CODES AND STANDARDS ENHANCEMENT INITIATIVE (CASE)

Nonresidential Cool Roofs

2013 California Building Energy Efficiency Standards

California Utilities Statewide Codes and Standards Team October 2011

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Table of Contents

Table of Figures

1. Purpose

The proposed revision to the Title 24 cool roof reflectance prescriptive standards for low-sloped nonresidential roofs will bring California's standards up to date with the current state of the market for available cool roofs. This measure proposal seeks to move the prescriptive standard to R_{aged} = 0.67 across all climate zones for most nonresidential buildings. High-rise residential, hotel, and motel building in climate zones 1 and 16 will continue to not have a reflectance standard.

The increase in the prescriptive reflectance level is projected to produce energy savings over the 15 year projected life of a cool roof of between $0.40/ft^2 and $1.35/ft^2, depending on the climate zone, for standard nonresidential buildings.

2. Overview

a. Measure Title	Nonresidential Cool Roof Reflectance Standard
b. Description	This proposal would raise the prescriptive reflectance requirement for nonresidential low-sloped cool roofs from R_{aged} = 0.55 to R_{aged} = 0.67. Climate zones 1 and 16 would now have a reflectance standard, also at R_{aged} = 0.67 in climate zones 2-15. For high-rise residential, hotel, and motel occupancies, the reflectance standard would be set at R_{aged} = 0.67 as well; those occupancies would continue to not have a reflectance standard in climate zones 1 and 16. There will be no change to the existing exceptions to the reflectance standards or to the conditions under which the reflectance standard must be complied with for roofing alterations and additions. The reflectance standard for steep-sloped roofs will be changed as well to match the new reflectance standard for residential structures.
c. Type of Change	The proposed code change is a prescriptive code measure. The change will be implemented primarily through the prescriptive levels set forth in Tables 143-A and 143-B and associated text in Sections 143 and 149.
d. Energy Benefits	The energy benefits below reflect savings based on the prototype building as described in the Methodology section, where more detail is provided. Briefly, the prototype building is a 130' X 130', single-floor energy model, with Title 24-2008 minimally-compliant walls, roof insulation, and HVAC. Internal loads and schedules were taken from the Title 24-2008 ACM for nonresidential and high-rise residential occupancies. Energy use was modeled with roofing reflectance levels ranging from 0.08 to 0.87, including models at 0.55 and 0.67. All models used an emittance of 0.85, in accordance with the default assumptions of the NACM. The model used updated weather and TDV files.

CZ1	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	12,496	1.66	-78.4	255,014.9
Savings per square foot	0.74	9.8E-05	-4.6E-03	15.1
CZ2	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	3,832	0.87	-8.4	90,279.6
Savings per square foot	0.23	5.1E-05	-5.0E-04	5.3

	CZ3	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	3,319	0.68	-3.3	75,778.0	
	Savings per square foot	0.20	4.0E-05	-2.0E-04	4.5	
	CZ4	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	3,866	0.85	-2.3	91,009.4	
	Savings per square foot	0.23	5.0E-05	-1.3E-04	5.4	
	CZ5	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	4,599	1.05	-5.8	108,913.7	
	Savings per square foot	0.27	6.2E-05	-3.4E-04	6.4	
	CZ6	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	7,948	1.95	-3.7	195,781.1	
	Savings per square foot	0.47	1.2E-04	-2.2E-04	11.6	
	CZ7	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	6,693	1.56	-0.5	164,323.0	
	Savings per square foot	0.40	9.2E-05	-2.8E-05	9.7	

	CZ8	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	7,523	1.81	-1.0	183,923.9	
	Savings per square foot	0.45	1.1E-04	-6.2E-05	10.9	
	CZ9	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	3,582	0.91	-0.2	87,711.0	
	Savings per square foot	0.21	5.4E-05	-1.1E-05	5.2	
	CZ10	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	4,382	0.93	-0.9	102,212.6	
	Savings per square foot	0.26	5.5E-05	-5.6E-05	6.0	
	CZ11	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	3,893	0.88	-11.7	91,824.5	
	Savings per square foot	0.23	5.2E-05	-6.9E-04	5.4	
	CZ12	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**	
	Per Unit Measure	NA	NA	NA	NA	
	Per Prototype Building	3,871	0.90	-10.0	92,014.1	
	Savings per square foot	0.23	5.3E-05	-5.9E-04	5.4	

	CZ13	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
	Per Unit Measure	NA	NA	NA	NA
	Per Prototype Building	4,093	0.92	-12.0	95,615.8
	Savings per square foot	0.24	5.4E-05	-7.1E-04	5.7
	CZ14	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
	Per Unit Measure	NA	NA	NA	NA
	Per Prototype Building	4,627	1.00	-10.3	107,643.6
	Savings per square foot	0.27	5.9E-05	-6.1E-04	6.4
	CZ15	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
	Per Unit Measure	NA	NA	NA	NA
	Per Prototype Building	5,157	0.97	-0.3	117,595.7
	Savings per square foot	0.31	5.7E-05	-1.7E-05	7.0
	CZ16	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
	Per Unit Measure	NA	NA	NA	NA
	Per Prototype Building	15,061	3.26	-142.7	328,191.1
	Savings per square foot	0.89	1.9E-04	-8.4E-03	19.4
	CZ2 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
	Per Unit Measure	NA	NA	NA	NA
	Per Prototype Building	6,049	1.99	-340.3	104,308.8
	Savings per square foot	0.36	1.2E-04	-2.0E-02	6.2

CZ3 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,813	2.46	-385.7	123,761.2
Savings per square foot	0.40	1.5E-04	-2.3E-02	7.3
CZ4 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,527	1.78	-248.5	122,723.3
Savings per square foot	0.39	1.1E-04	-1.5E-02	7.3
CZ5 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,766	2.39	-419.6	111,755.5
Savings per square foot	0.40	1.4E-04	-2.5E-02	6.6
CZ6 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	9,982	2.87	-165.6	226,861.6
Savings per square foot	0.59	1.7E-04	-9.8E-03	13.4
CZ7 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	9,238	2.62	-91.7	224,514.1
Savings per square foot	0.55	1.6E-04	-5.4E-03	13.3

CZ8 -Hi-Rise Res, Motel	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	6,884	1.67	-100.8	152,614.3
Savings per square foot	0.41	9.9E-05	-6.0E-03	9.0

CZ9 -Hi-Rise Res, Motel	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	7,661	1.90	-144.3	163,495.3
Savings per square foot	0.45	1.1E-04	-8.5E-03	9.7

CZ10 -Hi-Rise Res, Motel	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,027	0.52	-56.3	40,244.3
Savings per square foot	0.12	3.1E-05	-3.3E-03	2.4

CZ11 -Hi-Rise Res, Motel	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,158	0.48	-86.0	36,557.3
Savings per square foot	0.13	2.8E-05	-5.1E-03	2.2

CZ12 -Hi-Rise Res, Motel	Electricity Savings (kWh/yr)	Demand Savings (kW)	Natural Gas Savings (Therm/yr)	TDV Savings
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	7,162	1.78	-296.9	125,618.9
Savings per square foot	0.42	1.1E-04	-1.8E-02	7.4

CZ13 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,327	0.48	-79.3	40,234.8
Savings per square foot	0.14	2.8E-05	-4.7E-03	2.4

CZ14 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,263	0.50	-100.6	35,514.7
Savings per square foot	0.13	3.0E-05	-6.0E-03	2.1

CZ15 -Hi-Rise Res, Motel	**Electricity Savings (kWh/yr)**	**Demand Savings (kW)**	**Natural Gas Savings (Therm/yr)**	**TDV Savings**
Per Unit Measure	NA	NA	NA	NA
Per Prototype Building	2,669	0.49	-24.7	55,750.6
Savings per square foot	0.16	2.9E-05	-1.5E-03	3.3

Statewide Savings Estimates
The savings from this/these measures results in the following statewide first year energy savings. The present value savings of the measure over the 15 year life-cycle is also shown.

1. Non-Residential, New Construction

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.354	0.26	-1.63	$924,517
2	3.383	0.78	-1.69	$3,102,017
3	13.869	2.77	-2.77	$10,797,098
4	8.374	1.93	-1.09	$7,822,881
5	1.626	0.44	-0.55	$1,800,195
6	13.027	6.12	-2.87	$26,142,997

7	16.973	6.79	-0.48	$28,481,558
8	15.490	6.97	-0.96	$29,210,229
9	30.579	6.42	-0.34	$27,508,549
10	9.012	2.34	-0.50	$9,354,791
11	4.684	1.08	-3.23	$4,375,557
12	23.988	5.52	-14.15	$22,409,517
13	10.720	2.57	-7.61	$10,570,819
14	1.975	0.53	-1.21	$2,187,182
15	0.858	0.27	-0.01	$1,038,930
16	2.506	2.23	-21.05	$8,411,461
Total	157.418	47.02	-60.15	$194,138,300

2. High-Rise Residential (incl. hotels and motels), new construction

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.034	0.00	0.00	0
2	0.290	0.10	-5.79	$310,747
3	0.791	0.32	-18.20	$999,204
4	0.769	0.30	-11.54	$971,695
5	0.149	0.06	-3.73	$170,576
6	0.500	0.30	-4.90	$1,159,957
7	0.672	0.37	-3.63	$1,545,852
8	0.943	0.39	-5.66	$1,468,303
9	2.191	0.99	-18.62	$3,676,683
10	0.330	0.04	-1.09	$137,187
11	0.166	0.02	-0.84	$63,023
12	1.337	0.56	-24.07	$1,712,250
13	0.493	0.07	-2.32	$204,859
14	0.190	0.02	-1.14	$68,867
15	0.044	0.01	-0.07	$24,912
16	0.198	0.00	0.00	$0
Total	9.098	3.54	-101.61	$12,514,113

3. Total New Construction Statewide Impact

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.034	0.26	-1.63	$924,517
2	0.290	0.88	-7.49	$3,412,764
3	0.791	3.09	-20.97	$11,796,302
4	0.769	2.23	-12.63	$8,794,576
5	0.149	0.50	-4.29	$1,970,771
6	0.500	6.42	-7.77	$27,302,954
7	0.672	7.16	-4.10	$30,027,410
8	0.943	7.36	-6.62	$30,678,532
9	2.191	7.41	-18.96	$31,185,232
10	0.330	2.38	-1.60	$9,491,978
11	0.166	1.10	-4.08	$4,438,580
12	1.337	6.08	-38.23	$24,121,767
13	0.493	2.64	-9.93	$10,775,679
14	0.190	0.56	-2.34	$2,256,049
15	0.044	0.27	-0.08	$1,063,842
16	0.198	2.23	-21.05	$8,411,461
Total	9.098	50.56	-161.76	$206,652,413

4. Alterations (Re-Roofs) Nonresidential Statewide Impact

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	1.069	0.79	-4.92	$2,793,833
2	9.721	2.24	-4.86	$8,913,507
3	45.454	9.09	-9.09	$35,386,225
4	22.967	5.28	-2.99	$21,455,630
5	4.459	1.20	-1.52	$4,937,353
6	44.457	20.90	-9.78	$89,217,293
7	23.793	9.52	-0.67	$39,926,441
8	58.880	26.50	-3.65	$111,030,016

9	51.917	10.90	-0.57	$46,704,437
10	40.560	10.55	-2.27	$42,100,944
11	8.789	2.02	-6.06	$8,210,642
12	47.512	10.93	-28.03	$44,385,369
13	17.912	4.30	-12.72	$17,663,162
14	7.514	2.03	-4.58	$8,320,026
15	6.728	2.09	-0.11	$8,147,285
16	6.215	5.53	-52.21	$20,859,100
Total	397.948	123.85	-144.03	$510,051,264

Table 5: Alterations, High-Rise Residential (incl. hotels, motels)

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	0.078	0.00	0.00	0
2	0.606	0.22	-12.12	$649,968
3	2.827	1.13	-65.02	$3,570,404
4	1.397	0.54	-20.95	$1,763,804
5	0.271	0.11	-6.78	$309,626
6	1.961	1.16	-19.22	$4,546,195
7	1.862	1.02	-10.05	$4,284,169
8	2.562	1.05	-15.37	$3,989,712
9	2.232	1.00	-18.97	$3,745,468
10	1.904	0.23	-6.28	$790,336
11	0.339	0.04	-1.73	$129,185
12	2.215	0.93	-39.87	$2,835,304
13	0.695	0.10	-3.27	$288,712
14	0.306	0.04	-1.84	$111,176
15	0.339	0.05	-0.51	$193,459
16	0.261	0.00	0.00	$0
Total	19.855	7.63	-221.98	$27,207,518

6. Total Impact, Alterations

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	1.147	0.79	-4.92	$2,793,833
2	10.327	2.45	-16.98	$9,563,474
3	48.282	10.22	-74.12	$38,956,629
4	24.363	5.83	-23.94	$23,219,434
5	4.730	1.31	-8.30	$5,246,979
6	46.419	22.05	-29.00	$93,763,488
7	25.655	10.54	-10.72	$44,210,610
8	61.442	27.55	-19.03	$115,019,728
9	54.149	11.91	-19.54	$50,449,906
10	42.463	10.77	-8.55	$42,891,280
11	9.128	2.07	-7.80	$8,339,827
12	49.726	11.86	-67.90	$47,220,673
13	18.607	4.40	-15.99	$17,951,874
14	7.820	2.07	-6.42	$8,431,202
15	7.067	2.14	-0.62	$8,340,744
16	6.476	5.53	-52.21	$20,859,100
Total	417.804	131.49	-366.01	$537,258,781

7. Total Statewide Impact, New Construction and Alterations

CZ	ft2,x10^6	Elec Savings, GWh	Nat Gas Savings, 1000s Therm	PV Savings, $
1	1.536	1.053	-6.548	$3,718,349
2	14.000	3.336	-24.466	$12,976,238
3	62.942	13.312	-95.087	$50,752,931
4	33.507	8.053	-36.565	$32,014,010
5	6.506	1.811	-12.583	$7,217,750
6	59.946	28.470	-36.769	$121,066,442
7	43.299	17.700	-14.824	$74,238,020
8	77.876	34.904	-25.644	$145,698,260
9	86.918	19.314	-38.503	$81,635,138
10	51.806	13.157	-10.148	$52,383,257

	11	13.978	3.164	-11.872	$12,778,407	
	12	75.052	17.937	-106.125	$71,342,440	
	13	29.821	7.038	-25.916	$28,727,552	
	14	9.985	2.627	-8.762	$10,687,251	
	15	7.968	2.413	-0.703	$9,404,587	
	16	9.180	7.762	-73.259	$29,270,561	
	Total	584.320	182.052	-527.772	$743,911,194	
e. Non-Energy Benefits	Increasing the use of cool roofs will help to reduce the heat island effect by absorbing less heat on roof surfaces.					

f. Environmental Impact

There are no known significant environmental impacts associated with the proposed code change.

Material Increase (I), Decrease (D), or No Change (NC): (All units are lbs/year)

	Mercury	Lead	Copper	Steel	Plastic	Others (Titanium dioxide)
Per Unit Measure[1]	NC	NC	NC	NC	NA	0.0072 lb / ft2
Per Prototype Building[2]	NC	NC	NC	NC	NA	121.7 lb

The titanium dioxide estimate assumes an increase of up to 6% in TiO_2 by weight, from a standard product formulation of 5% to 10% TiO_2 by weight. This assumes a product coverage of 12 lb/100ft^2 (approximately 1 gallon/100ft^2). Crude titanium dioxide is first converted to titanium tetrachloride and re-oxidized under very high temperatures.

Water Consumption:

	On-Site (Not at the Powerplant) Water Savings (or Increase) (Gallons/Year)
Per Unit Measure[1]	NC
Per Prototype Building[2]	NC

Water Quality Impacts:

	Mineralization (calcium, boron, and salts	Algae or Bacterial Buildup	Corrosives as a Result of PH Change	Others
Impact (I, D, or NC)	NC	NC	NC	NC
Reasons	NC	NC	NC	NC

g. Technology Measures	If the measure requires or encourages a particular technology, address the following, otherwise skip this section. **Measure Availability:** Approximately half of all field applied coatings (134 of 248) and single-ply thermoplastic membranes (22 of 57) that currently meet the nonresidential low-sloped standard of R_{aged} = 0.55 will meet the new standard of R_{aged} = 0.67. Of the products currently meeting the low slope reflectance standard of R_{aged} = 0.55, the average R_{aged} for field applied coatings in 0.67 and the average R_{aged} for single-ply thermoplastics is 0.67. R_{aged} = 0.67 is readily available in the market. Carlisle Syntec, Cooley, Dow Roofing, Firestone, Johns Manville, Mule-Hide, Tremco, Versico and other manufacturers have single-ply membrane products with an aged reflectance of 0.67. **Useful Life, Persistence, and Maintenance:** Most cool roof products are projected to have a useful life of 10-15 years, although some can last longer. The performance of a high reflectance cool roof will be improved through regular washing to remove dirt accumulation that can darken the surface. Some cool roof coatings may need recoating after 7 to 8 years of operation.
h. Performance Verification of the Proposed Measure	There are no changes proposed to the existing performance verification process using CRRC ratings. Three-year aged reflectance as measured by CRRC procedures is used for performance verification.

i. Cost Effectiveness

a	b	c		e		f	g
Measure Name	Measure Life (Years)	Additional Costs[1]– Current Measure Costs (Relative to Basecase) ($)		PV of Additional[3] Maintenance Costs (Savings) (Relative to Basecase) (PV$)		PV of[4] Energy Cost Savings – Per Proto Building (PV$)	LCC Per Prototype Building ($)
		Per Unit	Per Proto Building	Per Unit	Per Proto Building		(c+e)-f Based on Current Costs
CZ1	15	$0.50	$8,450.00	NA	NA	$22,696	($14,246)
CZ2	15	$0.00	$0.00	NA	NA	$9,946	($9,946)
CZ3	15	$0.00	$0.00	NA	NA	$6,744	($6,744)
CZ4	15	$0.00	$0.00	NA	NA	$8,100	($8,100)
CZ5	15	$0.00	$0.00	NA	NA	$9,693	($9,693)
CZ6	15	$0.00	$0.00	NA	NA	$17,424	($17,424)
CZ7	15	$0.00	$0.00	NA	NA	$14,624	($14,624)
CZ8	15	$0.00	$0.00	NA	NA	$16,369	($16,369)
CZ9	15	$0.00	$0.00	NA	NA	$7,806	($7,806)
CZ10	15	$0.00	$0.00	NA	NA	$9,097	($9,097)
CZ11	15	$0.00	$0.00	NA	NA	$8,172	($8,172)
CZ12	15	$0.00	$0.00	NA	NA	$8,189	($8,189)
CZ13	15	$0.00	$0.00	NA	NA	$8,509	($8,509)
CZ14	15	$0.00	$0.00	NA	NA	$9,580	($9,580)
CZ15	15	$0.00	$0.00	NA	NA	$10,466	($10,466)
CZ16	15	$0.50	$8,450.00	NA	NA	$29,208	($20,758)
CZ1 - HRR	15	$0.50	$8,450.00	NA	NA	($1,700)	$10,150
CZ2 - HRR	15	$0.50	$8,450.00	NA	NA	$9,283	($833)
CZ3 - HRR	15	$0.50	$8,450.00	NA	NA	$11,014	($2,564)
CZ4 - HRR	15	$0.50	$8,450.00	NA	NA	$10,922	($2,472)
CZ5 - HRR	15	$0.50	$8,450.00	NA	NA	$9,946	($1,496)
CZ6 - HRR	15	$0.50	$8,450.00	NA	NA	$20,190	($11,740)
CZ7 - HRR	15	$0.50	$8,450.00	NA	NA	$19,981	($11,531)
CZ8 - HRR	15	$0.50	$8,450.00	NA	NA	$13,582	($5,132)
CZ9 - HRR	15	$0.50	$8,450.00	NA	NA	$14,551	($6,101)
CZ10 - HRR	15	$0.00	$0.00	NA	NA	$3,582	($3,582)
CZ11 - HRR	15	$0.00	$0.00	NA	NA	$3,253	($3,253)
CZ12 - HRR	15	$0.50	$8,450.00	NA	NA	$11,180	($2,730)
CZ13 - HRR	15	$0.00	$0.00	NA	NA	$3,581	($3,581)
CZ14 - HRR	15	$0.00	$0.00	NA	NA	$3,161	($3,161)
CZ15 - HRR	15	$0.00	$0.00	NA	NA	$4,962	($4,962)
CZ16 - HRR	15	$0.50	$8,450.00	NA	NA	$6,902	$1,548

a	b	c	d	e	f	g
Measure Name	Measure Life (Years)	Additional Costs[1]– Current Measure Costs	Additional Cost[2]– Post-Adoption Measure Costs	PV of Additional[3] Maintenance Costs (Savings)	PV of[4] Energy Cost	LCC Per Prototype Building ($)

j. Analysis Tools	No changes are needed to the performance analysis tools other than to update the Table 143-A and Table 143-B reflectance values for the reference design.
k. Relationship to Other Measures	This measure will interact, by way of available tradeoffs, with the new mandatory minimum reflectance levels being proposed by the California Energy Commission.

3. Methodology

The revised reflectance levels for low-sloped nonresidential cool roofs were developed by looking at a combination of factors, focused on market availability, potential energy savings, and product costs. The Cool Roof Rating Council website was used to assess product availability, followed by calls to roofing supply distributors throughout California to determine what roofing products were currently available for sale and at what price per square foot. Our research indicated that with a significant number of products now on the market with aged CRRC ratings, the market is ready to move to a standard of R_{aged} = 0.67 by 2014.

For those building types in climate zones that do not presently have a low-sloped cool roof standard, existing studies and RS Means were used to assess the likely price premium of moving from a dark roof to a cool roof. Those studies include:

Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements, by Lawrence Berkeley National Lab for Pacific Gas & Electric for the 2005 Title 24 code update process

Guidelines for Selecting Cool Roofs, Department of Energy, 2010

Building Construction Cost Data, RS Means, 2010

A single story, 16,900 ft^2 office building was modeled using EnergyPlus and the new Title 24 2013 TDV and weather files. Roof reflectance levels from .08 to 0.87 were modeled, including models at reflectance levels of 0.55 and 0.67. The buildings used standard assumptions from the NACM and code minimum attributes for HVAC and insulation, varying the values by climate zone as set forth by Title 24. Two major categories of buildings were analyzed, a standard office occupancy and a high-rise residential occupancy.

	Occupancy Type (Residential, Retail, Office, etc)	Area (Square Feet)	Number of Stories	Other Notes
Prototype 1	Office	16,900	1	
Prototype 2	High-rise res	16,900	1	

Figure 1. Prototype Key Characteristics

3.1 Statewide Savings Estimates

The statewide energy savings associated with the proposed measures will be calculated by multiplying the energy savings per square foot with the statewide estimate of new construction in 2014. Details on the method and data source of the nonresidential construction forecast are in section 7.2.

4. Analysis and Results

4.1 Product Availability

Looking first to the question of product availability, the research showed that there are a sufficient number of products on the market at or near the R_{aged} = 0.67 level to support the adoption of that standard for enforcement starting in 2014. There are over 200 products listed on the CRRC database that meet the proposed R_{aged} = 0.67 standard. More products are likely coming on the market before the proposed standard would take effect in 2014.

Analyzing the availability of single-ply thermoplastics (TPO and PVC) as well as field applied coatings using the CRRC database, the following availability information summarizes the state of the market. For those two product types, cool roofs over R_{aged} = 0.55 are converging on an average R_{aged} of 0.67.

	Average R_{aged} of products with $R_{aged} \geq 0.55$	**Products with $R_{aged} \geq 0.67$**		**Products with $R_{aged} \geq 0.55$**
Field-applied coatings	0.70	134	of	248
Single-ply Thermoplastics	0.67	22	of	57

Figure 2: Product Availability Summary

Stakeholders raised concerns after the June 2011 workshop that the requirement of an aged reflectance of 0.67 would eliminate over a third of the products on the market. They expressed particular concern over the impact the proposed change would have on built-up roofing products that are widely used for low-sloped roofing. In particular, re-roofing, which by some estimates accounts for approximately 70% of the roofing market, allows for less flexibility in selecting roofing products. Only a couple of BUR products meet the current 0.55 aged reflectance standard, and none would meet the proposed standard.

To address this issue, AEC developed a simplified insulation tradeoff procedure for re-roofing and alterations.

4.2 Cool Roof Product Costs, R_{aged} = 0.55 to R_{aged} = 0.67

With commercial low-sloped cool roofs products moving toward average R_{aged} values of 0.67, this proposed measure actually has a measure cost that is less expensive than the historical standard. Within the cool roof market, many of the products with R_{aged} values close to 0.55 are actually tinted versions of the more conventional white versions of the same product. The products with the darker reflectance can, therefore, actually have a higher initial cost while also driving higher energy costs. For field-applied coatings, costs are flat in relation to reflectance throughout the range from R_{aged} = 0.67 to R_{aged} = 0.80. Below the level of R_{aged} = 0.67 prices appear to actually increase.

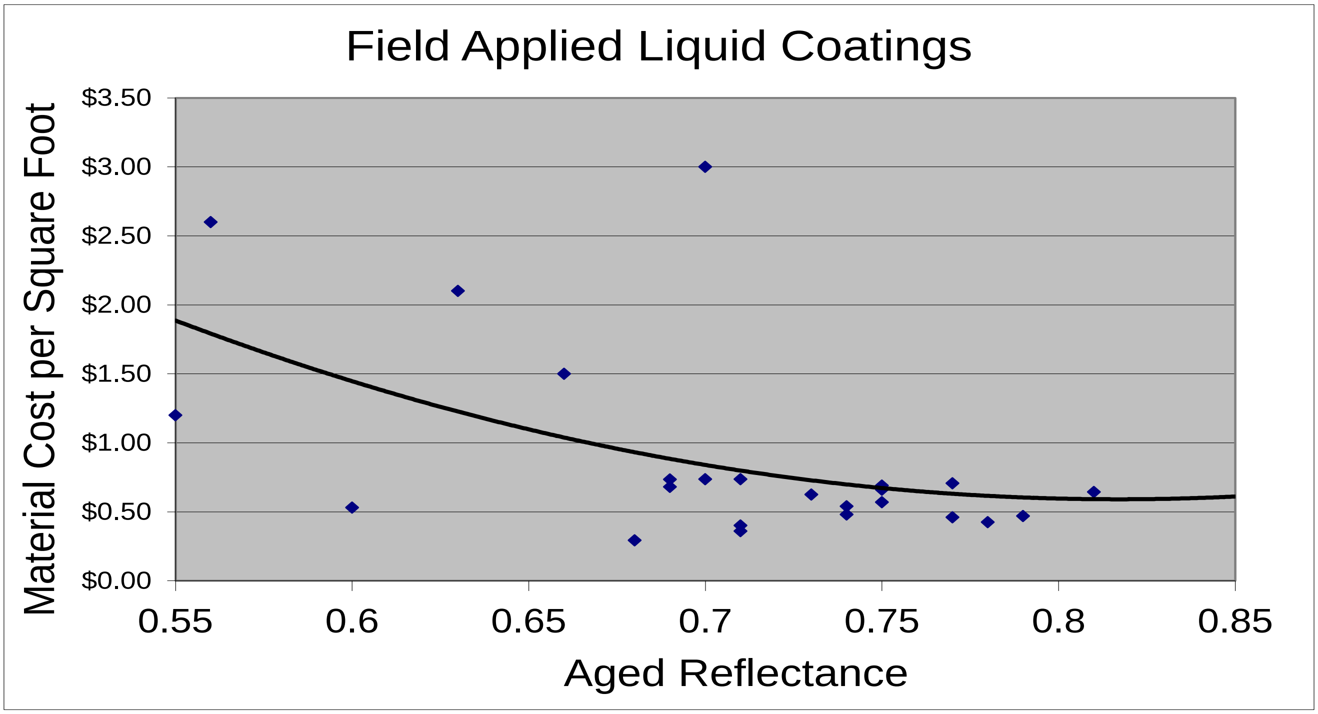

Figure 3. Cost of Field Applied Coatings

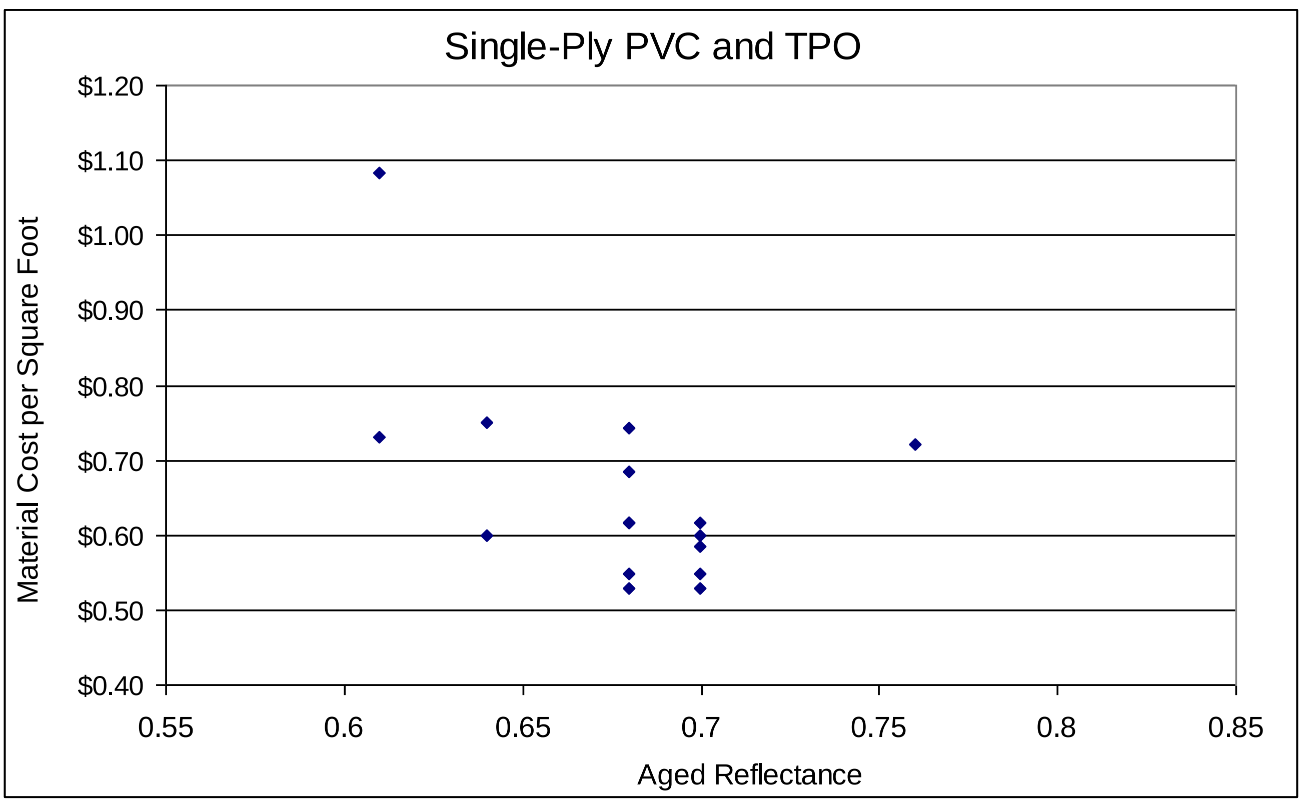

Figure 4. Material Cost of Single-Ply Membranes

For single-ply membranes, the lowest cost products appear to be in the R_{aged} = 0.67 range.

An additional comparison is to compare the installed cost of a built-up roof with a cool cap sheet that meets the 2008 Title 24 cool roof requirements (ρ=0.55) with the installed cost of a single-ply roof that meets the new proposed requirement (ρ=0.67). This incremental installed costs, from cost surveys, is estimated at $0.30/ft^2. This number will be used as a conservative estimate for the incremental cost.

4.3 Cool Roof Product Costs, from No Standard to R_{aged} = 0.67

For standard nonresidential buildings in climate zones 1 and 16 and high-rise residential, hotel, motel buildings in climate zones 1-9, 12, and 16 for, there is no existing cool roof standard. For those instances, the baseline against which a shift to an R_{aged} = 0.67 standard should be evaluated is a dark roof.

For this study cost surveys were used to determine product cost for single ply roofing and for field-applied coatings. Additional cost surveys developed with ARMA were performed to determine:

1. Installed cost of built-up roofs (BURs), both cool and non-cool options
2. Installed cost of single-ply roofs
3. Installed cost of modified bitumen roofs
4. Costs of factory-applied and field-applied coatings
5. Costs to recoat
6. Re-roof costs if replaced with a BUR
7. Re-roof costs if replaced with a cool BUR
8. Re-roof costs if replaced with a single ply roof

A cost survey was sent to roofing contractors throughout the state, covering the San Francisco Bay Area, the Sacramento Valley, Los Angeles, San Diego, Fresno and San Bernardino areas. Only a fraction of those contacted agreed to provide feedback on the survey, and only a few survey responses were received.

The incremental cost to make a non-cool roof cool by adding a cool cap sheet to a built-up roof is estimated at $0.54/ft^2. The incremental installed cost of a roofing system with a reflectance that meets the proposed requirement over a roofing system that meets the current roof reflectance requirement of 0.55 is $0.30/ft^2. Therefore, the incremental cost to go from a non-cool roof to a cool roof that meets the new proposed requirement is $0.84/ft^2.

Some survey respondents indicated that installing a single-ply roof on a re-roof can actually be less expensive than a built-up roof with a cool cap sheet. The higher of the incremental costs were used as the cost estimate as a conservative assumption.

4.4 Energy Savings and Cost Effectiveness for Nonresidential Buildings

Using energy models for a standard nonresidential buildings, the proposed measure shows 15 year energy savings of between $0.40/ft^2 and $1.03/ft^2 in climate zones 2 through 15 that presently have a standard of R_{aged} = 0.55. In those climate zones, because the additional cost is $0.30/ft^2, the proposed measure is cost effective.

In climate zones 1 and 16, where there is not presently a cool roof standard, the energy models show projected 15 year energy savings of \$1.34/ft^2 and \$1.73/ft^2. With an estimated measure cost of \$0.84/ft^2 to move from no standard to R_{aged} = 0.67, the proposed measure is cost effective in those climate zones as well. Due to product availability, an aged reflectance of 0.67 makes a more appropriate prescriptive standard for this code cycle, the 2013 Standards update.

The cool roof reflectance standard should, therefore, be moved to R_{aged} = 0.67 for all climate zones for standard nonresidential buildings.

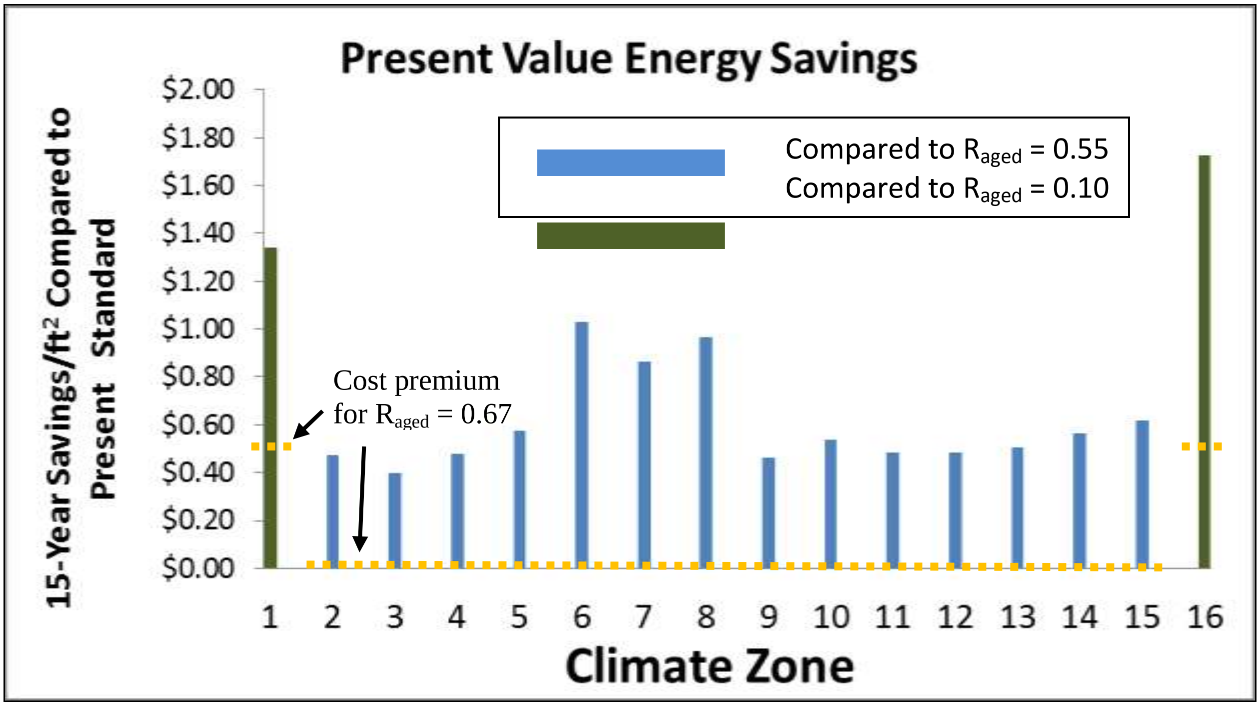

Figure 5. Life-Cycle Energy Savings by Climate Zone, Nonresidential

4.5 Energy Savings and Cost Effectiveness for High-Rise Residential, Hotel, and Motel Buildings

Using energy models for a high-rise residential building, the proposed measure shows 15 year energy savings of between \$0.19/ft^2 and \$0.29/ft^2 in climate zones 10, 11, 13, 14, and 15 that presently have a standard of R_{aged} = 0.55. In those climate zones, because there is no additional cost for the proposed measure, the proposed measure is cost effective.

For the climate zones where there is not presently a cool roof standard, the energy models show projected 15 year energy savings in climate zones 2-9 and 12 for R_{aged} = 0.67 that exceed the estimated measure cost of \$0.50/ft^2.

The cool roof reflectance standard should, therefore, be moved to R_{aged} = 0.67 for climate zones 2-15 for high-rise residential, hotel, and motel buildings.

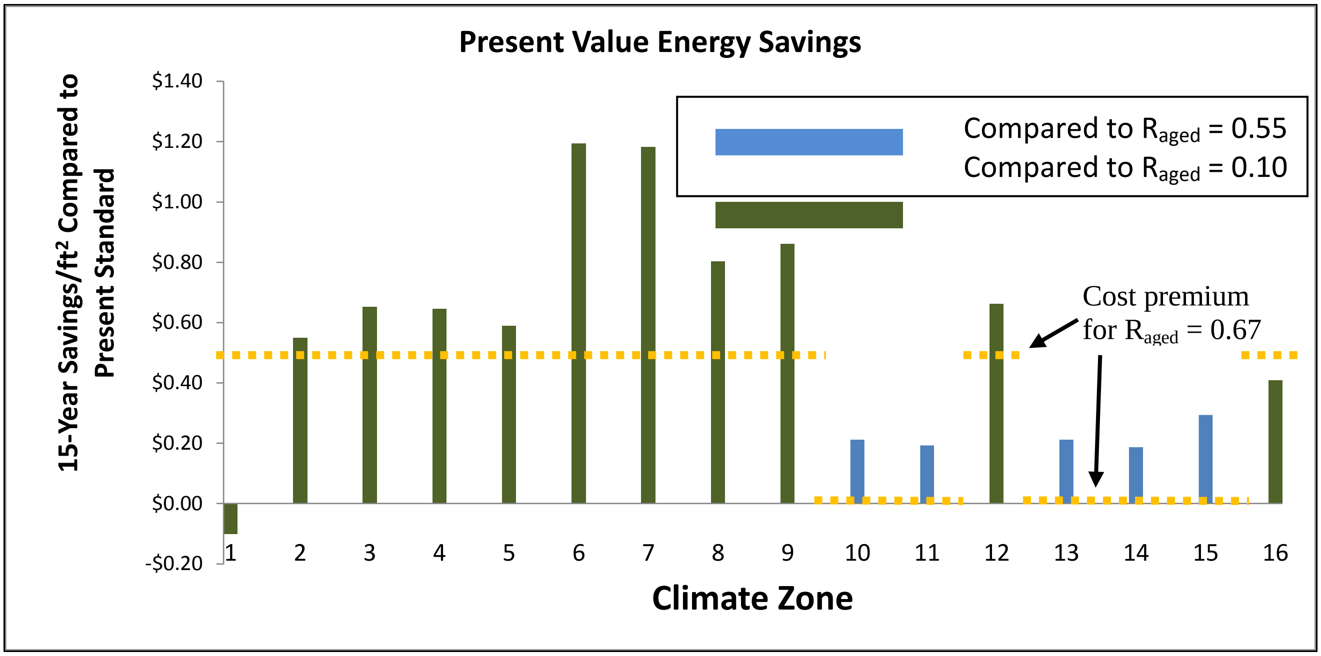

Figure 6. Life-Cycle Energy Savings by Climate Zone, High-Rise Residential

4.6 Insulation Tradeoff for Roof Alterations

The initial proposal would require the replacement of a roof with a roofing system with an aged reflectance of 0.67, matching the prescriptive requirement. After meetings with stakeholders, AEC and CEC staff thought that the limitations of available reflective products for re-roofs created the need for more flexibility in alterations. The proposed requirement of 0.63 aged reflectance applies to alterations.

In response to stakeholders' concerns about the lack of product options that can be used in re-roofing, AEC developed a simplified tradeoff table that can be used with alterations. As the baseline, AEC assumed a lower level of insulation than is required for new construction. The amount of insulation assumed is the values in Section 149 of the 2008 Title 24 Standards, R-8 of continuous insulation (U=0.081) for temperate climates and R-14 of continuous insulation (U=0.055) for inland and mountain climates. Parametric energy simulations were run by varying the roof envelope assembly between over five insulation levels corresponding from 0.01 to 0.081. A linear correlation was developed between TDV energy use and U-factor. For each set of insulation runs, reflectance levels were varied in increments of 0.05 down to a minimum of 0.1. The same set of simulations was performed for the high-rise residential occupancy.

Refl.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**Avg**
0.67																	
0.6	3.6	3.2	3.3	2.5	3.6	2.8	3.3	2.5	2.2	2.9	2.5	2.7	2.5	2.7	2.2	2.6	**2.8**
0.55	6.2	5.4	5.5	4.2	6.1	4.6	5.4	4.2	3.5	5.0	4.2	4.5	4.1	4.5	3.8	4.4	**4.7**

0.5	8.7	7.5	7.6	5.8	8.4	6.3	7.5	5.8	5.1	6.9	5.8	6.2	5.6	6.2	5.2	6.2	**6.6**
0.45	11.3	9.4	9.6	7.3	10.8	8.2	9.5	7.4	6.5	8.7	7.3	7.9	7.1	7.9	6.5	7.9	**8.3**
0.4	13.8	11.2	11.6	8.8	13.0	9.8	11.4	8.8	7.7	10.4	8.8	9.5	8.5	9.4	7.9	9.6	**10.0**
0.3	18.8	14.6	15.1	11.5	17.1	12.8	15.0	11.3	10.0	13.3	11.6	12.3	11.2	12.3	10.4	12.8	**13.1**
0.2	23.6	17.5	18.4	13.9	20.8	15.5	18.2	13.8	12.2	16.1	14.1	14.9	13.6	15.0	12.6	15.8	**16.0**
0.1	28.1	20.2	21.1	16.1	23.7	18.0	21.1	16.2	14.0	18.5	16.5	17.3	15.9	17.8	14.8	18.6	**18.6**

Figure 7. Insulation Tradeoff Analysis Results, Non-Residential Occupancy

Refl	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	**Avg**
0.67																	
0.6	-0.1	2.0	1.9	2.2	1.9	2.7	3.2	2.7	2.4	2.2	1.8	1.9	1.9	1.8	2.0	1.4	2.0
0.55	0.0	3.3	3.3	3.6	3.1	4.5	5.2	4.4	3.8	3.7	2.9	3.1	3.0	2.9	3.2	2.3	3.3
0.5	0.2	4.5	4.5	5.0	4.3	6.2	7.2	6.0	5.2	5.0	3.9	4.3	4.2	4.0	4.4	3.2	4.5
0.45	0.4	5.6	5.7	6.3	5.5	7.7	9.0	7.5	6.5	6.2	5.0	5.3	5.2	5.1	5.6	4.0	5.7
0.4	0.7	6.7	6.8	7.5	6.6	9.1	10.6	8.9	7.8	7.4	5.9	6.4	6.2	6.0	6.6	4.8	6.8
0.3	1.4	8.7	8.9	9.7	8.6	11.8	13.7	11.5	10.0	9.6	7.7	8.3	8.1	7.9	8.6	6.3	8.8
0.2	2.1	10.5	10.8	11.7	10.5	14.1	16.4	13.8	12.1	11.6	9.4	10.1	9.8	9.6	10.5	7.6	10.7
0.1	2.9	12.1	12.5	13.5	12.1	16.2	18.9	15.8	13.9	13.4	10.9	11.7	11.4	11.1	12.2	8.9	12.3

Figure 8. Insulation Tradeoff Analysis Results for High-Rise Residential Occupancy

To establish an easy-to-use tradeoff, AEC and CEC staff decided to average results from all climates to develop a single required insulation level, regardless of climate. Also, one table was developed that would apply to alterations for both non-residential and high-rise residential occupancies. A lower aged reflectance limit of 0.25 is used to promote products with some level of reflective properties. The results are shown below.

Aged Reflectance Greater Than	Required Continuous Insulation
0.60	R-3
0.55	R-4
0.50	R-6
0.45	R-8
0.40	R-10
0.30	R-13
0.25	R-15

Figure 9. Proposed Insulation Tradeoff Table for Alterations

This tradeoff table would only apply to re-roofs and alterations, as covered under Section 149 of the Title 24 Standards. New construction projects can use the performance approach to demonstrate compliance. As there is no mandatory reflectance requirement, the California Title 24 Part 6 efficiency code does not exclude any roofing products.

4.7 No Changes to the Exceptions for the Cool Roof Requirements

At present, there is no proposal to adjust the exceptions to Section 143(a)1. of the energy code. Even through the reflectance standard is being raised to R_{aged} = 0.67from R_{aged} = 0.55, a ballasted roof of 25 lbs/ft^2 will still be considered to provide an equivalent amount of energy benefits for the building.

4.8 Statewide Savings Estimates

The total energy savings potential for this measure for new construction for non-residential buildings (157.42 million square feet) is 47.02 GWh, -60,150 therm (net gas increase). Applying the CEC conversions for TDV energy, this amounts to a present value cost savings of $194,138,300 over the 15-year measure life.

The total energy savings potential for this measure for new construction for high-rise residential buildings and hotels (9.1 million square feet) is 3.54 GWh, -101,610 therm (net gas increase). Applying the CEC conversions for TDV energy, this amounts to a present value cost savings of $12,514,113 over the 15-year measure life.

The market for alterations (re-roofs) is approximately 70% of the total roofing market. The total statewide impact, as outlined in the Overview section, is an annual reduction of 182.6 GWh, an increase in heating energy equivalent to -528,000 therm, and a present value savings of $743.9 million over the 15-year measure life.

5. Recommended Language for the Standards Document, ACM Manuals, and the Reference Appendices

5.1 New Construction and Additions

The proposed change in nonresidential low-sloped reflectance standards will be implemented through Section 143 of the code. The low-sloped reflectance standard in Tables 143-A and Table 143-B will be revised as follows for aged reflectance levels:

Climate Zone:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
143-A Nonres	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
143-B High-Rise	NR	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	NR

Section 143(a)1.a.i. shall be amended to read, "Nonresidential buildings with low-sloped roofs ~~in climate zones 2-15~~ shall have a minimum 3-year aged solar reflectance of ~~0.55~~ 0.67 and a minimum thermal emittance of 0.75, or a minimum aged SRI of ~~64~~ 78."
Section 143(a)1.a.iii. shall be amended to read, "High-rise residential buildings and hotels and motels with low-sloped roofs in climate zones ~~10, 11, 13,14, and 15~~ 2-15shall have a minimum 3-year aged solar reflectance of ~~0.55~~ 0.67 and a minimum thermal emittance of 0.75, or a minimum aged SRI of ~~64~~ 78."
Table 143-C, applicable to relocatable school buildings shall also be amended to incorporate an aged reflectance standard of 0.67 for low-sloped roofs.

5.2 Alterations (including reroofing)

With respect to alterations, Section 149(b)1.B.i would be amended to state, "Nonresidential buildings with low-sloped roofs ~~in climate zones 2-15~~ shall have a minimum aged solar reflectance of ~~0.55~~ 0.67 and a minimum thermal emittance of 0.75, or a minimum SRI of ~~64~~ 78."
Similarly, Section 149(b)1.B.iii. would be amended to state, "iii. High-rise residential buildings and hotels and motels with low-sloped roofs in climate zones ~~10, 11, 13,14, and 15~~ 2-15 shall have a minimum aged solar reflectance of ~~0.55~~ 0.63 and a minimum thermal emittance of 0.75, or a minimum SRI of ~~64~~ 78." A tradeoff table with insulation will be provided, as shown in this report. The minimum required aged reflectance level for the tradeoff table will be 0.25.

The overall envelope TDV energy approach in Section 143 of the Standards can be removed, since the simplified insulation tradeoff provides an alternative for alterations:

~~(b) **Overall Envelope TDV Energy Approach.**~~
~~The total TDV Energy of the overall envelope of the proposed building, TDV_{prop}, shall be no greater than the total TDV Energy of the overall envelope of a standard building, TDV_{std}, as calculated in Reference Nonresidential Appendix NA5 "Envelope Tradeoff Procedure". In making the calculations, it shall be assumed that the orientation and area of each envelope component of the standard building are the same as in the proposed building. If the proposed building has Window-Wall-Ratio greater than 40 percent or Skylight-Roof-Ratio greater than 5 percent, the area of walls and windows or roofs and skylights will be adjusted accordingly in the standard building to cap the WWR at 40 percent and SRR at 5 percent.~~

Similarly, Reference Appendix NA5, which documents the Overall Envelope TDV Energy Approach, can be removed.

5.3 Nonresidential Steep-Sloped Roofs and Residential Low-Sloped Roofs

The new residential reflectance standards for steep-sloped roofs, proposed at R_{aged} = 0.20 will be applied to the nonresidential steep-sloped standards, likely for the same climate zones as the nonresidential low-sloped standard of R_{aged} = 0.67.

The new nonresidential reflectance standards for low-sloped roofs, proposed at Raged = 0.67, will be applied to the residential low-sloped standards, likely for climate zones 2-15 where Raged = 0.67 has been shown to be cost effective for high-rise residential structures.

5.4 ACM Manual

Aside from updating the baseline to match the prescriptive requirement, there are no changes planned to the ACM Manual for this measure.

6. Bibliography and Other Research

Literature:

Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements, by Lawrence Berkeley National Lab for Pacific Gas and Electric for the 2005 Title 24 code update process

Guidelines for Selecting Cool Roofs, Department of Energy, 2010

Building Construction Cost Data, RS Means, 2010

Roofing supply distributors were contacted throughout California to collect cost data on single-ply thermoplastic and liquid-applied coating cool roof materials.

7. Appendices

7.1 Additional Cost Sources

In addition to the cost surveys distributed to manufacturers and to California roof contractors, the following additional cost sources provide informative context. However, these additional sources were not used in cost effectiveness calculations.

The DOE paper on cool roofs from 2010, *Guidelines for Selecting Cool Roof*, provided the following summary information on the cost of moving from a dark roof to a cool alternative:

Table 5: Roof Surfaces, Cool Alternatives, and Approximate Price Premiums*

Roof	Typical Non-Cool Surface	Cool Alternative	Price Premium ($/ft²)
Built-Up Roof	Mineral aggregate embedded in flood coat	Light-colored aggregate, like marble chips, gray slag	0.00
	Asphaltic emulsion	Field applied coating on top of emulsion	0.80-1.50
	Mineral surfaced cap sheet	White mineral granules	0.50
Metal[$]	Unpainted metal	May already be cool	0.00
		Factory applied white paint	0.20
	Painted metal	Cool-colored paint	0.00-1.00+
Modified Bitumen	Mineral surfaced cap sheet	Factory applied coating, white mineral granules	0.50
	Gravel surface in bitumen	Light colored gravel	0.00
	Metallic foil	May already be cool	0.00
		Field applied coating	0.80-1.50
	Asphalt coating	Field applied coating on top of asphaltic coating	0.80-1.50
Shingles[$]	Mineral granules	White granules	0.00
		Cool-colored granules	0.35-0.75
Sprayed Polyurethane Foam	Liquid applied coating	Most coatings are already cool to protect the foam	0.00
	Aggregate	Light colored aggregate	0.00
Thermoplastic Membranes	White, colored, or dark surface	Choose a white or light colored surface	0.00
Thermoset Membranes	Dark membrane, not ballasted (adhered or mechanically attached)	Cool EPDM formulation	0.10-0.15
		Factory cool ply or coating on dark EPDM	0.50
Tiles[$]	Non-reflective colors	Clay, slate: naturally cool	0.00
		Cool colored coatings	0.00

*Premiums are the extra cost, per square foot of roof area, of installing the cool roof option as compared with the corresponding non-cool option. Premiums are based on achieving the minimum cool roof characteristics described in Table 1. Values are approximate, and are based on discussions with roofing contractors, manufacturers, wholesalers, and RSMeans cost data.
[$]These roofs may be used in steep slope applications where cool roof requirements are less stringent. Uncoated metal roofs normally meet requirements for steep slope, but not for low slope. Premiums for shingles & tiles are based on steep slope requirements. All other premiums are based on low slope requirements.

The LBNL study for the 2005 Title 24 update provided the following summary information on the cost of moving from a dark roof to a cool alternative:

Roofing Product	Cool Variety	Cost Premium ($/ft²)
ballasted BUR	use white gravel	up to 0.05
BUR with smooth asphalt coating	use cementitious or other white coatings	0.10 to 0.20
BUR with aluminum coating	use cementitious or other white coatings	0.10 to 0.20
single-ply membrane (EPDM, TPO, CSPE, PVC)	choose a white color	0.00 to 0.05
modified bitumen (SBS, APP)	use a white coating over the mineral surface	up to 0.05
metal roofing (both painted and unpainted)	use a white or cool color paint	0.00 to 0.05
roof coatings (dark color, asphalt base)	use a white or cool color coating	0.00 to 0.10
concrete tile	use a white or cool color	0.00 to 0.05
cement tile (unpainted)	use a white or cool color	0.05
red clay tile	use cool red tiles	0.10

7.2 Non-Residential Construction Forecast details

7.2.1 Summary

The Non-Residential construction forecast dataset is data that is published by the California Energy Commission's (CEC) demand forecast office. This demand forecast office is charged with calculating the required electricity and natural gas supply centers that need to be built in order to meet the new construction utility loads. Data is sourced from Dodge construction database, the demand forecast office future generation facility planning data, and building permit office data.

All CASE reports should use the statewide construction forecast for 2014. The TDV savings analysis is calculated on a 15 or 30 year net present value, so it is correct to use the 2014 construction forecast as the basis for CASE savings.

7.2.2 Additional Details

The demand generation office publishes this dataset and categorizes the data by demand forecast climate zones (FCZ) as well as building type (based on NAICS codes). The 16 climate zones are organized by the generation facility locations throughout California, and differ from the Title 24 building climate zones (BCZ). HMG has reorganized the demand forecast office data using 2000 Census data (population weighted by zip code) and mapped FCZ and BCZ to a given zip code. The construction forecast data is provided to CASE authors in BCZ in order to calculate Title 24 statewide energy savings impacts. Though the individual climate zone categories differ between the demand forecast published by the CEC and the construction forecast, the total construction estimates are consistent; in other words, HMG has not added to or subtracted from total construction area.

The demand forecast office provides two (2) independent data sets: total construction and additional construction. Total construction is the sum of all existing floor space in a given category (Small office, large office, restaurant, etc.). Additional construction is floor space area constructed in a given year (new construction); this data is derived from the sources mentioned above (Dodge, Demand forecast office, building permits).

Additional construction is an independent dataset from total construction. The difference between two consecutive years of total construction is not necessarily the additional construction for the year because this difference does not take into consideration floor space that was renovated, or repurposed.

In order to further specify the construction forecast for the purpose of statewide energy savings calculation for Title 24 compliance, HMG has provided CASE authors with the ability to aggregate across multiple building types. This tool is useful for measures that apply to a portion of various building types' floor space (e.g. skylight requirements might apply to 20% of offices, 50% of warehouses and 25% of college floor space).

The main purpose of the CEC demand forecast is to estimate electricity and natural gas needs in 2022 (or 10-12 years in the future), and this dataset is much less concerned about the inaccuracy at 12 or 24 month timeframe.

It is appropriate to use the CEC demand forecast construction data as an estimate of future years construction (over the life of the measure). The CEC non-residential construction forecast is the best publicly available data to estimate statewide energy savings.

7.2.3 Alterations Estimate

The Alterations estimate assumes that the average roof has a sixteen year life span, resulting in a 6% applicability of existing floor area for most building types. For schools and restaurants it is assumed that only half of the roof area is a low-sloped roof. These percentages, when used with the HMG construction estimate and forecast, show an alterations market that is approximately 70% of the total roofing market, a number consistent with what has been provided by the roofing industry.

7.2.4 Citation

"NonRes Construction Forecast by BCZ v7"; Developed by Heschong Mahone Group with data sourced August, 2010 from Abrishami, Moshen at the California Energy Commission (CEC)