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June 9, 2011 Staff Workshop - 2013 Building Energy Efficiency Standards

I respectfully submit the following written comments regarding the draft fenestration criteria for nonresidential and highrise residential buildings, as presented at the June 9 staff workshop.

By way of introduction, I have worked specifically in the area of fenestration energy performance and energy codes for 13 years. I have worked in a broad capacity across all aspects of the fenestration industry, including both individual companies and trade associations representing glass manufacturers, glazing fabricators, glazing contractors, and commercial window / framing manufacturers. I have been active with development of national model energy codes such as the International Energy Conservation Code (IECC) and the new International Green Construction Code (IgCC). I am a voting member of the ASHRAE 90.1 committee, and also hold an ex-officio position on the board of directors for NFRC. I am not representing any of these particular entities here, but wish to share my experience as it pertains to California's efforts to update Title 24.

I applaud and support CEC's goals to continue to increase building energy performance, including the effort to include daylighting. Daylighting is very important – however, specifying good daylighting design is not easy. Daylighting design is inherently complicated, and unfortunately, I believe the well intentioned effort to simplify has inadvertently led to a faulty approach with many unintended problems. These problems have the potential to work against CEC's goals and actually harm energy efficiency, while also creating barriers to use of new technologies, and in the worst case, hinder the use of safety glazing products.

These comments will highlight the major concerns, as well as possible solutions.

<u>Daylighting Design</u>

VT is only one small aspect of daylighting, and without considering other factors, is simply the wrong metric. Daylighting design is complex. Ultimately, the lighting designer must work towards providing a specific amount of light (lumens / ft2) in the workspace. To do so, the designer must look at a number of factors: the specific geometry of the building and room, the distribution (laterally and vertically) of the windows, the size of the windows, the window properties, the effects of glare, interior and exterior shading, lighting fixture location, and lighting control strategies. All this needs to be overlaid with the purpose of the space, and other building requirements that may apply regarding safety, structural loads, fire resistance, seismic performance, etc. It is incorrect and problematic to focus on just one of these many aspects, especially one that has less impact and causes other problems as noted below.

The Heschong Mahone Group, together with Southern California Edison and other sponsors, hosted a Daylighting Forum in May 2010 with over 80 invited experts involved with daylighting.

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One express purpose of this forum was to determine how the use of daylighting could be accelerated in energy codes and standards. From this workshop, it was clear that there is not just one simple approach, and that it is very challenging to prescriptively specify daylighting design. Nonetheless, if it is to be included in a prescriptive path, California needs to look to the approaches being taken by other green and updated standards, including ASHRAE 189.1, IgCC, and the 2012 IECC. These better approaches will be described towards the end of this document.

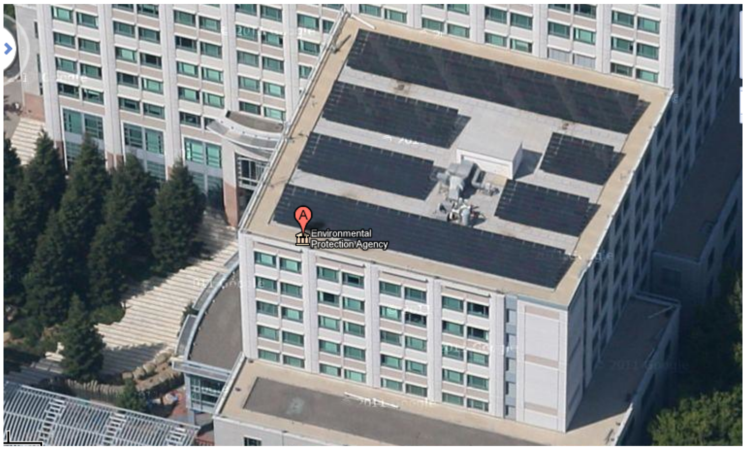
<u>Problems created by the VT requirement</u>

VT is the wrong metric.

The proposed VT requirement does not account for distribution or size of glazing. A simple example shows how this is flawed. A space with 15% window-to-wall ratio (WWR) and 44% VT (fixed windows) would meet the proposed requirement. The same space with 30% WWR and 22% VT would bring in the exact same amount of light, and in a better way – the windows and light would be spread more and create less contrast glare between the window and wall. However, this second space – which does a much better job of daylighting – would not comply. This is a flaw with using VT, instead of a more accurate approach like effective aperture.

Daylighting is about the right amount of light, <u>not</u> the highest amount of light.

Higher VT is not always a good thing. Daylighting design needs to bring in a sufficient amount of exterior light, but it needs to do so in an effective manner – spread laterally and deep in the space, but minimizing direct glare (straight view of the sun) and contrast glare (lighter and darker areas from adjacent windows and walls). If glare is not accounted for, blinds will be shut and electrical lighting will be turned on, working against the goal of energy efficiency. Below are real examples of this problem. Note that even the glazing in these examples would *not* comply with the proposed combined VT and SHGC requirements, which would be even more problematic.



It has been claimed that the glare issue can be resolved by use of overhangs / external shading and active use of blinds. However, if the proposal for Title 24 is relying on external shading or internal blinds for mitigating glare, then those costs must also be included in the analysis. External shading (overhangs, sunshades, louvers, etc) is an excellent measure that I strongly support, and this has been factored into some of the green building standards like ASHRAE 189.1. However, external shading could only be included as a requirement there because ASHRAE 189.1 has no cost effectiveness requirement. Unfortunately, the payback period for overhangs and sunshades has proven too long for inclusion in base energy standards like ASHRAE 90.1. I do not know one way or the other about the cost effectiveness of interior blinds, but in addition to including the cost, there is concern that they are actively closed to mitigate glare, but *not* as often actively reopened once the glare situation has changed. Automatically controlled shading systems can be a good solution, but then the cost of the controls must also be included.

For the above reasons and others, the European trend towards super high VT has already reversed, where advanced designers have realized that products with moderate VT that purposely balance glare and daylighting are more appropriate. California does not want to be lagging on the wrong side of this green building trend.

The VT requirement creates barriers to products that save more energy.

The draft prescriptive VT and SHGC requirements are set based on a specific glass package: double pane glazing with high VT triple-silver low-e on clear glass on the #2 surface. (It also includes some assumption about the frame width and performance, although those details have not been shared.) This particular product is the extreme endpoint in terms of VT and SHGC from a spectral physics standpoint – it is not physically possible to lower SHGC or increase VT any further without resulting in an undesirably colored product. Therefore, anything that even slightly deviates away from this specific package in either one of the parameters becomes a problematic scenario. This includes a number of products that would actually save more energy, but would not comply:

- *Triple glazing* – complies with U, and either VT or SHGC but not both
- *Double glazing with two low-e coatings* (known as the #2 / #4 configuration) – complies with U, and either VT or SHGC but not both
- *New 2nd generation triple silver low-e coatings* purposely designed with lower SHGC and lower VT — complies with U and SHGC, but not VT
- *Other coatings with lower SHGC than required* — outperforms on SHGC and can save more energy but won't comply with VT
- *Dynamic glazing* – an important technology on DOE's Roadmap for Net Zero-Energy Buildings
- *Building Integrated Photovoltaics (BIPV)* – generates energy but won't comply with both VT and SHGC
- Any coating (including triple-silver low-e) on any sort of tint, including high performance tints – outperforms with SHGC, but does not comply with VT

Does the commission really want to be seen as *discouraging* the use of above-code products, like triple glazing? This does not make sense.

The VT requirement creates barriers to products used for <u>safety</u> and other purposes.

Of even greater concern, the same over-constrained specification based on a specific glass package would hinder the use of products needed to satisfy other building requirements:

- *Laminated glass used as safety glazing in hazardous locations* defined by the building code – complies with either VT or SHGC but not both.
- *Laminated gla*ss *required in overhead glazing (sloped glazing and skylights)* – This is required by the building code to prevent falling glass fragments if the glazing is broken. This could only comply with either VT or SHGC, but not both.
- *Laminated or filmed glass used in seismic applications* – these products are used to retain broken glazing during seismic racking, to reduce the hazard from glass fragments

during a seismic event. These products could only comply with either VT or SHGC, but not both.

- Products using *thicker glass* than what was assumed in the analysis – thicker glass may be required by the building code based on design load and glass size, but thicker glass will reduce the VT compared to whatever thickness was assumed in the analysis.
- Applications that require a *wider frame profile for structural reasons* – this is not only highrise buildings, but also wide spans on lowrise, or locations with higher wind loads. A wider frame would comply with SHGC, but not VT.
- *Laminated glass used for acoustic performance* – acoustic glazing is used in hospitals, schools, offices, airports, and hotels as part of green design with improved environmental quality. This could only comply with either VT or SHGC, but not both.

Area-weighted averaging and trade-off options are not sufficient solutions.

It has been claimed that area-weighted averaging of VT and SHGC, envelope trade-offs, or the performance path are sufficient to handle product groups like those identified above. Area-weighted averaging could help to some degree with one situation (higher VT clerestory paired with lower VT vision area configurations), but unfortunately, many architects are still not using that design, and it still would not help with almost every other product listed above (e.g. the designer is not going to put laminated seismic glazing in only part of the building).

Also, the use of the performance path or envelope trade-off cannot be used as a basis to justify problems in the prescriptive path, which will still inappropriately create barriers and bias against the use of certain products during the design and specification process. Finally, area-weighted averaging or trade-off methods do no good for replacement windows or small area retrofits.

The energy savings from controls far outweighs savings from VT.

I have significant questions about the conclusions made in the presentation about the impact of the proposed VT requirement and potential energy savings. I agree *daylighting* and *daylighting controls* save a very large amount of energy, but I am skeptical about the amount of savings associated specifically with VT.

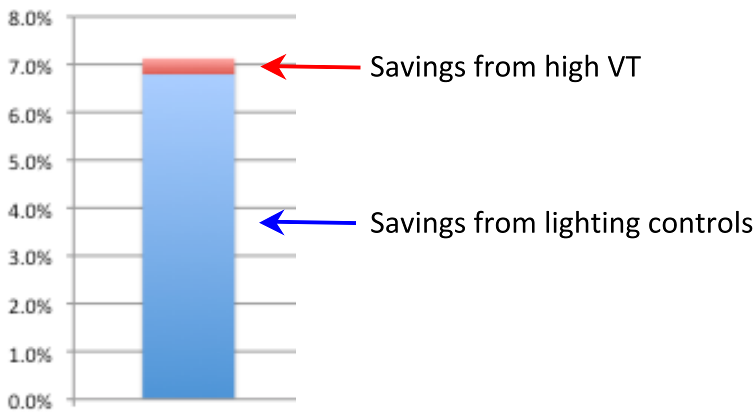
The presentation claimed that there is a 37% loss in LCC savings if there is no VT requirement. Without the ability to examine the detailed calculations and assumptions, it is difficult to ascertain the basis for this number, and it seems to contradict other work.

Prof. Steve Treado and Prof. Rick Mistrick of Pennsylvania State University performed a daylighting study for use in discussion with the ASHRAE 90.1 envelope subcommittee. (The report has been submitted to ASHRAE Transactions, but not yet published.) They used the ASHRAE 90.1 medium office prototype building model developed by Pacific Northwest National Laboratory, which is also used in the official DOE energy code determinations. For a building with 30% WWR, the use of daylighting controls resulted in a 6.8% reduction in total source energy use. Adding a higher VT glass (compliant with the proposed VT requirement) in place of a lower VT glass resulted in a further reduction of only 0.3%.

In other words, 95% of the daylighting energy savings came from the controls, and only 5% came from VT.

It is also interesting to note that the total source energy use could be reduced a further 6.2% by modifying the room configuration and lighting control strategy – reemphasizing the point that daylighting design has much more to do with other factors than it does with VT. Although this analysis was for a building in Atlanta, both Atlanta and the bulk of the California population are in the same IECC climate zone 3.

	Total Source Energy (GJ)	% Savings	Incremental % Savings
No controls	6988	--	
Add lighting controls	6513	6.8%	6.8%
Add high VT	6490	7.1%	0.3%
Further optimization (room depth, control strategy)	*6055*	*13.4%*	*6.2%*



As far as I know, the draft analysis for California did not model any examples with and without daylight controls to understand the relative impact of controls versus VT on daylighting energy savings. This, together with disclosure of the complete analysis data, may help reveal the basis for the claimed 37% loss in savings – whether that was due to controls and not VT, whether it was a mathematical comparison using a different baseline (in which case, the error would have been propagated by then incorrectly multiplying this 37% by the total state 30 year LCC present value), or something else altogether.

<u>Considerations for the SHGC requirement</u>

While the focus of my comments is on VT and daylighting, I do have a few comments about the proposed SHGC requirements.

Climate Zones

The maximum SHGC in ASHRAE 90.1 and IECC has also been set to 0.25, but only in ASHRAE / IECC climate zones 1-3. The maximum SHGC was specifically note reduced below 0.40 in zones 4-6.

In contrast, the proposed criteria for Title 24 sets a maximum SHGC of 0.17 – 0.26 for *all* climate zones across California, even in the colder areas where lower SHGC is not always beneficial.

For consistency, I suggest a simple 0.25 SHGC be applied to all zones except California zones 12 and 16 (corresponding to IECC zones 4-6), where the maximum SHGC should be 0.40.

Orientation

The model building used in the draft analysis had uniform glazing on all sides. However, glazing performance is strongly dependent on orientation. The benefit of low SHGC glazing is clear for west-facing facades, but at the same time, is not warranted on north-facing facades where a relaxation in SHGC may be beneficial to allow better daylighting. I would recommend further analysis on the effect of different glazing orientations, and whether it would be prudent to have different SHGC requirements for different orientations (or at least west and north).

Product type

I appreciate the inclusion of different product types (e.g. fixed, operable, curtain wall), which have different ratings based on NFRC standard sizes. However, there may still be an issue within the operable category. With the overprescribed proposed VT and SHGC, I do not believe both casement/awning windows and slider/hung windows can simultaneously qualify. If the criteria are set around the casement (with a lower glass-to-frame ratio), then sliders will meet the VT but not SHGC. If the criteria are set around the slider (with a higher glass-to-frame ratio), then casements will meet the SHGC but not the VT. This is another unintended consequence of the combined SHGC and VT criteria. It is also interesting to note that of the 22 windows used to develop the curve fit in the draft CASE report, *not a single window* would meet the combined proposed SHGC and VT criteria.

SOLUTIONS: Alternate Approaches to Daylighting

While the initial analysis and draft requirements were well intentioned – to promote daylighting – the use of a minimum VT requirement is oversimplified, has the potential to *increase* energy use, creates barriers to the use of products that actually save more energy, and creates barriers to the use of products required for safety applications. VT is simply a fatally flawed metric, and the commission needs to look to more appropriate methods to promote daylighting.

For any specification to be technically appropriate, it must account for glazing area and distribution in the space. This is best handled in the performance path, but if the commission is determined to include sidelighting and toplighting in the prescriptive path, then it must not shy away from effective aperture (EA) based methods. Here it is useful to examine what other codes and standards are doing.

GREEN BUILDING STANDARDS:

ASHRAE 189.1

ASHRAE's green building standard sets a sidelighting effective aperture requirement only for offices and classrooms on the north, south, and east facades:

EA ≥ 0.10 in zones 1,2, 3A, 3B (approx. California zones 2, 6-11, 13-15)

EA ≥ 0.15 in zones 3C, 4-8 (approx. California zones 1, 3-5, 12, 16)

This is in coordination with lighting controls, of course.

The sidelighting effective aperture is defined similar to that in Title 24. There are analogous, but different, effective aperture requirements for toplit spaces.

Additionally, the combined width of the primary sidelighted areas must be ≥ 75% of façade width, to ensure adequate glazing distribution.

There are also minimum reflectances for interior surfaces on ceilings (80%) and high partitions (70%).

International Green Construction Code (IgCC)

The IgCC will be finalized this fall, and includes a set of prescriptive daylighting criteria developed by daylighting experts with the International Association of Lighting Designers (IALD), American Institute of Architects (AIA), and New Buildings Institute (NBI).

The IgCC sets daylighting criteria for Group A-3, B, E, F, M or S occupancies, with exceptions for certain specific spaces (e.g. theatres, refrigerators, alterations, etc.).

Fenestration must meet a minimum effective aperture based on sky type:

EA ≥ 0.10 for sky type A (roughly California zones 3-10, 12-15, and south half of 16)

EA ≥ 0.12 for sky type B (roughly California zones 1, 2, 11, and north half of 16)

This is in coordination with lighting controls, of course.

The sidelighting effective aperture is calculated similar to that in Title 24, with some minor differences. There are analogous, but different, effective aperture requirements for spaces lit by rooftop monitors and skylights.

Additionally, a certain percentage of the occupied floor area must be within the daylit area to ensure adequate glazing distribution (50% for one- and two-story buildings, 25% for taller buildings).

BASE STANDARDS:

ASHRAE 90.1

Currently, ASHRAE 90.1 has extensive lighting control requirements (recently updated), but no VT or EA requirement for windows.

In the proposal addendum "bb" (still under review), the prescriptive path sets a new requirement of either **VT / SHGC ≥ 1.1** or **Sidelighting Effective Aperture ≥ 0.15**.

This only applies where lighting controls are required, as energy savings without associated controls are highly questionable. (While the controls requirements have been greatly expanded, the base codes still do not require controls in absolutely every space.)

The sidelighting effective aperture is defined similar to that in Title 24.

There are exceptions for products outside the scope of NFRC 200 (which cannot get VT ratings), and spaces already toplit by skylights or rooftop monitors.

2012 IECC

The New Buildings Institute authored new simplified daylighting requirements for the prescriptive path as part of their package for a 30% increase in stringency.

For buildings between 30-40% WWR in zones 1-6 (all of California climate zones), there is a new requirement for **VT / SHGC ≥ 1.1**.

This is only applies where there are automatic daylighting controls, and 50% of the conditioned floor area must be within a daylight zone to ensure adequate glazing distribution.

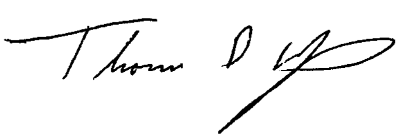
There is also an exception for products outside the scope of NFRC 200.

If helpful, I can provide the specific code language used by each of these.

RECOMMENDATIONS

- First and foremost, the minimum VT requirement must be removed for the numerous problems described above.
- Second, I recommend that California be proactive and adopt something similar to the green standards (ASHRAE 189.1 or IgCC). This approach is the most technically appropriate, builds on expert work from IALD, AIA, and NBI, and avoids the problems outlined in my previous comments. This would be based on the currently defined sidelighting effective aperture already in Title 24. To aid enforcement, the commission could also require that the EA calculations be certified by a registered design professional, taking the burden off of the code official.
- As an alternative, the commission could also look at adopting criteria similar to one of the base standards (ASHRAE 90.1 or IECC). Although not as technically rigorous as the green standards, this approach would be somewhat simpler than the green standards while still far better than the currently proposed minimum VT.

Best regards,



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