McHugh Energy Consultants

efficiency research
analysis
policy

Tuesday, May 08, 2012

California Energy Commission
Attention: Docket No. 12-BSTD-1
Dockets Office
1516 Ninth Street, MS-4
Sacramento, CA 95814
ryasny@energy.ca.gov

Re: Docket No. 12-BSTD-1 Response to ARMA Comments Dated May 4, 2012

Dear Commissioner Douglas,

I am writing in support of the proposed cool roof requirements as they provide significant savings to California businesses, reduce energy related emissions, reduce expenditures on additional electricity infrastructure to serve peak cooling loads and reduce loss of money to other states to pay for imported power. As posted on the CEC website[1], the "Nonresidential Cool Roofs" CASE study estimates that one year's worth of nonresidential and high-rise residential new construction and alterations would save 182 GWh/yr of electricity consumption , result in an increased gas consumption of approximately 0.527 Million therms/yr and because the electricity cost savings are significantly larger than the added gas consumption, the overall present valued savings is $743 Million[2]. This cost savings is equivalent to an annual savings of $62 Million/yr in the first year and is $124 Million/yr in the second year as more buildings are built and more roofs are replaced. The stakes for correctly making the trade-offs between insulation and cool roofing is substantial.

However I believe is it desirable to provide to industry the flexibility to make trade-offs between roof material properties and insulation as long as they result in the same energy budget as contained in the performance approach or a look-up table that approximates the same results. My understanding from conversations with Bill Callahan from the Associated Roofing Contractors and with CEC staff and the IOU CASE team is that a simplified performance trade-off tool would be created to allow the flexibility to make simple trade-offs while preserving the overall energy savings described above.

The ARMA comment letter dated May 4, 2012 and signed by Reed B. Hitchcock, believes that this approach somehow over-values cool roofs versus added roofing insulation. The rest of this

[1] http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/current/Reports/Nonresidential/Envelope/2013_CASE_NR_Cool_Roofs_Oct_2011.pdf

[2] Over a 15 year period of analysis at a 3% real discount rate

PO Box 2878
Fair Oaks, CA
Tel 916.966.8600
Fax 916.471.3863
jon@mchughenergy.com
http:/www.mchughenergy.com

letter documents why I think the ARMA approach underestimates the energy savings from cool roofs for most nonresidential buildings and why their methodology for trade-offs is incompatible with the TDV trade-off methodology that has been in effect in the Title 24 standards since 2005. The CASE team, led by Architectural Energy Corporation (AEC), has used a method to develop the trade-offs that is in conformance with the TDV methodology as contained in the Title 24 performance approach and as documented in the Alternative Compliance Method (ACM) manual.

Since the adoption of the 2005 Title 24 standards, California has pursued a policy direction that provides a balanced approach for evaluating the long term impact of energy consumption due to building design choices. This balanced approach considers the long term cost of energy consumption and peak demand as embedded in the time dependent valuation (TDV) factors in the performance approach and this same approach is also used to evaluate the cost-effectiveness of measures. As a result, measures that reduce peak electrical demand on hot summer afternoons are valued highly as they reduce expenditures in the transmission and distribution infrastructure in addition to the high cost of power sold into the electrical system at these times. When the performance trade-off approach is applied, the calculation rule set, as contained in the ACM manual, requires an hourly calculation of energy impacts and these hourly energy values are multiplied by hourly TDV values to yield an energy budget. If the proposed design budget is less than or equal to the standard design budget, the proposed design complies with the performance approach compliance method. My responses to the comments made by ARMA are within the context of how the performance method makes trade-offs between measures as described above.

Cool roofs have high solar reflectance and high thermal emittance so that when the sun is shining a cool roof is significantly cooler than a (typically dark colored) low reflectance roof. The primary benefit of a cool roof is to reduce air conditioning loads and cools roofs have their greatest impact on hot sunny afternoons in the summer. When it is cold outside and the building is being heated, the cool roof is actually detrimental as one would prefer to have a warm roof to reduce heating loads. But given the relative costs of air conditioning and heating the cooling reduction cost benefits vastly outweigh the negatives associated with increased heating loads. Buildings with higher internal gains from plug loads and people have more hours of air conditioning and thus benefit more from cool roofs than buildings which have lower internal gains. Adding insulation to a roof has a year round impact as it reduces both cooling loads in the summer and heating loads in the winter. This technical understanding of how the two trade-off measures (cool roofs vs. roof insulation) as evaluated though the performance approach provides the background to my responses to ARMA's comments.

During the June 10th workshop, Dr. Jim Hoff of the Center for Environmental Innovation presented a preliminary study which he thought showed that the increase from 0.55 solar reflectance to 0.70 would have little impact on the energy cost savings. Dr. Hoff was using the DOE and Oak Ridge National Lab's Cool Roof Calculator to conduct the energy cost calculations. I asked Dr. Hoff if the DOE calculator could export hourly energy data so we could apply the TDV values to the energy results. Dr. Hoff was under the impression that hourly values could be exported from the DOE calculator. However, the following exchange with the author of the Cool Roof Calculator, Dr Andre Desjarlais at Oak Ridge National Labs, explains the shortcomings of this tool for use in developing Title 24 trade-offs, as there is no hourly data available for conducting a TDV analysis and also that the analysis assumes the building has no internal loads:[3]

MR. DESJARLAIS: …. This is a family of curve fits and compares a series of experiments that were performed at ORNL to predict the energy loads in the building. It's clearly different from the analysis that Dan has done. This analysis does not include a building. It has no building. It's looking simply at the energy flowing through the ceiling. Clearly the difference between your analysis and our analysis is that you selected a building and your building has a family of internal loads. This has no internal loads. So the tool was designed to demonstrate what the minimum potential benefit of a cool roof is. I think you selected a building where you can get any answer you want depending on the building you select and the loads you put inside. I was going to ask, and it's part of Reed's request, I think you need to tell us a lot about the building that you've used to model and then we need to decide how typical that is of buildings in assessing your calculations. Our analysis shows this is the roof flow and whatever you're doing inside the building obviously varies that. But this is, effectively, a building that has no internal load. So. It is just a family of curve fits and algorithms and so there is no hourly data per se.

The following back and forth is excerpted from the May 10th transcript pages 191- 194

MR. MCHUGH: No, no. That's quite alright. What I think I'm hearing is that you've got a tool that gives kind of an absolute minimum savings from a cool roof. And I agree with the comments that Dr. Desjarlais brought up which is there's an analysis done using a more refined tool, the hourly tool, and I'm sure the AEC would be quite happy with sharing the assumptions, the internal loads and those sorts of things. So you're looking at a simulation that has no internal loads, which is extremely atypical for commercial buildings, a COP of 2 which is the same of an EER of 6.8, energy costs of $0.16 which might be fine for looking at average costs but since we're looking at air conditioner loads, actually the TDVs have—they're looking at the 15 year projection of costs. Those average costs, I believe, are $0.18 and for an evaluation of air conditioning you're probably looking at costs that are maybe double that if you actually look at the TDVs for the hot times of year. This is useful but probably less useful than the initial analysis that's been done. I think we'd all welcome your review of the assumptions and a more detailed analysis. Thanks.

MR. DESJARLAIS: Okay. Well you ask them, well we compete it to other models. Well, great. And I'm not sure that I agree 100 percent of your comment on what is a typical commercial building. I would suggest in a warehouse, a conditioned warehouse, the internal loads are probably closer to zero than the loads that were selected here. Clearly, in an office building we're substantially underestimating the loads. And you're absolutely right about TDV. We assume a flat rate of electricity costs and that's not captured in this particular tool. But I wanted to defend my tool because one, I developed it and two, I think it has been compared more

---

[3] 2013 Title 24 Proceedings, June 10, 2011 transcript pp. 190-191 http://www.energy.ca.gov/title24/2013standards/prerulemaking/documents/2011-06-10_workshop/2011-06-10_transcript.pdf

rigorously than Energy Plus has. I think that that's an important feature that Energy Plus is really weak on.

MR. MCHUGH: So is your tool being compared to some test cells that don't have any internal loads? Because you said there's no internal gains in your tool. So you've got a good comparison to something that doesn't have internal gains which, yeah, for warehouses that's probably pretty useful but of course warehouses, many of those are only semi conditioned so we wouldn't have— the main benefit of course is for air conditioning savings so we're really looking at schools and offices and retail and that sort of thing. I think it's great that there's this tool but nonetheless we have a methodology that requires sort of an hourly analysis because of the severe impact on demand costs, which are substantially higher, so I think it's great that there's tool. I just wonder if it's really going to be that useful for what we're trying to evaluate. Thanks.

The end result of this back and forth with the developer of the DOE Cool Roofs Calculator is that the simplified software tool estimates the heat flows though a roof for a space with no internal gains and will tend to underestimate the value of a cool roof for spaces with internal loads,. Furthermore that the tool is a regression equation and has no way of exporting hourly energy consumption which can be converted into a energy budget through the use of the time dependent valuation (TDV) factors. Finally, given the relative coincidence of savings due to cool roofs with the times of highest TDV values (i.e. coincident with electrical system peak demand) versus the significantly lower coincidence with energy savings from insulation, one would expect that the TDV effective rate for cool roof savings in $/kWh is going to be significantly higher than the effective rate for insulation. As a result, an estimation tool that can only evaluate annual energy savings and multiply it by a fixed energy rate will have a different trade-off between insulation and cool roofs. One would expect that less insulation would be needed to trade-off against a cool roof under a "flat" valuation than under a TDV evaluation. However the flat valuation of energy is less accurate than a TDV evaluation.

Thus I am not surprised that the ARMA team found that less insulation is required to trade-off against a cool roof using the DOE Cool Roof Calculator than as proposed by the CASE team which is using an hourly EnergyPlus simulation and the hourly TDV values. From my perspective the CASE team is conducting the calculation correctly and the ARMA analysis is using a simplified tool and is not applying the TDV values and not getting the same result.

This is what the May 4th ARMA docketed letter had to say about their analysis:

<u>Insulation and Solar Reflectance Trade-off</u>

At the hearings, roofing industry representatives recommended tradeoffs for insulation when lower values of solar reflectance are used, both above and below deck. Commission staff responded that they agreed with these recommendations, and we appreciate that direction. However, in review of the trade-off values for U-factors for solar reflectance using widely accepted Department of Energy modeling tools, our experts have identified that there is a substantial penalty for the use of insulation in place of the cool roof. This penalty is explained in detail in Appendix A attached. It is our recommendation that until this information is reviewed in its entirety and corrective action is taken, that 15-day language for approval is grossly premature.

It should be noted that the detailed EnergyPlus hourly simulation approach that uses engineering first principles to calculate heat flows of buildings is sponsored by the Department of Energy. The Oak Ridge National Laboratory Cool Roof Calculator that uses a simplified regression model is also sponsored by the Department of Energy. As documented above, during the Title 24 proceeding the developer of the Cool Roof calculator stated that it was "designed to demonstrate what the minimum potential benefit of a cool roof is." It is this Cool Roof Calculator that is being referred to in the ARMA comment as the "*widely accepted Department of Energy modeling tools.*" Though a calculation of minimum potential benefit of a cool roof is appropriate for a simple estimation tool, the more rigorous approach taken by the CASE team using EnergyPlus is designed to provide a more even-handed comparison with other measures within the context of the TDV trade-off approach. In summary the ARMA team is asking the CEC to delay the standards because the CASE team's detailed simulation and financial impact did not match their simplified approximation of energy savings and financial impact.

Based on the above documentation of the shortcomings of the ARMA analysis, I recommend that the California Energy Commission reject ARMA's docketed comments on the insulation and solar reflectance trade-off due to lack of merit.

Sincerely,

Jon McHugh

Jon McHugh, P.E.

McHugh Energy Consultants Inc.

Cc: William Pennington, CEC
Maziar Shirakh, CEC
Martha Brook, CEC
Payam Bozorgchami, CEC