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FOR
ENVIRONMENTAL
INNOVATION
IN ROOFING

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July 19, 2011

California Energy Commission
Dockets Office, MS-4
Re: Docket No. 10-BSTD-01
1516 Ninth Street
Sacramento, CA 95814-5512

Reference: Docket No. 10-BSTD-01
June 10, 2011 Staff Workshop - 2013 Building Energy Efficiency Standards

Dear California Energy Commissioners and Staff:

The Center for Environmental Innovation in Roofing wishes to thank you for the opportunity to present an incremental energy analysis at the June 10, 2011 workshop. (A copy of the analysis is enclosed as a separate PDF file.) As a key voice of the roofing industry in regard to energy, environment and innovation, the Center applauds the efforts of the California Energy Commission to improve its roof energy standards and challenge our industry to continuously improve the performance of our products. However, we are concerned that implementation of the new roof-related standards as proposed during the workshop may result in an unwanted level of market disruption along with a possible degradation of performance of roofing products that may not be fully tested for long-term rooftop performance.

Many roofing industry stakeholders testified at the workshop about the potential for market disruption and degradation of product performance, and we expect that these stakeholders will provide you with ample data to support their conclusions in regard to product availability and performance. For our part, we would like provide additional comments regarding the potential benefits of the proposed new roofing standards so that you may have sufficient information regarding both the potential risks and benefits of the code-change proposal as presented at the June 10, 2011 workshop.

The primary intent of our analysis was to demonstrate that the short-term energy savings gained by raising the Title 24 prescriptive low-slope roof reflectance minimum from 0.55 to 0.70 (or 0.67 as most recently proposed) would amount to only a few pennies per square foot of affected roof surface area per year. Even if our analysis were based on a peak energy cost $0.25 / KWH or more throughout the entire air conditioning season, the maximum savings even in the hottest and sunniest California climate zones would still amount to less than $0.03 per square foot on an annual basis. Based on this analysis, we believe the relatively small amount of potential energy savings identified may not justify the market dislocation and the use of untested roofing products over the next three to five years, especially if no trade-off allowance was provided for roofing products with lower aged reflectivity.

A secondary intent of our analysis was to demonstrate that because roof reflectance and roof insulation work together in a complementary continuum of benefit and cost, the inclusion of trade-off strategies in the code is especially beneficial for roofing designers and building owners. In all cases, an increase in one of these two key variables compensates proportionately and predictably for a decrease in the other variable. Because the combined effect of reflectance and insulation is linear and predictable, informed roofing designers and building owners can employ a trade-off strategy not only to optimize the benefit of roof reflectivity and roof insulation but also to optimize the roof system design and selection using other factors such as durability and life cycle cost.

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Based on our analysis, we would suggest that the continued inclusion of a reflectance / insulation trade-off along a broad continuum of values continues to be beneficial to the citizens of California. In addition, based on a review of the CRRC database, it would appear that the trade-off exemption for roof reflectivity could be upgraded to a minimum aged reflectivity of 0.25 without eliminating many widely-used low-slope roofing products, including standard granule-surfaced asphalt cap sheets and traditional built-up roofing gravel. The following table provides suggested trade-off values for aged reflectivity and insulation R-value for all climate zones:

Aged Solar Reflectance:	Trade-Off R-Value (In addition to prescriptive minimum)
0.67	N/A
0.60	Add R-2
0.50	Add R-4
0.40	Add R-6
0.25	Add R-8

These trade-off values are based on an attached model run of the DOE Cool Roof Calculator (Attachment A) for a typical California city (Fresno) located in the highest roof insulation R-value zone, with a current prescriptive R-value of R=25.6 (U= 0.0139). As indicated in the attached DOE Cool Roof Calculator summary, a black roof with aged reflectance of 0.05 would need to be insulated to an R-value of 33.3 as compared to a cool roof with aged reflectance of 0.67 and a base R-value of 25.6. The trade-off differential in R-value difference is R-7.7 which has been rounded in our recommendation to R-8 for the least reflective category.

Using this suggested trade-off method, state-wide energy savings would be increased in a number of ways. First, all new roofs that would otherwise comply with current regulations would require at least an additional R-2 of insulation. Second, because current regulations establish no absolute prescriptive minimum for aged solar reflectance, the recommended minimum aged reflectance level of 0.25 would provide additional overall energy savings. And finally, because the additive R-value is based on modeling for the highest current R-value climate zone, additional energy savings would be provided for all lower R-value climate zones.

Finally, although we appreciated the opportunity to present our analysis at the workshop, we were disappointed by the lukewarm reception given the DOE / Oak Ridge National Laboratory (ORNL) “Cool Roof Calculator” employed by the Center research staff. Because impacts of solar radiation on the roof have been measured in extensive laboratory and field trials by ORNL (Attachment B) and because these measurements have been used to develop highly predictive algorithms in the Cool Roof Calculator, we believe this tool provides the simplest and best way to estimate the performance of cool roofing systems. In addition, because the benefits of cool roofs serve are directly related to their reduction of solar impacts, we would suggest that a whole-building energy analysis is not necessary to fully quantify the energy benefits of reflective roof surfaces. Whole-building analysis may even be counterproductive to achieving an ease of understanding, examination of alternatives, and - most importantly – quantification of marginal benefits of key input variables such as roof surface reflectivity, insulation thermal value and energy costs. As a consequence, we continue to advocate for the use of simple,

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transparent and highly flexible analytical tool such as the DOE / ORNL Cool Roof Calculator, especially to evaluate the short-term impacts of changes in any of these variables. The value of this calculator is even more critical because we have yet to receive any definitive data regarding the energy calculations used to develop the June 10, 2011 workshop recommendations presented by your consultant.

As the commission continues to work on the 2013 edition of Title 24, the Center would be happy to provide additional research and analysis to support your efforts. We look forward to working with you in developing workable and achievable improvements in Title 24, and we would be happy to provide any additional information you may need.

Yours very truly,

Jas. L. Hoff

Dr. James L. Hoff, DBA
Research Director

Att: 2

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ATTACHMENT A:

DOE COOL ROOF CALCULATOR MODEL SUMMARY IDENTIFYING A TYPICAL INSULATION TRADE-OFF
(City of Fresno, Comparing Aged Reflectivity of 0.67 to 0.05)

DOE Cool Roof Calculator

Estimates Cooling and Heating Savings for Flat Roofs with Non-Black Surfaces

- Developed by the U.S. Department of Energy's Oak Ridge National Laboratory (Version 1.2)

- This version of the calculator is for small and medium-sized facilities that purchase electricity without a demand charge based on peak monthly load. If you have a large facility that purchases electricity with a demand charge, run the CoolCalcPeak version in order to include the savings in peak demand charges from using solar radiation control.

- What you get out of this calculator is only as good as what you put in. If you CLICK HERE , you'll find help in figuring out the best input values. Some things, such as the weathering of the solar radiation control properties and the effects of a plenum, are especially important. You'll also find help in figuring out your heating and cooling system efficiencies and proper fuel prices.

- To compare two non-black roofs, print out results of separate estimates for each vs. a black roof. Manually compute the difference in savings to compare the two non-black roofs.

- If your energy costs are determined by on-peak and off-peak rates, print out results of separate estimates with on-peak and off-peak rates for the same roof. Judge what fraction of the savings with on-peak rates is appropriate.

My State	California
My City	Fresno
Click to see Data for All 243 Locations	
My Proposed Roof:	
R-value (HIGH=20; AVG=10; LOW=5) [h·ft²·°F/Btu]	25.6
Solar reflectance, SR (HIGH=80; AVG=50; LOW=10) [%]	67
Infrared emittance, IE (HIGH=90; AVG=60; LOW=10) [%]	80
My Energy Costs and Equipment Efficiencies	
Summertime cost of electricity (HIGH=0.20; AVG=0.10; LOW=0.05) [$/KWh]	.25
Air conditioner efficiency (Coefficient of Performance) (HIGH=2.5; AVG=2.0; LOW=1.5)	2
Energy source for heating (choose one)	(●) Electricity ( ) Fuel
If electricity, wintertime cost (HIGH=0.20; AVG=0.10; LOW=0.05) [$/KWh]	.125
If fuel, cost (Natural gas: HIGH=1.00; AVG=0.70; LOW=0.50) [$/Therm] (Fuel oil: 2002 East coast=0.85; 2002 Midwest=0.70) [$/Therm]	
Heating system efficiency (Furnace or boiler: HIGH=0.8; AVG=0.7; LOW=0.5) (Electric heat pump: HIGH=2.0; AVG=1.5) (Electric resistance: 1.0)	1.5
[Calculate My Annual Savings Relative to a Black Roof]	
Net Savings [$/ft² per year]	0.087
Cooling savings [$/ft² per year]	0.097
Heating savings (heating penalty if negative) [$/ft² per year]	-0.01
Insulation in Black Roof to Yield Same Annual Energy Savings:	
Upgrade from R- 25.6 to R- 33.3 [h·ft²·°F/Btu]	
Details of Comparison:	
Heating degree days for location chosen [Annual °F-day]	2601.5
Cooling degree days for location chosen [Annual °F-day]	1883.5
Solar load for location chosen [Annual Average Btu/ft² per day]	1658.8
Cooling load for black roof (SR=5%;IE=90%) [Btu/ft² per year]	4602
Heating load for black roof (SR=5%;IE=90%) [Btu/ft² per year]	3895
Cooling load for proposed roof [Btu/ft² per year]	1941
Heating load for proposed roof [Btu/ft² per year]	4311

ATTACHMENT B:
DOE COOL ROOF CALCULATOR RESEARCH BIBLIOGRAPHY

Petrie, T. W., Wilkes, K. E., Desjarlais, A. O., "Effect of Solar Radiation Control on Electricity Demand Costs - An Addition to the DOE Cool Roof Calculator," Proceedings, Performance of Exterior Envelopes of Whole Buildings IX International Conference, December 2004.

Desjarlais, A. O., Petrie, T. W., Miller, W.A., Stovall, T. K., "A Web-based Tool to Estimate the Energy Savings Associated With Solar Radiation Control Applied to Commercial Roofing Systems," in 12th International Roofing and Waterproofing Conference, proceedings of the National Roofing Contractors Association and Bitumen Waterproofing Association, Orlando, FL, September 2002.

Miller, W. A., Cheng, M. D., Pfiffner, S., Byars, N., "The Field Performance of High-Reflectance Single-Ply Membranes Exposed to Three Years of Weathering in Various U. S. Climates," Final Report to SPRI, Inc., August 2002.

Miller, W.A. and Roodvoets, D. L. and Desjarlais A. 2004. "Long Term Reflective Performance of Roof Membranes," proceedings of the Roof Consultants Institute, Reno, NV, April 2004

Petrie, T.W., J.A. Atchley, P.W. Childs, and A.O. Desjarlais. 2001. "Effect of Solar Radiation Control on Energy Costs – A Radiation Control Fact Sheet for Low-Slope Roofs," Proceedings on CD, Performance of the Exterior Envelopes of Whole Buildings VIII: Integration of Building Envelopes Atlanta, GA: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.

Wilkes, K.E. 1989. "Model for Roof Thermal Performance," Report ORNL/CON-274. Oak Ridge, TN: Oak Ridge National Laboratory.

Wilkes, K.E., T.W. Petrie, J.A. Atchley, and P.W. Childs. 2000. "Roof Heating and Cooling Loads in Various Climates for the Range of Solar Reflectances and Infrared Emittances Observed for Weathered Coatings," pp. 3.361-3.372, Proceedings 2000 ACEEE Summer Study on Energy Efficiency in Buildings. Washington, D.C.: American Council for an Energy Efficient Economy.

Roof Reflectance and Energy Savings: An Incremental Analysis

Prepared For:

California Energy Commission

Staff Workshop on Draft Revisions for Residential and Nonresidential Buildings for Possible Inclusion in the 2013 Building Energy Efficiency Standards

June 10, 2011

Prepared By:

Center for Environmental Innovation in Roofing

Dr. James L. Hoff, DBA, Research Director

June 8, 2011

Objectives

- Examine energy savings between aged solar reflectance of 0.55 and 0.70:
  - For incremental savings provided above 0.55 up to 0.70
  - For different California locations / climate zones
  - Across a range of roof U/R values
  - At today’s electrical costs for commercial facilities
  - Using a recognized calculation tool

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Methodology

- **Calculation Tool:**
  - DOE / ORNL Cool Roof Calculator (Ver. 1.2)
  - Includes nominal Cooling Degree Days plus Solar Loads for each location
- **Locations:**
  - San Francisco (Zone 3)
  - Los Angeles (Zone 6)
  - Sacramento (Zone 12)
- **Roof Aged Solar Reflectance Values:**
  - 0.05 (Black Comparison Roof)
  - 0.55 (Current Title 24 Prescriptive Standard / Proposed Mandatory Minimum)
  - 0.70 (Proposed Title 24 Prescriptive Standard)
- **Roof U/R Values**
  - U=0.075 / R=13.33 (Proposed Title 24 Mandatory Minimum*)
  - U=0.050 / R=20.00 (Current ASHRAE 90.1 Prescriptive Minimum**)

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*For wood framed and other roofs
**For roofs with insulation above deck

Other Assumptions

- Cost of Electricity = $0.126 / KWH
  - Source: EIA 2011 "Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State," California Commercial Sector
- Roof Emissivity = 0.80
- Air Conditioner Coefficient of Performance (COP) = 2.0
- Heating Loads Not Included in Analysis

SAMPLE PAIRED COMPARISON: SR55R13 versus SR70R13 (Los Angeles)

DOE Cool Roof Calculator

U.S. DOE Oak Ridge National Laboratory (Ver. 1.2)

SR55R13

MY CITY	California
MY STATE	Los Angeles
MY PROPOSED ROOF	
R-Value	13.33
Solar Reflectance %	55%
Infrared Emittance %	80%
MY ENERGY COST / EFFICIENCY	
Summertime Cost of Electricity ($/KWH)	$0.12
Air Conditioning C.O.P.	2.0
COOLING SAVINGS* ($/ ft²)	**$0.026**
DETAILS OF COMPARISON	
Cooling Degree Days (Annual °F – Day)	469.5
Solar Load (Ann. Ave. BTU / ft² per Day)	1579.1
Cooling Load For Black Roof* (BTU/ft²)	3196
Cooling Load for Proposed Roof (BTU/ft²)	1731

*Cooling savings compared to a black roof (SR=0.05, E=0.90)

DOE Cool Roof Calculator

U.S. DOE Oak Ridge National Laboratory (Ver. 1.2)

SR70R13

MY CITY	California
MY STATE	Los Angeles
MY PROPOSED ROOF	
R-Value	13.33
Solar Reflectance %	70%
Infrared Emittance %	80%
MY ENERGY COST / EFFICIENCY	
Summertime Cost of Electricity ($/KWH)	$0.12
Air Conditioning C.O.P.	2.0
COOLING SAVINGS* ($/ ft²)	**$0.035**
DETAILS OF COMPARISON	
Cooling Degree Days (Annual °F – Day)	469.5
Solar Load (Ann. Ave. BTU / ft² per Day)	1579.1
Cooling Load For Black Roof* (BTU/ft²)	3196
Cooling Load for Proposed Roof (BTU/ft²)	1231

*Cooling savings compared to a black roof (SR=0.05, E=0.90)

NET COOLING SAVINGS: REFLECTIVE VERSUS BLACK ROOF

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Summary of Paired Comparisons

AT R = 13.33	San Francisco		Los Angeles		Sacramento	
AGED SOLAR REFLECTANCE:	0.55	0.70	0.55	0.70	0.55	0.70
Cooling Load for Black Roof (Annual BTU / FT^2)	507	507	3196	3196	6203	6203
Cooling Load for Reflective Roof (Annual BTU / FT^2)	274	194	1731	1231	3383	2430
NET ELECTRICITY SAVINGS (Annual $/ FT^2)	$0.004	$0.006	$0.027	$0.036	$0.052	$0.070

AT R = 20.00	San Francisco		Los Angeles		Sacramento	
AGED SOLAR REFLECTANCE:	0.55	0.70	0.55	0.70	0.55	0.70
Cooling Load for Black Roof (Annual BTU / FT^2)	320	320	2011	2011	3889	3889
Cooling Load for Reflective Roof (Annual BTU / FT^2)	172	121	1082	2104	2104	1501
NET ELECTRICITY SAVINGS (Annual $/ FT^2)	$0.003	$0.004	$0.017	$0.023	$0.033	$0.044

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Summary of Incremental Energy Savings

SR55 versus SR70

One-Year Savings

	San Francisco	Los Angeles	Sacramento
At R=13.33	$0.002	$0.009	$0.018
At R=20.00	$0.001	$0.006	$0.011

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Sensitivity Analysis

- Cost of Electricity
  - Sensitivity is linear
- Roof U/R Value
  - Increasing R value to 20 from the proposed 13.33 mandatory minimum closely correlates with a similar increase of aged SR to 0.70 from 0.55
- Roof Emissivity
  - Sensitivity is minimal: Increasing emissivity to 0.90 adds a maximum of $0.003 annually in hot, sunny climate zones
- Air Conditioner Efficiency
  - Sensitivity can vary from a reduction of up to 1¢ annually for higher A/C efficiencies (2.5 COP) to an increase of up to 2¢ annually for lower A/C efficiencies (1.5 COP)
- Addition of Heating to Analysis
  - Little or no effect in hot, sunny climate zones such as Los Angeles or Sacramento, but significant negative effect in cool, cloudy climate zones such as San Francisco (Up to a 3¢ annual penalty)