \div 4131) \\ &= 0.001158 \times \text{CFM} \end{aligned} \quad (8)$$

And for VAV:

$$\begin{aligned} \text{BHP} &= 0.0013 \times \text{CFM} + \text{A} \\ &= 0.0013 \times \text{CFM} + (0.9 \times \text{CFM} \div 4131) \\ &= 0.001518 \times \text{CFM} \end{aligned} \quad (9)$$

The intent of this measure is to align the prescriptive and performance requirements for fan power. To be conservative, the 2019-T24-CASE Report-Proposals Based on ASHRAE-90.1 assumed that only 25 percent of new construction follows a prescriptive compliance pathway. Similar assumptions were used to calculate statewide energy savings by applying measure savings to only 25% of the new construction building stock.

5. Equipment Efficiency – §110.2

CASE Measure ID: 2019-NR-ASHRAE90.1F

The 2019 Standards have revised equipment efficiency requirements for single zone packaged vertical air conditioners (SPVAC) and single zone packaged vertical heat pumps (SPVHP) less than 65,000 Btuh as reflected in Table 110.2-E of the 2019 Standards.

It is assumed that SPVAC and SPVHP systems account for 12% and 30% of all school buildings respectively. Since these systems are not part of any of the existing prototypes, variants of existing small school prototype were created. Two variants were created by changing the HVAC system of the Small School prototype to SPVAC and SPVHP. This measure was modeled and applying the efficiency requirements from Table 110.2-E to SPVAC and SPVHP systems less than 65,000 Btuh.

In addition, the 2019 Standards increased equipment part-load efficiency requirements for several different systems (Table 110.2-A, Table 110.2-B, Table 110.2-H, Table 110.2-I in the 2019 Standards). While this will reduce energy use, compliance software cannot model IEER properly. Therefore IEER efficiency improvements were not reflected in the impact analysis.

6. Demand Controlled Ventilation for Classrooms – §120.1(c)3

CASE Measure ID: 2019-NR-ASHRAE90.1F

The 2019 Standards have removed classroom spaces from the demand controlled ventilation (DCV) exemption requirement, in essence requiring DCV for classroom spaces with design occupancy level of 25 people, or 1000 square feet or greater area. This measure was modeled by specifying DCV in classroom spaces in the Small School and Large School prototypes.

7. Occupancy Sensor Ventilation – §120.1(c)5 and 120.2(e)3

CASE Measure ID: 2019-NR-ASHRAE90.1F

Occupancy sensor based ventilation control is required in enclosed office, conference and corridor space types per the 2019 Title 24 requirements. The occupancy sensor requirement also allows the ventilation thresholds to drop to zero during unoccupied hours of business hours in these space types. Previously ventilation was not allowed to go below minimum threshold levels at periods of non-occupancy during business hours.

This measure was modeled in the Small and Medium Office prototypes. The office prototypes consist of four perimeter zones and a core zone. For modeling this measure the core zone and north perimeter zones are assumed to be open offices, the East perimeter conference and South and West zones are assumed to be enclosed offices. The occupancy schedules of the conference and enclosed offices spaces were modified to represent a variable occupancy profile. The modified schedule developed by the CASE team to model this measure was aggressive resulting in over 50% reduction in FLH compared to ACM office schedule. For this analysis a new set of schedules that results in a weekly FLH about 25% less compared to the NACM schedule was created. This new schedule set is based on a typical week comprising of 5 unique WD schedules and a Sat and Sun schedule. The original ACM office occupancy schedule profile plot and a comparison of the modified office occupancy profile plot are shown in Figures below:

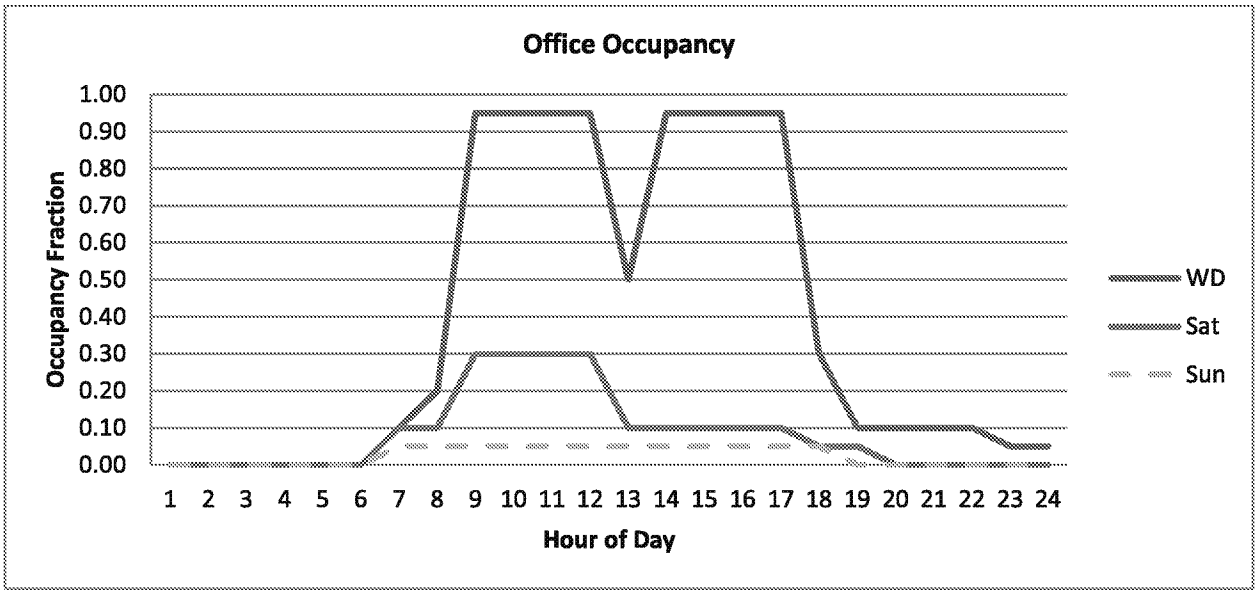

Figure 5 - NACM Office Occupancy Schedule

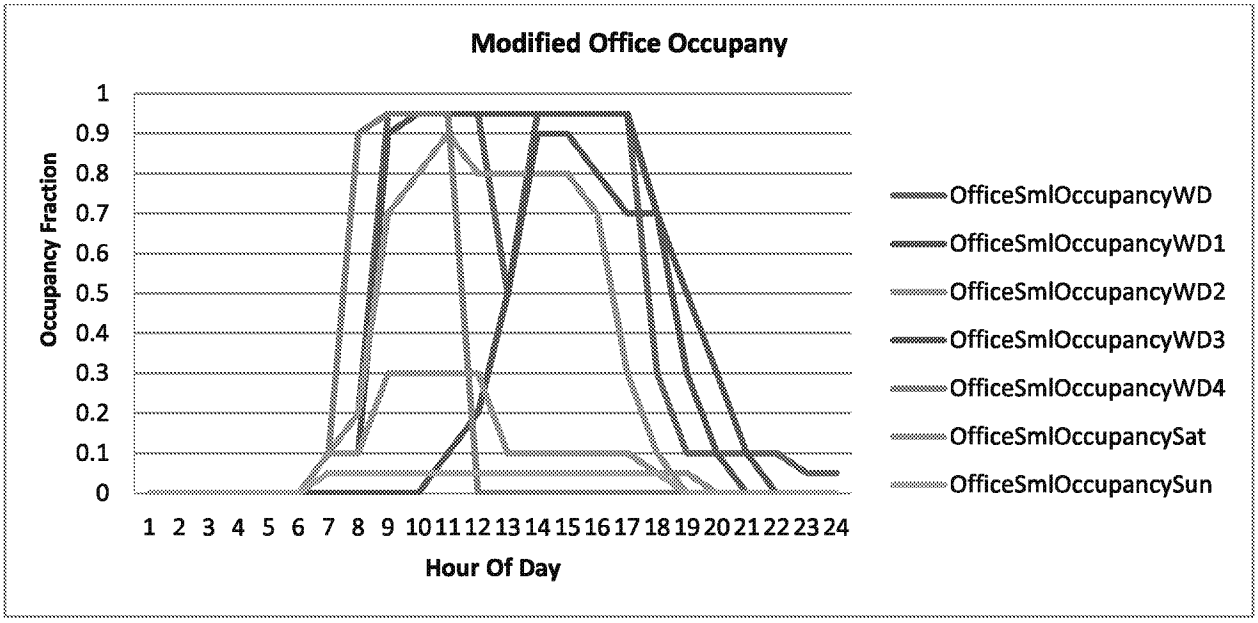

Figure 6 - Modified Office Occupancy schedule

Assembly schedules were also modified. The current NACM assembly schedule is not well suited for a conference space within a typical office building as the occupancy profile is based on a typical assembly building with heavier occupancy during weekends and weeknights.

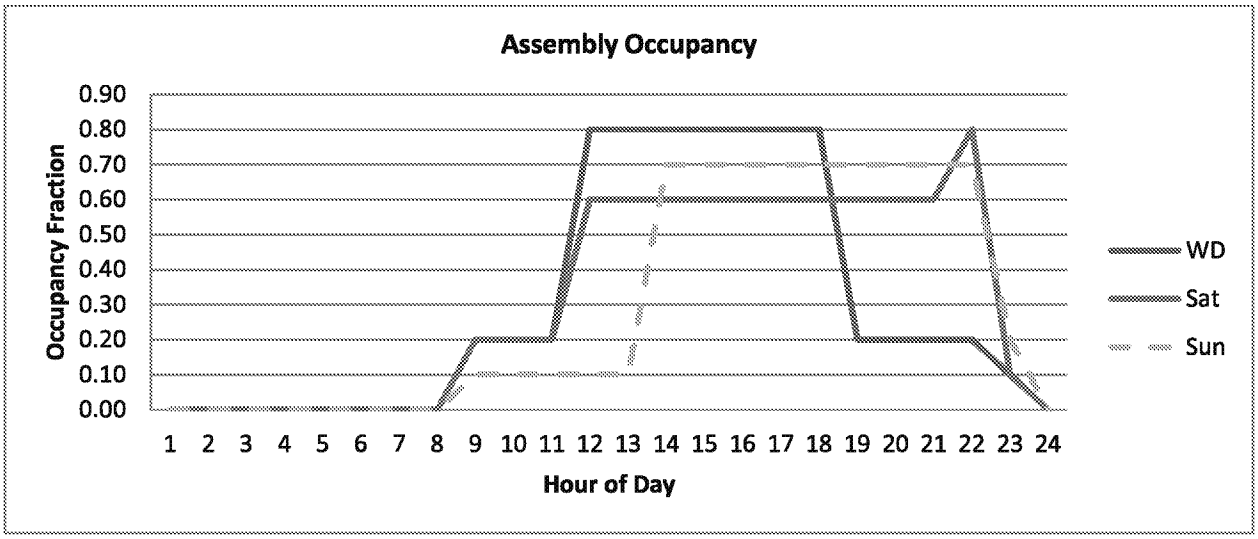

Figure 7 - NACM Assembly Occupancy Schedule

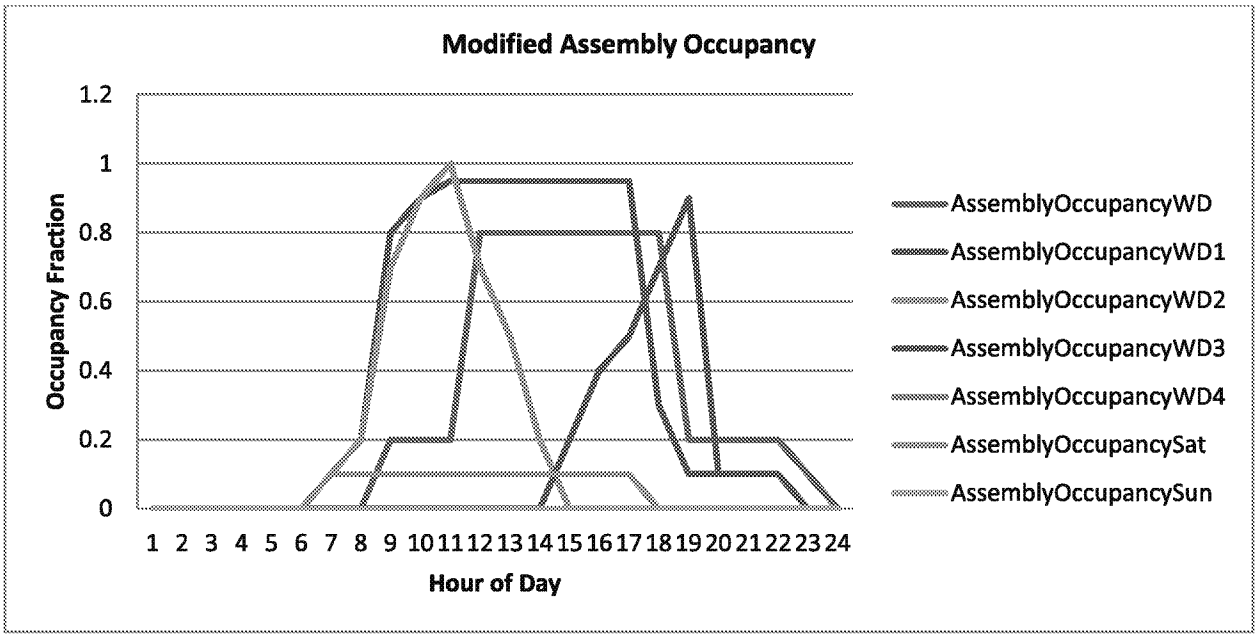

Figure 8 - Modified Assembly Occupancy Schedule for Conference Space

Corresponding thermostat and ventilation availability schedules were created based on the modified occupancy schedules see Appendix 4: Schedules for Occupancy Based Ventilation Control included with this report for more details. The measure was then modeled by applying the modified occupancy schedules in both baseline and measure cases and NACM schedules for thermostat set point and ventilation for the 2016 baseline case and modified versions for the measure case. The unit savings were then applied to small office and medium office within the large office construction forecast data to calculate statewide savings.

8. Cooling Tower Minimum Efficiency – §140.4

CASE Measure ID: 2019-NR-MECH1-F

The 2019 Standards have increased the prescriptive requirement for cooling tower efficiency for all cooling towers with a design condenser flow rate of 900 GPM or higher. This measure increases the prescriptive requirement from 42.1 GPM/HP to 60 GPM/HP for all cooling towers with a design condenser flow rate of 900 GPM or higher (300 chiller tons), according to Table 110.2-G of the standards. This measure was modeled by adjusting all prototypes that have a cooling tower with condenser flow rate above 900 GPM. The large office and high rise apartment prototypes were impacted by this measure. Similar to the fan power measure, this new requirement does not increase the stringency of the performance approach as the intent of this measure is to align the prescriptive and performance requirements for cooling towers. Hence for being conservative in the calculation of statewide energy savings the unit savings from this measure was applied to only 25% of the new construction large office and high-rise apartment and high- rise apartment portion of the college building stock.

3.7.4 Process

9. Variable Exhaust Flow Control – §140.9 and 141.1

CASE Measure ID: 2019-NR-MECH3-F

The 2019 Standards require that laboratories meet the discharge requirements in ANSI Z9.5 and to limit the power consumption of laboratory and process facility exhaust systems. Previously there were no requirements for the power demand of laboratory and process facility discharge exhaust systems in the state. This measure was modeled by setting the fume hoods to 0.65 W/CFM in the Medical Office/Lab prototype model. The baseline was modeled as a constant speed fan with 0.78 W/cfm. The unit savings were then applied to the Medium office/Lab portion of the college construction forecast data to calculate statewide savings.

10. High Efficiency Fume Hoods – §140.9

CASE Measure ID: 2019-NR-MECH4-F

The 2019 Standards have added a prescriptive requirement for sash opening controls for laboratory fume hoods that can automatically open and close to maintain the airflow. This measure was modeled by applying a constant exhaust air flow fraction of 0.9 in the baseline case and a variable exhaust flow fan schedule with occupied average exhaust flow fraction of 0.36 and unoccupied exhaust flow fraction of 0.12. This measure was applied to the Medium Office/lab prototype. The unit savings were then applied to the Medium office/Lab portion of the college construction forecast data to calculate statewide savings.

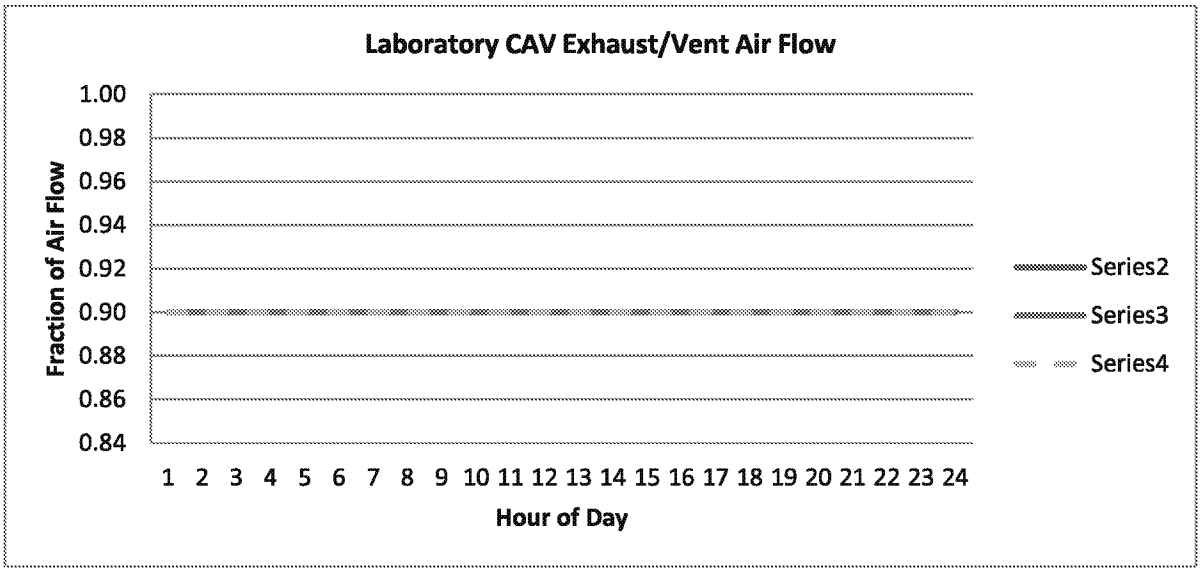

Figure 9 - Baseline CAV Exhaust Fan Schedule

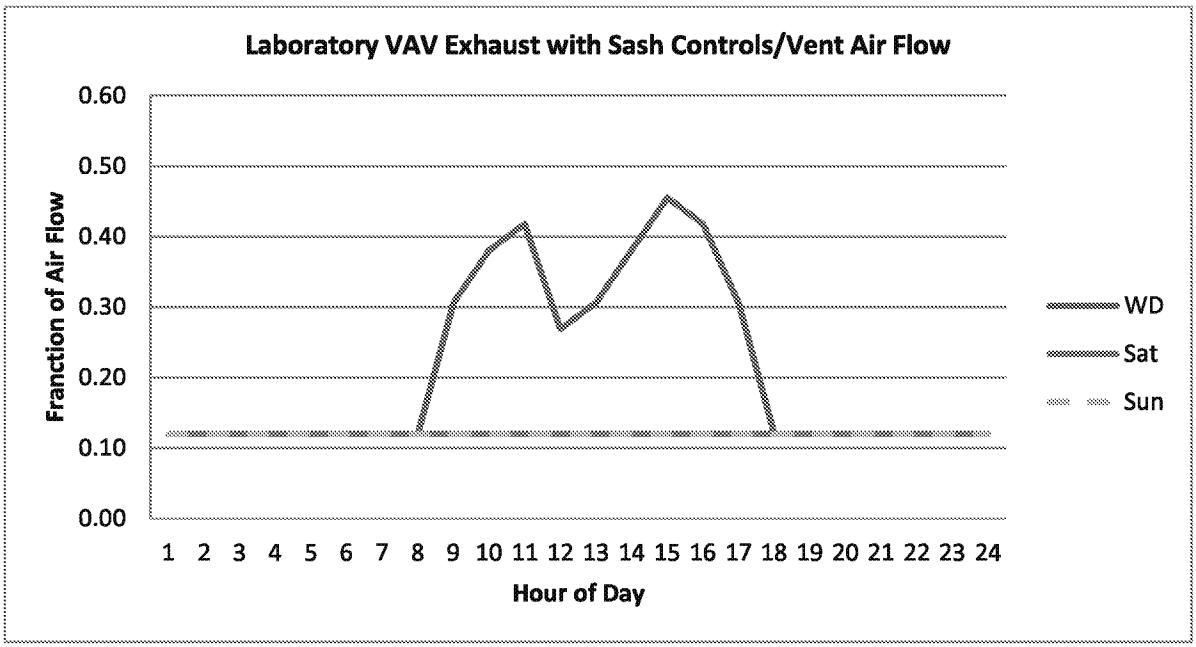

Figure 10 - VAV Exhaust Sash Control Ventilation Schedule

3.8 Measures with Savings from CASE Reports

A few of the measures included in this analysis will not be modeled using the building prototypes due to various reasons, including lack of interactive effects with other measures, complexity of modeling, unique assumptions applied in the CASE reports. For such measures, NORESCO extracted the estimated statewide savings directly from the CASE reports and added the CASE savings to the results of the impact analysis. The list of measures with savings extracted from the CASE reports is summarized below:

11. Indoor Lighting Controls: Manual ON Time-Switch – §130.1(c)5A, §130.1(c)5B

CASE Measure ID: 2019-NR-LIGHT4-F

For areas not required by §130.1(b) to have multi-level lighting controls, previous code cycles, inclusive of 2008-2016 code cycles, have allowed the use of automatic time-switch controls to comply with Title 24, Part 6 Shut-OFF requirements. Based on industry stakeholder feedback, changing the requirement to allow for lighting controls to be commissioned to manual ON could lead to significant energy savings by reducing the amount of time that nonresidential indoor lighting is turned ON when the space is not occupied. As a result, for areas not required by §130.1(b) to have multi-level lighting controls, the 2019 Standards have added an exception in §130.1(c) to allow lighting to be controlled by an occupancy sensor that automatically turns ON all lighting when the room is occupied (commissioned as manual ON).

This measure was not selected for modeling as spreadsheet calculation is deemed appropriate for this measure. The Statewide CASE Team estimated savings based on reasonable assumptions and spreadsheet calculations that alter the occupancy schedule and lighting load for building types and space types that will be affected by this measure. Additionally, the CASE Team applied an average time dependent valuation (TDV) factors to derive energy savings and peak demand reductions. For this impact analysis, the energy savings from the CASE report were incorporated into the final results. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Indoor Lighting Controls Report.

12. Outdoor Lighting Controls, 50% Reduction After-Hours – §130.2

CASE Measure ID: 2019-NR-LIGHT3-F

As related to this automatic scheduling control, Section 130.2(c) of the 2016 Standards required that outdoor luminaires can be controlled independently and scheduled to be turned off during certain hours of the night. Through the adoption of the 2019 Standards, it is now required that automatic scheduling controls shall be capable of reducing the outdoor lighting power of each controlled luminaire by at least 50 percent and no more than 90 percent, and also separately capable of turning the lighting luminaire OFF, during scheduled unoccupied periods. The 2019 requirements align with ASHRAE 90.1. To meet this requirement, the outdoor lighting controls must be capable of reducing power between 50 percent and 90 percent. This measure can be accomplished by having two or more independently scheduled ON/OFF control channels or by dimming lighting according to a schedule, or some combination of the two.

This measure was not selected for modeling as spreadsheet calculation is deemed appropriate for this measure. The Statewide CASE Team estimated savings based on reasonable assumptions, relevant scenarios and spreadsheet calculations that represent the savings attributed to adding multi-level control capability to time-switch controlled lighting, for building types and space types that will be affected by this measure. Additionally, the CASE Team applied an average time dependent valuation (TDV) factors to derive energy savings and peak demand reductions. For this impact analysis, the

energy savings from the CASE report were incorporated into the final results. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Outdoor Lighting Controls Report.

13. Outdoor Lighting Controls, Remove 75 Watt Threshold for Bi-Level Motion Controlled Lighting – §130.2(c)3

CASE Measure ID: 2019-NR-LIGHT3-F

The 2019 Standards have removed the wattage threshold of 75 watts for spaces where bi-level motion sensing controls are required to reduce lighting power of each luminaire by at least 50 percent when no motion is detected in the area for longer than 15 minutes during normally occupied periods. The spaces affected include parking lots, gas station canopies, gas station hardscape and retail sales lots where luminaires are mounted lower than 24 feet. In addition, the scope for general hardscape lighting was reduced to cover only parking lots.

This measure was not selected for modeling as spreadsheet calculation is deemed appropriate for this measure. The Statewide CASE Team estimated the energy savings based on reasonable assumptions regarding space types and occupancy-based controls that would be impacted by the removal of the 75 watts threshold. Since this measure is not climate sensitive, the CASE Team applied statewide average TDV factors to derive energy savings and peak demand reductions. For this impact analysis, the energy savings from the CASE report were incorporated into the final results. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Outdoor Lighting Controls Report.

14. Waterside Economizers – §140.4(e)

CASE Measure ID: 2019-NR-ASHRAE90.1F

The 2019 Standards have increased control and performance requirements for buildings with waterside economizers. The CASE report used an estimate that 3% of all large offices have a waterside economizer. The CASE Team calculated savings using a model with VAV systems without airside economizers. It is unclear how common this application of a waterside economizer is used, because airside economizers will generally be used for VAV systems. Waterside economizers are typically used when airside economizers are not feasible, such as when a dedicated outdoor air system (DOAS) is used to provide ventilation. The ductwork in a DOAS is typically sized to provide minimum required ventilation air and is therefore not capable of using an airside economizer. However, data on the number and type of projects using DOAS is not available in the CASE report, so it is not possible to calculate statewide savings for changes in waterside economizer system performance requirements for this scenario. Therefore, NORESCO has included the CASE report estimate of savings, as data was not available to calculate an alternative estimate. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Proposals-Based-on-ASHRAE-90.1 Report.

15. Transfer Air for Exhaust Air Makeup – §140.4(o)

CASE Measure ID: 2019-NR-ASHRAE90.1F

This measure is a prescriptive requirement included in the 2019 Standards that expands the 2016 Title 24, Part 6 requirement for kitchen exhaust transfer air to other types of exhaust systems, such as toilet exhaust and lab exhaust. For spaces with high exhaust air makeup, the exhaust air systems are required to use available transfer air first to supply for exhaust air makeup. Transfer air for exhaust makeup, for spaces such as toilets and labs, has been commonly used in many designs for many years. This measure matches the same requirement that was added to ASHRAE 90.1 in 2013. Through this measure, the 2019 Standards will regulate systems that were not previously regulated, as there were previously no limitations on the amount of conditioned air that could be used to replace air being exhausted. According to the CASE report, the proposed code change will specifically require that spaces with exhaust requirements that are higher than the ventilation cfm or the cfm required to meet the heating or cooling load is made up with transfer air instead of 100 percent outside air or 100 percent supply air.

This measure was not selected for modeling due to simulation constraints and the minimal interactive effect between this measure and other measures included in this impact analysis. The Statewide CASE Team modeled the energy savings based on guidance from the Energy Commission on the type of prototype buildings affected and estimated savings using ASHRAE 90.1 prototypes for nonresidential buildings available in CBECC-Com. The medium office/laboratory prototype building was used, since this measure will directly affect laboratory buildings. For this impact analysis, the energy savings from the CASE report were incorporated into the final results. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Proposals-Based-on-ASHRAE-90.1.

16. Economizer Fault Detection Diagnostics – §120.2(i) and 140.9(a)

CASE Measure ID: 2019-NR-MECH2-F

The 2019 Standards require automated economizer fault detection and diagnostics (FDD) controls for systems with built-up air handling units with design cooling capacity greater than 54,000 Bth/hr (4.5 tons) and equipped with an airside economizer. This requirement expands upon the existing mandatory code language in Section 120.2(i) which requires economizer FDD for nonresidential packaged and split air handling HVAC systems of the same specifications. As a result, the 2019 Standards will apply the FDD requirement to all air handlers, both packaged and built-up systems, greater than 54,000 Btu/hr in size and equipped with an air-side economizer.

According to the CASE report, this code change would require the detection and reporting of the following economizer faults listed in 120.2(i)7 for built-up systems as well as packaged systems:

- Air temperature sensor failure/fault
- Not economizing when it should
- Economizing when it should not
- Damper not modulating
- Excess outdoor air

This measure was not selected for modeling due to simulation constraints and the minimal interactive effect between this measure and other measures included in this impact analysis. In addition, there is little to no empirical data available on the probability of detecting faults, according to the investigation conducted by the CASE Team. Therefore, the CASE Team worked with leading FDD experts to develop a set of conservation assumptions for Fault Incidence Rates and FDD Benefit, as documented in Table 4 of the 2019-T24-CASE-Report-Economizer-FDD-for-Built-up-Air-Handlers. The savings in the CASE report were modeled based on these assumptions. For this impact analysis, the energy savings from the CASE report were incorporated into the final results. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Economizer-FDD-for-Built-up-Air-Handlers.

17. Adiabatic Condensers – §120.6

CASE Measure ID: 2019-NR-MECH6-F

The 2019 Standards have added mandatory efficiency and control requirements for systems with adiabatic fan-powered condensers according to Table 120.6-B in the 2019 Standards. This requirement defines an adiabatic condenser as a refrigeration system component that condenses refrigerant vapor by rejecting heat to air mechanically circulated over its heat transfer surface, causing a temperature rise in the air, with the additional capability to utilize evaporative precooling of the entering air, for operation only during high ambient temperatures, and accomplished as part of a single factory-made and rated unit. In prior versions of Title 24, Part 6, adiabatic condensers were not mentioned in the code. The new mandatory requirements apply to refrigerated warehouses and commercial refrigeration.

This measure was not selected for modeling due to simulation constraints and the minimal interactive effect between this measure and other measures included in this impact analysis. The CASE Team leveraged DOE 2.2 modeling software to simulate the adiabatic condensers and compared current design practices to design practices that will comply with the proposed requirements. As there are no code requirements for adiabatic condensers, the CASE Team developed the adiabatic condenser scenario based on current design practices and code requirements applicable to air-cooled and evaporative cooled condensers. For this impact analysis, the energy savings from the CASE report were incorporated into the final results. More details on the savings methodology can be found in the 2019-T24-CASE-Report-Adiabatic-Condensers.

3.9 Analysis and Detailed Results

The efficiency measures listed above were applied to the Title 24-2016 baseline models in the order listed. Measures were added cumulatively. Table 34 through

Table 42 below show the savings for various measures or groups of measures. Table 43 shows the overall savings for all the new construction measures.

Table 34 – Non-residential Statewide First-Year Savings for New Construction Lighting Power Densities

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	7.0	0.4	0.5	-0.01	0.19
2	72.5	6.1	3.8	-0.05	1.63
3	368.2	31.8	18.6	-0.25	7.68
4	172.8	16.0	8.9	-0.10	3.80
5	32.8	2.8	1.7	-0.02	0.69
6	250.7	24.4	12.1	-0.10	5.10
7	189.3	19.4	9.3	-0.07	3.93
8	371.2	36.7	17.6	-0.14	7.71
9	485.4	48.2	22.6	-0.16	9.87
10	285.7	27.2	13.8	-0.11	6.16
11	54.2	4.6	3.0	-0.03	1.34
12	323.1	28.0	16.8	-0.20	7.24
13	113.4	10.0	6.2	-0.07	2.81
14	52.7	4.7	2.6	-0.03	1.20
15	45.9	4.9	2.2	-0.01	0.94
16	69.1	4.7	3.9	-0.07	1.65
Total	**2,893.9**	**270.0**	**143.7**	**-1.42**	**61.94**

Table 35 – Non-residential Statewide First-Year Savings for New Construction Lighting Controls, Occupant Sensing Controls in Restrooms

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	0.0	0.0	0.0	0.00	0.00
2	0.4	0.0	0.0	0.00	0.02
3	1.4	0.1	0.2	0.00	0.07
4	0.8	0.1	0.1	0.00	0.03
5	0.1	0.0	0.0	0.00	0.01
6	1.0	0.1	0.1	0.00	0.04
7	1.0	0.1	0.1	0.00	0.04
8	1.5	0.1	0.1	0.00	0.06
9	1.6	0.2	0.2	0.00	0.07
10	1.8	0.2	0.1	0.00	0.06
11	0.4	0.0	0.0	0.00	0.02
12	1.8	0.2	0.2	0.00	0.12
13	1.0	0.1	0.1	0.00	0.03
14	0.3	0.0	0.0	0.00	0.01
15	0.4	0.0	0.0	0.00	0.01
16	0.3	0.0	0.0	0.00	0.01
Total	**13.9**	**1.3**	**1.3**	**-0.02**	**0.60**

Table 36 – Non-residential Statewide First-Year Savings for New Construction Outdoor Lighting Power Allowance

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	2.6	0.3	0.1	0.00	0.04
2	23.8	3.2	1.1	0.02	0.50
3	125.7	17.4	5.2	0.08	2.15
4	56.2	7.7	2.5	0.03	1.21
5	10.8	1.4	0.5	0.01	0.19
6	92.7	12.9	3.8	0.04	1.73
7	59.9	7.9	2.6	0.02	1.27
8	134.4	19.1	5.5	0.06	2.68
9	165.2	23.4	6.8	0.08	3.52
10	94.8	12.1	4.1	0.04	2.21
11	18.2	2.3	0.9	0.01	0.49
12	110.5	14.9	4.8	0.07	2.56
13	38.3	4.9	1.8	0.02	1.03
14	18.3	2.4	0.8	0.01	0.43
15	15.3	1.9	0.7	0.00	0.37
16	26.8	3.4	1.1	0.02	0.50
Total	**383.0**	**47.2**	**17.4**	**0.0**	**5.4**

Table 37 – Non-residential Statewide First-Year Savings for Other New Construction Fan System Power

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	0.4	0.0	0.0	0.00	0.01
2	4.9	0.5	0.3	0.00	0.10
3	23.5	2.3	1.2	-0.01	0.45
4	11.9	1.2	0.6	0.00	0.24
5	2.0	0.2	0.1	0.00	0.04
6	21.3	2.3	1.0	0.00	0.37
7	12.7	1.3	0.6	0.00	0.26
8	34.5	3.6	1.5	0.00	0.73
9	41.6	4.4	1.8	-0.01	0.78
10	23.6	2.3	1.1	-0.01	0.46
11	4.0	0.4	0.2	0.00	0.09
12	26.8	2.4	1.2	-0.01	0.58
13	7.7	0.8	0.5	0.00	0.16
14	4.8	0.5	0.2	0.00	0.10
15	4.1	0.5	0.2	0.00	0.06
16	5.7	0.5	0.3	0.00	0.13
Total	**229.6**	**23.4**	**10.8**	**-0.06**	**4.55**

Table 38 – Non-residential Statewide First-Year Savings for Other New Construction Equipment Efficiency

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	0.2	0.0	0.0	0.00	0.00
2	1.3	0.1	0.0	0.00	0.01
3	2.5	0.3	0.0	0.00	0.01
4	2.7	0.2	0.0	0.00	0.03
5	0.3	0.0	0.0	0.00	0.00
6	2.4	0.2	0.0	0.00	0.02
7	2.1	0.2	0.0	0.00	0.02
8	4.8	0.4	0.0	0.00	0.04
9	6.2	0.5	0.0	0.00	0.06
10	8.8	0.7	0.1	0.00	0.08
11	2.7	0.2	0.0	0.00	0.03
12	9.4	0.8	0.1	0.00	0.10
13	5.4	0.5	0.0	0.00	0.06
14	1.8	0.2	0.0	0.00	0.02
15	2.6	0.2	0.0	0.00	0.03
16	1.4	0.2	0.0	0.00	0.01
Total	**54.4**	**4.7**	**0.4**	**0.00**	**0.51**

Table 39 – Non-residential Statewide First-Year Savings for Other New Construction Demand Controlled Ventilation for Classrooms

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	0.6	0.3	0.0	0.01	0.01
2	3.3	1.0	0.1	0.06	0.37
3	8.5	3.2	0.3	0.21	0.66
4	6.5	1.7	0.2	0.09	0.95
5	1.0	0.4	0.0	0.02	0.05
6	4.6	1.2	0.2	0.07	0.69
7	4.2	1.0	0.2	0.05	0.63
8	6.7	1.7	0.3	0.10	1.48
9	10.4	2.1	0.5	0.13	2.73
10	13.0	2.8	0.3	0.11	1.86
11	4.8	1.1	0.1	0.04	0.61
12	18.3	4.7	0.5	0.21	2.55
13	9.3	2.4	0.3	0.09	1.22
14	2.6	0.7	0.1	0.03	0.38
15	2.9	0.4	0.1	0.01	0.41
16	2.4	1.3	0.0	0.08	0.20
Total	**99.1**	**26.1**	**3.3**	**1.32**	**14.79**

Table 40 – Non-residential Statewide First-Year Savings for Other New Construction Occupancy Sensor Ventilation

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	1.1	0.3	0.0	0.00	0.01
2	22.2	5.1	0.5	0.03	0.29
3	145.7	34.6	3.3	0.23	1.91
4	52.3	12.3	1.2	0.08	0.62
5	9.6	2.3	0.2	0.02	0.12
6	102.1	23.3	2.5	0.15	1.38
7	53.7	11.6	1.3	0.07	0.72
8	150.6	34.9	3.9	0.22	1.82
9	191.0	43.8	4.9	0.27	2.28
10	50.1	11.6	1.2	0.07	0.61
11	9.2	2.1	0.2	0.01	0.12
12	96.2	22.0	2.2	0.14	1.12
13	16.5	3.8	0.4	0.02	0.21
14	10.8	2.4	0.3	0.02	0.14
15	6.0	1.3	0.2	0.01	0.08
16	23.8	5.7	0.6	0.04	0.33
Total	**940.9**	**217.1**	**23.1**	**1.38**	**11.76**

Table 41 – Non-residential Statewide First-Year Savings for Other New Construction Lab Process Load Measures

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	1.2	0.1	0.0	0.00	0.01
2	6.9	0.8	0.3	0.00	0.07
3	31.0	3.7	1.1	0.00	0.30
4	15.7	1.9	0.6	0.00	0.15
5	3.0	0.4	0.1	0.00	0.03
6	19.2	2.3	0.7	0.00	0.19
7	15.8	1.9	0.6	0.00	0.15
8	26.7	3.3	1.0	0.00	0.26
9	31.4	3.9	1.2	0.00	0.31
10	23.1	2.8	0.8	0.00	0.22
11	5.9	0.7	0.2	0.00	0.06
12	28.6	3.5	1.0	0.00	0.27
13	11.8	1.4	0.4	0.00	0.11
14	4.1	0.5	0.1	0.00	0.04
15	3.1	0.4	0.1	0.00	0.03
16	7.2	0.9	0.3	0.00	0.07
Total	**234.7**	**28.5**	**8.6**	**-0.01**	**2.27**

Table 42 – Non-residential Statewide First-Year Savings for Other New Construction Cooling Tower Efficiency

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	0.0	0.0	0.0	0.00	0.00
2	0.1	0.0	0.0	0.00	0.01
3	0.3	0.0	0.0	0.00	0.01
4	0.4	0.0	0.0	0.00	0.01
5	0.0	0.0	0.0	0.00	0.00
6	0.6	0.1	0.0	0.00	0.02
7	0.4	0.0	0.0	0.00	0.01
8	1.0	0.1	0.0	0.00	0.03
9	1.8	0.2	0.0	0.00	0.06
10	0.6	0.0	0.0	0.00	0.02
11	0.1	0.0	0.0	0.00	0.00
12	0.8	0.1	0.0	0.00	0.03
13	0.2	0.0	0.0	0.00	0.01
14	0.1	0.0	0.0	0.00	0.00
15	0.1	0.0	0.0	0.00	0.00
16	0.0	0.0	0.0	0.00	0.00
Total	**6.6**	**0.5**	**0.2**	**0.00**	**0.20**

Table 43 – Total Non-residential New Construction Statewide First-Year Savings

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	10.8	1.3	0.6	0.0	0.2
2	118.2	14.8	5.3	0.0	2.6
3	625.2	83.4	26.2	0.2	10.6
4	280.8	35.8	12.4	0.1	6.2
5	51.6	6.6	2.3	0.0	0.9
6	448.9	59.7	18.6	0.1	8.0
7	295.7	36.8	13.0	0.1	5.9
8	667.7	89.4	27.5	0.1	12.7
9	850.1	112.2	34.8	0.2	17.5
10	430.2	49.9	19.1	0.1	10.2
11	85.7	9.7	4.2	0.0	2.6
12	545.1	66.7	23.9	0.2	13.3
13	172.3	20.0	8.6	0.1	5.2
14	83.3	9.6	3.7	0.0	2.1
15	69.6	7.8	3.2	0.0	1.8
16	120.9	15.0	5.5	0.0	2.4
Total	**4,856.1**	**618.8**	**208.8**	**1.20**	**102.05**

4 NON-RESIDENTIAL INTERIOR LIGHTING ALTERATIONS

4.1 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, and Table 140.6-C.

4.2 Methodology

The impact of new lighting systems in existing buildings is due to the difference between the 2016 and 2019 standards. Although the lighting systems being replaced are expected to have significantly higher energy consumption than those which are compliant with the 2016 standard, the savings claimed here are only the additional savings for improvements beyond those already required by the 2016 standard. The analysis was performed by comparing 2016 compliant buildings to the same buildings with 2019 compliant lighting systems. The results were weighted by the existing floor area in each climate zone, and buildings were classified as shown in Table 25.

Note that the analysis assumes minimal compliance with the standards. Section 141.0, specifically Table 141.0-E, provides exceptions to certain control requirements if the lighting power is less than 85% of the lighting power allowance specified in Section 140.6(c)2, Area Category Method. However, the assumption of this study is that minimal compliance is interpreted to mean that the lighting power is equal to the Area Category Method lighting power allowance, and so none of the exceptions apply. Also, the assumption is that lighting alterations meet the requirements of Section 141.0(b)Ji. Section 141.0(b)Jii compliance is not assumed as no information is available as to the characteristics of the existing luminaires being replaced. It was assumed that lighting systems are replaced every 15 years, meaning that $1/15^{th}$ of the existing floor area were included in the analysis. Existing floor area data came from the Non-Residential Construction Forecast dataset, shown in Table 44. The High Rise Apartment areas were taken from the Multi-family household data in the 2020 Residential Forecast. It is assumed that 26% of the total multifamily household comprises of High Rise Residential units.

Table 44 – Existing Building Floor Area by Building Types and Climate Zone from the Non-Residential Construction Forecast (million ft²)

	California Climate Zone																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	TOTAL
Small Office	3	12	39	28	5	39	45	53	48	57	15	75	32	9	12	12	484
Restaurant	1	5	18	10	2	26	13	37	39	37	4	21	10	7	5	7	241
Retail	5	36	151	88	17	152	92	216	209	181	32	179	69	35	28	42	1532
Food	2	10	35	23	4	38	28	54	51	50	11	47	23	9	9	11	406
Warehouse	2	25	132	60	12	141	61	198	188	194	35	160	59	36	35	33	1372
Ref. Warehouse	0	2	9	5	1	6	1	8	6	4	4	12	10	1	1	2	72
School	4	20	77	45	9	67	44	94	84	87	22	92	49	16	14	18	741
College	2	11	45	25	5	38	24	52	55	36	9	42	18	6	4	11	382
Hospital	2	13	53	32	6	40	33	59	71	42	13	63	27	8	6	12	482
Hotel	2	13	61	29	6	42	39	60	59	41	7	47	15	7	7	9	443
Large Office	3	42	254	99	19	186	101	270	325	97	16	176	28	23	11	47	1695
Hi-Rise Res.	3	34	195	76	15	105	104	163	303	101	23	142	48	21	14	40	1387
TOTAL	28	223	1068	520	101	877	585	1265	1438	927	191	1056	389	180	146	243	9237

4.3 Analysis and Detailed Results

The changes to the lighting power density and restroom lighting control requirements were analyzed as described in Section 3. The results are shown below in Table 45.

Table 45 – Non-residential Statewide First-Year Savings for Lighting System and Restroom Control Alterations in Existing Buildings

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	25.6	1.5	1.7	0.0	0.7
2	236.5	20.1	12.9	-0.17	5.47
3	1,188.3	104.7	60.4	-0.77	24.85
4	560.0	52.5	30.2	-0.34	12.73
5	106.6	9.3	5.7	-0.07	2.34
6	963.7	95.7	48.9	-0.41	20.28
7	715.1	74.9	34.4	-0.24	14.29
8	1,425.8	144.0	70.4	-0.54	30.38
9	1,815.8	185.2	86.6	-0.60	37.13
10	1,012.4	97.9	49.2	-0.38	21.65
11	181.4	15.9	10.3	-0.11	4.54
12	1,045.6	92.3	55.5	-0.66	23.87
13	379.8	34.2	21.4	-0.23	9.51
14	188.8	17.0	9.5	-0.10	4.26
15	151.9	16.4	7.0	-0.03	3.02
16	246.7	17.0	13.8	-0.23	5.81
Total	**10,243.9**	**978.5**	**517.9**	**-4.92**	**220.81**

5 NON-RESIDENTIAL HVAC ALTERATIONS

5.1 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. The small packaged vertical heat pump and small packaged vertical air conditioners are impacted by this measure.

5.2 Methodology

The impact of HVAC equipment replacements in existing buildings is due to the difference between the 2016 and 2019 standards. Although the HVAC systems being replaced are expected to have significantly higher energy consumption than those which are compliant with the 2016 standard, the savings claimed here are only the additional savings for improvements beyond those already required by the 2019 standard. This was analyzed by comparing the 2016 compliant buildings that use SPVAC and SPVHP against the buildings with same systems with efficiencies that are compliant with the 2019 standard. The results were weighted by the existing floor area in each climate zone, with buildings classified as in Table 25. It was assumed that packaged units are replaced every 20 years, meaning that we 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 23.

5.3 Analysis and Detailed Results

The HVAC alteration requirements were analyzed as described above. The results are shown below in Table 46.

Table 46 – Non-residential Statewide First-Year Savings for SPVAC and SPVHP HVAC Replacements on Existing Buildings

CZ	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
1	0.4	0.0	0.0	0.00	0.00
2	3.0	0.3	0.0	0.00	0.03
3	6.3	0.7	0.0	0.00	0.04
4	6.5	0.6	0.0	0.00	0.07
5	0.7	0.1	0.0	0.00	0.00
6	8.1	0.7	0.1	0.00	0.06
7	4.2	0.4	0.0	0.00	0.03
8	15.4	1.3	0.1	0.00	0.12
9	17.6	1.3	0.1	0.00	0.18
10	18.4	1.4	0.1	0.00	0.18
11	5.5	0.5	0.0	0.00	0.06
12	19.7	1.6	0.1	0.00	0.20
13	11.2	1.1	0.1	0.00	0.13
14	3.9	0.3	0.0	0.00	0.04
15	4.7	0.4	0.0	0.00	0.05
16	3.1	0.3	0.0	0.00	0.01
Total	**128.7**	**11.0**	**1.0**	**0.00**	**1.18**

6 NON-RESIDENTIAL OVERALL ENERGY SAVINGS

6.1 Non-residential Total Savings

The energy savings for each of the measures or groups of measures listed above in Tables 34 through 42 for New Constructions, and Tables 45 through 46 for Alterations, are listed in Table 47, which also shows the overall statewide energy impacts on non-residential buildings of the 2019 Standards. These savings have been adjusted to distribute interactive effects across all measures, as described by Equation 2.

Table 47 – Non-residential Statewide First-Year Savings for the 2016 Energy Standard

Measure or Group of Measures	TDV GBtu	Site GBtu	Elec GWh	Gas Mtherm	Demand MW
Indoor Lighting Power Densities	2,489	201	131	-0.27	45.2
Indoor Lighting Manual ON Time-Switch	26	1	0	0.00	0.0
Indoor Occupant Sensing Light Controls in Restrooms	12	1	1	0.00	0.4
Outdoor Lighting Controls - Scheduling Controls	55	8	2	0.00	0.0
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold	80	10	3	0.00	0.2
Fan System Power	197	17	10	-0.01	3.3
Equipment Efficiency	47	3	0	0.00	0.4
Waterside Economizers	4	1	0	0.00	0.0
Transfer Air for Exhaust Air Makeup	18	5	0	0.03	0.9
Demand Controlled Ventilation for Classrooms	85	19	3	0.25	10.8
Occupant Sensor Ventilation Requirements	809	162	21	0.27	8.6
Cooling Tower Minimum Efficiency	6	0	0	0.00	0.1
Economizer Fault Detection Diagnostics	31	4	1	0.01	1.1
Variable Exhaust Flow Control and High Efficiency Fume Hoods	202	21	8	0.00	1.7
Adiabatic Condensers (Option B)	20	2	1	0.00	0.1
Outdoor Lighting Power Allowance	329	35	16	0.00	4.0
New Construction Total	4,410	492	197	0.27	76.6
Lighting Alterations	10,244	978	518	-4.92	220.8
Indoor Lighting Manual ON Time-Switch	79	4	1	0.00	0.0
Outdoor Lighting Controls - Scheduling Controls	160	23	7	0.00	0.0
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold	235	30	9	0.00	0.1
HVAC Alterations	129	11	1	0.00	1.2
Alterations Total	10,847	1,046	536	-4.92	222.1
TOTAL	**15,258**	**1,538**	**733**	**-5**	**299**

7 POLLUTANT EMISSIONS

7.1 Emission Factors

The energy savings listed above will result in reduced emissions of pollutants into the atmosphere. These emissions reductions are based on reduced combustion of coal, oil and natural gas in power plants, and reduced combustion of natural gas on site. Table 48 lists emissions factors for four criteria pollutants (oxides of nitrogen, oxides of sulfur, carbon monoxide, and particulate matter smaller than 2.5 nM) plus CO_2 equivalents as provided by the California Energy Commission.

Table 48 – 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

7.2 Emission Impacts

The emission factors from above were applied to the statewide energy savings derived in this impact analysis. Table 49 lists the pollutant emissions that the 2019 Energy Standard will avoid.

Table 49 – Statewide First-Year Emissions Reductions for the 2019 Energy Standard (tons)

	Savings (tons)				
Measures	**NOx**	**SOx**	**CO**	**PM2.5**	**CO2e**
Indoor Lighting Power Densities	2.11	0.45	4.25	1.34	61,322
Indoor Lighting Manual ON Time-Switch	0.01	0.00	0.01	0.00	183
Indoor Occupant Sensing Light Controls in Restrooms	0.02	0.00	0.04	0.01	566
Outdoor Lighting Controls - Scheduling Controls	0.06	0.01	0.08	0.02	1,088
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold	0.08	0.01	0.11	0.03	1,464
Fan System Power	0.20	0.03	0.34	0.10	4,671
Equipment Efficiency	0.01	0.00	0.01	0.00	178
Waterside Economizers	0.00	0.00	0.01	0.00	77
Transfer Air for Exhaust Air Makeup	0.15	0.00	0.08	0.02	377
Demand Controlled Ventilation for Classrooms	1.21	0.02	0.59	0.12	2,892
Occupant Sensor Ventilation Requirements	1.73	0.08	1.27	0.33	11,617
Cooling Tower Minimum Efficiency	0.00	0.00	0.01	0.00	67
Economizer Fault Detection Diagnostics	0.07	0.00	0.05	0.01	487
Variable Exhaust Flow Control and High Efficiency Fume Hoods	0.19	0.03	0.28	0.08	3,734
Adiabatic Condensers (Option B)	0.02	0.00	0.02	0.01	327
Outdoor Lighting Power Allowance	0.40	0.06	0.58	0.17	7,603
Non-residential New Construction Total	6.26	0.70	7.73	2.27	96,653
Lighting Alterations	-8.81	1.67	9.53	3.92	221,258
Indoor Lighting Manual ON Time-Switch	0.03	0.00	0.04	0.01	549
Outdoor Lighting Controls - Scheduling Controls	0.17	0.02	0.24	0.07	3,197
Outdoor Lighting Controls - Bi-Level, Remove 75 Watt Threshold	0.23	0.03	0.33	0.10	4,300

HVAC Alterations	0.02	0.00	0.04	0.01	464
Non-residential Alterations Total	-8.36	1.73	10.18	4.11	229,767
Non-residential Total	***-2.10***	***2.43***	***17.91***	***6.38***	***326,420***
Single-Family Newly Constructed Buildings and Alterations	69,919	4,422	60,308	16,302	312,062
Multi-Family Newly Constructed Buildings and Alterations	6,846	648	7,558	2,172	45,024
Residential Total	***76,765***	***5,070***	***67,866***	***18,474***	***357,086***
TOTAL	**76,763**	**5,072**	**67,884**	**18,480**	**683,506**

REFERENCES

1. Title 24, 2019 Statewide CASE Reports:
   http://title24stakeholders.com/2019casetopics/

2. Title 24, 2019 Energy Code Staff Supplements:
   http://www.energy.ca.gov/title24/2019standards/rulemaking/documents/code-staff-supplements/index.php

3. Title 24, Part 6, 2019 15-day Language (Multiple CEC Dockets):
   https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-BSTD-02

4. Title 24, Part 6, 2016
   http://www.energy.ca.gov/2015publications/CEC-400-2015-037/CEC-400-2015-037-CMF.pdf

5. Alternative Calculation Method Approval Manual (2019)
   https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=17-BSTD-02

APPENDICES

Appendix 1 – Prototype Model Description

Appendix 2 – Area Weighted LPD Calculation

Appendix 3 – Outdoor LPA Calculation

Appendix 4 – Schedules for Occupancy Based Ventilation Control