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Richard Karney
US Department of Energy
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Emily Zachery
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RE: **Energy Star Windows Criteria Revision**

Dear **Mr. Karney and Ms. Zachery**:

Thanks for the opportunity to provide comments on these important proposed revisions. I am writing to provide additional technical data and analysis for DOE to consider in evaluating its proposed revisions. My analysis is based, in part, on my overall professional experience related to the energy efficiency of windows and their impacts on buildings, and the needs of manufacturers and consumers.

I believe that I bring a somewhat unique perspective to the discussion as an engineer with expertise in window performance, building energy simulation and market transformation. My expertise with window performance primarily stems from founding and operating the NFRC accredited simulation laboratory WESTLab, which has rated hundreds of fenestration product lines for North American manufacturers over many years, as well as many years of active service within NFRC, including service as the Technical Committee chair and on the NFRC Board. In the field of building energy simulation, I am the author of the Micropas building energy simulation software, widely used for building code compliance, utility incentive programs and the Energy Star Homes programs in California and the southwest. As a consultant for the California Energy Commission and numerous other clients, I have conducted innumerable simulations and analyses of proposed code and voluntary program building criteria. Finally, my market transformation experience related to windows includes developing the educational materials and implementing window energy efficiency training programs in California and other states that helped to move these markets towards more efficient window products.

My comments are based on studying the draft criteria and analysis, detailed study of the additional information provided at LBNL's web site, attending the stakeholder meeting in August, and numerous interactions with stakeholders since this revision process was announced. While there are many issues surrounding setting the new criteria, I will focus my analysis and comments in this letter on the impact of window solar heat gain on peak cooling demand, modeling uncertainties and my evaluation of the proposed criteria for climate zones ES4 and ES5 in Phase II.

Peak Cooling Demand

For the most part, the draft criteria paper dismisses peak demand issues, particularly in northern climates, based on expected market penetrations, and presents no data. This is a problem because meeting peak demand is one of the most significant issues facing the utility industry and is ultimately very costly to the consumer. This is true even in northern climates where most utilities are now summer peaking due in a large part to residential air conditioner use. Minimizing peak demand is also one of the keys to improving the reliability of the electricity grid.

The impact of peak demand must be considered in order to get the right performance levels. Without including it, the criteria will be skewed inappropriately towards higher solar gain products when lower solar gain products have more economic benefits. It also is a reason to have maximum (not minimums or trade-offs) SHGC levels in northern climates and to consider even lower SHGC levels in central and southern climates.

Including peak demand does complicate the analysis. However, there are several ways this could be accomplished. For example, the criteria could be set on the basis of the lowest life cycle cost where the costs include the cost of meeting peak demand including extra power plants, transmission lines, distribution facilities and larger HVAC systems. Another method to at least partially reflect peak demand would be to use energy costs that depend on the time of day – power used on peak is often much more expensive that power used off peak. California, for example, uses the concept of time dependent valuation in its building standards, where the source multiplier varies based on the time of day and the time of the year. If detailed analysis is not possible, then the trade-offs offered in zones ES4 and ES5 should be reconsidered, and preferably eliminated, to account for the impact of peak demand.

Analysis of LBNL Peak Cooling Demand Data

While no electric peak demand data is presented in the draft criteria paper, LBNL actually calculated peak cooling energy data for nearly 40,000 combinations including:

- location (98 cities)
- foundation type (basement, crawlspace, slab)
- stories (1, 2)
- vintage (existing, new)
- HVAC (furnace/AC, heatpump)
- floor area (1700, 2600, 2800)
- window area (255, 390, 420)
- window type (51 types)

This data is found on the LBNL website. Starting with the LBNL data, I developed a spreadsheet to determine the importance of peak demand in each region of the country. The spreadsheet calculates the average summer electric peak demand for each prototype home with a specific window for each region. The average peak demand values are then subtracted to calculate the savings. Simple averages are used to keep the analysis manageable. In essence, this approach assumes that new and existing construction each represent 50% of the market and that the smaller and larger prototypes are each 50% of the market. These are reasonable assumptions for a first-cut analysis. The peak data in the spreadsheets assume that every home has an air conditioner and that the DOE2 capability to autosize the air conditioner is used. While these assumptions, along with market penetrations, could be examined more fully, the data is very useful even in this simplified manner.

Of the 51 window types included in the LBNL analysis, I have selected four to illustrate the impact of SHGC on peak demand. The four windows I have selected are listed in Table 1. To be conservative, the low solar gain window is compared to a moderate solar gain window as identified by LBNL. Comparing the low solar gain case to a high SHGC window would show even greater peak demand savings.

Table 1

Window Descriptions from LBNL Report		
Name	U-factor	SHGC
Wood/Vinyl Clear Double	0.493	0.564
Wood/Vinyl Bronze Double	0.493	0.466
Wood/Vinyl Sputter Low-E (e = 0.10) Moderate Solar Gain	0.350	0.436
Wood/Vinyl Spectrally Selective Low-E (e = 0.04) Low Solar Gain	0.339	0.294

Table 2 shows the average peak demand savings per home of the low solar gain window compared to the moderate solar gain window using the window properties in Table 1. Thus, this analysis effectively shows the impact by city of a 0.14 increase in SHGC (0.436-0.294; although there is a slight change in U-factor, it is inconsequential for purposes of the peak demand analysis). The simple average peak demand savings from the lower SHGC window for all cities is 0.32, with a maximum of 0.44 and a minimum of 0.25. The spread between the minimum and the maximum peak demand savings is not very large considering the range of climates across the nation.

Table 2

Average Peak Demand Savings Per Home (kW) Low Solar Gain Compared to Moderate Solar Gain					
	New		Existing		
City	1 Story	2 Story	1 Story	2 Story	Average
AK_Anchorage	0.18	0.29	0.35	0.46	0.32
AK_Fairbanks	0.20	0.35	0.48	0.51	0.38
AL_Birmingham	0.17	0.31	0.24	0.40	0.28
AL_Mobile	0.16	0.31	0.27	0.40	0.29
AR_Little_Rock	0.19	0.35	0.25	0.45	0.31
AZ_Flagstaff	0.17	0.27	0.26	0.42	0.28
AZ_Phoenix	0.23	0.42	0.33	0.55	0.38
AZ_Prescott	0.19	0.33	0.27	0.43	0.30
AZ_Tucson	0.22	0.39	0.31	0.50	0.35
CA_Arcata	0.57	0.39	0.23	0.43	0.41
CA_Bakersfield	0.22	0.39	0.30	0.51	0.35
CA_Daggett	0.25	0.44	0.33	0.56	0.39
CA_Fresno	0.20	0.36	0.27	0.46	0.32
CA_Los_Angeles	0.19	0.38	0.27	0.47	0.33
CA_Red_Bluff	0.28	0.49	0.39	0.63	0.44
CA_Sacramento	0.21	0.38	0.29	0.47	0.34
CA_San_Diego	0.18	0.34	0.27	0.43	0.30
CA_San_Francisco	0.28	0.46	0.32	0.56	0.40
CO_Denver	0.19	0.31	0.26	0.43	0.30
CO_Grand_Junctio	0.20	0.33	0.28	0.44	0.31
CT_Hartford	0.20	0.35	0.29	0.46	0.32
DC_Washington	0.19	0.34	0.29	0.45	0.32
DE_Wilmington	0.18	0.32	0.24	0.41	0.28
FL_Daytona_Beach	0.13	0.32	0.25	0.42	0.28
FL_Jacksonville	0.17	0.31	0.24	0.40	0.28
FL_Miami	0.16	0.29	0.24	0.41	0.27
FL_Tallahassee	0.17	0.32	0.24	0.42	0.29

FL_Tampa	0.18	0.32	0.25	0.42	0.29
GA_Atlanta	0.19	0.33	0.25	0.42	0.30
GA_Savannah	0.16	0.31	0.23	0.39	0.27
HI_Honolulu	0.16	0.29	0.23	0.41	0.27
IA_Des_Moines	0.20	0.33	0.28	0.44	0.31
ID_Boise	0.18	0.30	0.29	0.41	0.30
IL_Chicago	0.18	0.33	0.27	0.43	0.30
IL_Springfield	0.20	0.34	0.27	0.44	0.31
IN_Indianapolis	0.19	0.37	0.26	0.42	0.31
KS_Wichita	0.20	0.35	0.27	0.46	0.32
KY_Lexington	0.19	0.33	0.27	0.44	0.31
KY_Louisville	0.19	0.33	0.26	0.43	0.30
LA_Lake_Charles	0.17	0.32	0.26	0.44	0.29
LA_New_Orleans	0.16	0.26	0.23	0.39	0.26
LA_Shreveport	0.21	0.37	0.29	0.49	0.34
MA_Boston	0.17	0.28	0.26	0.41	0.28
MD_Baltimore	0.18	0.32	0.25	0.41	0.29
ME_Portland	0.20	0.34	0.30	0.46	0.33
MI_Detroit	0.18	0.32	0.27	0.42	0.30
MI_Grand_Rapids	0.18	0.31	0.28	0.45	0.30
MI_Houghton	0.15	0.29	0.24	0.36	0.26
MN_Duluth	0.22	0.36	0.33	0.47	0.35
MN_Intl_Falls	0.20	0.34	0.26	0.39	0.30
MN_Minneapolis	0.19	0.39	0.26	0.43	0.32
MO_Kansas_City	0.17	0.29	0.26	0.41	0.28
MO_St_Louis	0.19	0.34	0.27	0.45	0.31
MS_Jackson	0.19	0.33	0.25	0.44	0.30
MT_Billings	0.22	0.32	0.30	0.46	0.33
MT_Great_Falls	0.20	0.34	0.30	0.45	0.32
NC_Charlotte	0.19	0.31	0.25	0.38	0.28
NC_Raleigh	0.18	0.29	0.25	0.44	0.29
ND_Bismarck	0.19	0.35	0.28	0.42	0.31
NE_Omaha	0.20	0.35	0.28	0.44	0.32
NH_Concord	0.20	0.36	0.30	0.47	0.33
NJ_Atlantic_City	0.20	0.32	0.28	0.44	0.31
NM_Albuquerque	0.18	0.33	0.25	0.46	0.30
NV_Las_Vegas	0.24	0.41	0.34	0.53	0.38
NV_Reno	0.21	0.36	0.27	0.48	0.33
NY_Albany	0.18	0.35	0.26	0.43	0.31
NY_Buffalo	0.21	0.37	0.32	0.49	0.34
NY_New_York	0.18	0.30	0.28	0.44	0.30
OH_Cleveland	0.19	0.32	0.25	0.42	0.29
OH_Dayton	0.15	0.23	0.23	0.37	0.25
OK_Oklahoma_City	0.14	0.26	0.29	0.49	0.29
OR_Medford	0.26	0.42	0.35	0.56	0.40
OR_Portland	0.18	0.37	0.33	0.49	0.34
PA_Philadelphia	0.19	0.32	0.22	0.36	0.27
PA_Pittsburgh	0.17	0.28	0.25	0.39	0.27
PA_Williamsport	0.19	0.33	0.27	0.44	0.31
RI_Providence	0.18	0.35	0.26	0.40	0.30

SC_Charleston	0.19	0.34	0.29	0.46	0.32
SC_Greenville	0.19	0.34	0.23	0.40	0.29
SD_Pierre	0.23	0.40	0.32	0.51	0.36
TN_Memphis	0.18	0.35	0.28	0.46	0.32
TN_Nashville	0.20	0.35	0.31	0.49	0.34
TX_Amarillo	0.19	0.34	0.29	0.47	0.32
TX_Brownsville	0.18	0.32	0.26	0.44	0.30
TX_El_Paso	0.21	0.37	0.30	0.49	0.34
TX_Fort_Worth	0.18	0.32	0.26	0.45	0.30
TX_Houston	0.14	0.25	0.24	0.40	0.26
TX_Lubbock	0.17	0.31	0.23	0.40	0.28
TX_San_Antonio	0.18	0.33	0.26	0.42	0.30
UT_Cedar_City	0.21	0.33	0.29	0.46	0.32
UT_Salt_Lake	0.21	0.34	0.30	0.46	0.33
VA_Richmond	0.18	0.30	0.25	0.40	0.28
VT_Burlington	0.20	0.33	0.29	0.45	0.32
WA_Seattle	0.27	0.47	0.39	0.62	0.44
WA_Spokane	0.23	0.40	0.33	0.52	0.37
WI_Madison	0.20	0.34	0.30	0.46	0.33
WV_Charleston	0.17	0.30	0.24	0.39	0.28
WY_Cheyenne	0.19	0.31	0.27	0.43	0.30
Average	0.20	0.34	0.28	0.45	0.32
Maximum	0.57	0.49	0.48	0.63	0.44
Minimum	0.13	0.23	0.22	0.36	0.25

A common misperception is that peak demand doesn't matter in northern climates. Table 3 shows results aggregated by the proposed Energy Star climate zones. The average is 0.32. This table also shows that the northerly climate zones like ES5a and ES5 have a calculated peak cooling demands bigger than most southerly climate zones. In short, in homes where air conditioners are installed, this data shows that summer electric peak demand is similar for all climate zones, even the northern ones.

Table 3

Average Peak Demand Savings Per Home (kW)					
Low Solar Gain Compared to Moderate Solar Gain					
Climate	New		Existing		
Zone	1 Story	2 Story	1 Story	2 Story	Average
ES5a	0.21	0.36	0.35	0.50	0.35
ES5	0.20	0.35	0.29	0.44	0.32
ES4	0.19	0.32	0.27	0.43	0.30
ES3	0.21	0.33	0.26	0.44	0.31
ES2	0.20	0.35	0.28	0.46	0.32
ES1	0.17	0.32	0.26	0.43	0.29
Average	0.20	0.34	0.28	0.45	0.32

In order to isolate the impact of 0.1 increase in window SHGC, I also compared in Table 4 two windows with the same U-factor and with a difference in SHGCs of exactly 0.1. This analysis also shows greater peak demand impact in northern zones and shows that each 0.1 SHGC increase accounts for an average 0.22/kW average increase in peak demand. Given the wide ranges of SHGCs considered in the proposed northern trade-offs (from 0 to 0.55), the impact of trade-offs, if utilized, could have substantial negative impacts on peak demand.

From this data, a simple assessment of the potential regional impact of increasing SHGC can be made. For example, according to US Census data, the average housing starts in the Northeast and Midwest over the past five years was approximately 615,000. Assuming that the replacement market is the same size as the new construction market, then with only a 0.1 reduction in average SHGC, this equates to 271 MW of power generation. This is about the size of two small power plants and saves 10,800 MW over 40 years.

Table 4

Average Peak Demand Savings Per Home (kW)					
Bronze Double Compared to Clear Double					
Climate	New		Existing		
Zone	1 Story	2 Story	1 Story	2 Story	Average
ES5a	0.16	0.26	0.22	0.35	0.25
ES5	0.14	0.26	0.20	0.33	0.23
ES4	0.14	0.23	0.19	0.31	0.22
ES3	0.13	0.23	0.18	0.31	0.21
ES2	0.13	0.24	0.18	0.31	0.22
ES1	0.12	0.22	0.18	0.30	0.20
Average	0.14	0.24	0.19	0.32	0.22

Energy Modeling Uncertainty

A major study such as the draft analysis requires many choices related to the building energy simulations upon which conclusions are based. Two of the most important choices are the software and the modeling assumptions.

This study used DOE2, one of the most respected energy analysis programs available. I recently had the opportunity to work with RemDesign, also a respected energy analysis program widely used to demonstrate compliance with building codes, voluntary programs like Energy Star Homes and with home energy ratings.

One of the studies I did included running a 2689 ft2 home with 2006 IECC energy features in five northern climates including Minneapolis, Seattle, Spokane, Portland and Concord. Two vinyl windows were modeled in this study, a low solar gain product (U-factor 0.34 / SHGC 0.32) and a high solar gain product (U-factor 0.37 / SHGC 0.56). In all of the climates but Spokane, RemDesign total source heating plus cooling energy results show that a low solar gain window had lower energy use than a high solar gain window. The savings ranged from -1% for Spokane to as 1.6% for Minneapolis.

This example illustrates two issues. One is that different software can yield different results and that the estimated energy differences we are sometimes comparing are so small as to be too close to call or within a reasonable margin of error. In the Minneapolis case, the difference in estimated heating and cooling cost was $8 per year out of about $1600. Small changes in assumptions could easily cause a switch in which window shows the most savings. It should be noted that there are many different viewpoints on the appropriate assumptions. For example, the IECC uses different assumptions than this study. Assumptions as to operator decisions that vary from home to home (like shading and temperature setpoints) can have a large impact. Orientation is another important feature that is not examined in the analysis. Sensitivity analysis should be conducted to determine if trade-offs are energy neutral.

Another uncertainty is that the benefit of high solar gain windows on heating depends on useful passive solar heat gain that happens only a few hours of the day on windows that are not otherwise shaded and that have the proper orientation. On the other hand, low solar gain windows typically also have the lowest U-factors for a given IG design, and a lower U-factor is always of value, even when the sun is not shining.

Given the modeling uncertainty that any simulation analysis is based upon, drawing to fine a point on the results should be avoided.

Recommendations for Phase 2 Criteria

Based on the analysis above and my years of experience, I do not recommend establishing a trade-off for SHGC and U-factor in the northern climate zones for Phase 1 or Phase 2. However, if such a trade-off is established, I believe that it is in the interest of a successful Energy Star program that the Phase II trade-off criteria be modified in climate zones ES4 and ES5. This conclusion is in part related to the concerns expressed about peak demand and modeling uncertainty above, but also concerns that as a marketing program, it is important that whole product families can meet the criteria with the same triple glazed option.

Furthermore, as triple glazing is not in wide use yet, there are many unknowns as to how these products will be designed, manufactured and NFRC-rated. Putting too fine a point on the criteria too tight could push manufacturers towards making unwise choices of gap thicknesses, spacers, gas fills and coatings that could affect the durability, appearance and adoption of the new criteria. A wider range of solutions with both one and two layers of low emissivity coatings and gas fill choices should be allowed.

At the stakeholder's meeting in August, I made comments about my concerns that the combination of U-factor and SHGC criteria in Phase II result in a specification that is too limited when you consider that most homes need a variety of products (vertical slider, fixed, patio door, etc.) for a complete family of window products. There is also the issue that grids/dividers can lower SHGC values in some cases that would cause a product without dividers to meet the criteria, but a product with the dividers would not meet the criteria.

Figure 1 illustrates some of the issues with the proposed criteria for climate zone ES5 related to the product family concept and dividers. Plotted on the graph is a family of products including a vertical slider, a casement, a fixed and a sliding patio door. Each product is shown with and without dividers/grids. Each mark is a specific triple glazed insulating glass (IG) option. The overall insulating glass width and gas fill is shown at the bottom. To keep the graph simple, only one Low E coating and surface is included. For a given product and divider, the various IG widths form a horizontal line.

Products to left of orange line meet proposed Phase 2 ES5 criteria. Products to the left of the blue dashed line have a U-factor of 0.28 or less, the maximum value in the proposed criteria. The violet, red and green lines represent alternative trade-offs that DOE should consider that would allow increasing numbers of products. This graph will change for every frame design and product operator type, and with grids/dividers. Grids/dividers shift the product SHGC values down, making it more difficult to meet the trade-off criteria.

The problem illustrated by Figure 1 is that with the specified low emissivity coating, only the fixed window consistently meets the criteria. The same low emissivity coating on other operator types either barely meet the criteria with the widest IG or don't meet it at all if dividers are included. The same pattern would repeat itself for any given glass option. I believe that this is going to cause major confusion among manufacturers, salespeople and buyers, especially in big box stores where products are stocked.

Setting aside the issue of the benefits of lower solar gain until the discussion of Figure 2, there are several possible solutions to the family problem. One is to move the trade-off criteria to one of the other lines that allow for more products to meet the criteria, such as the red line in this case with a cap of 0.28 U-factor shown with the blue dashed line.

Figure 1

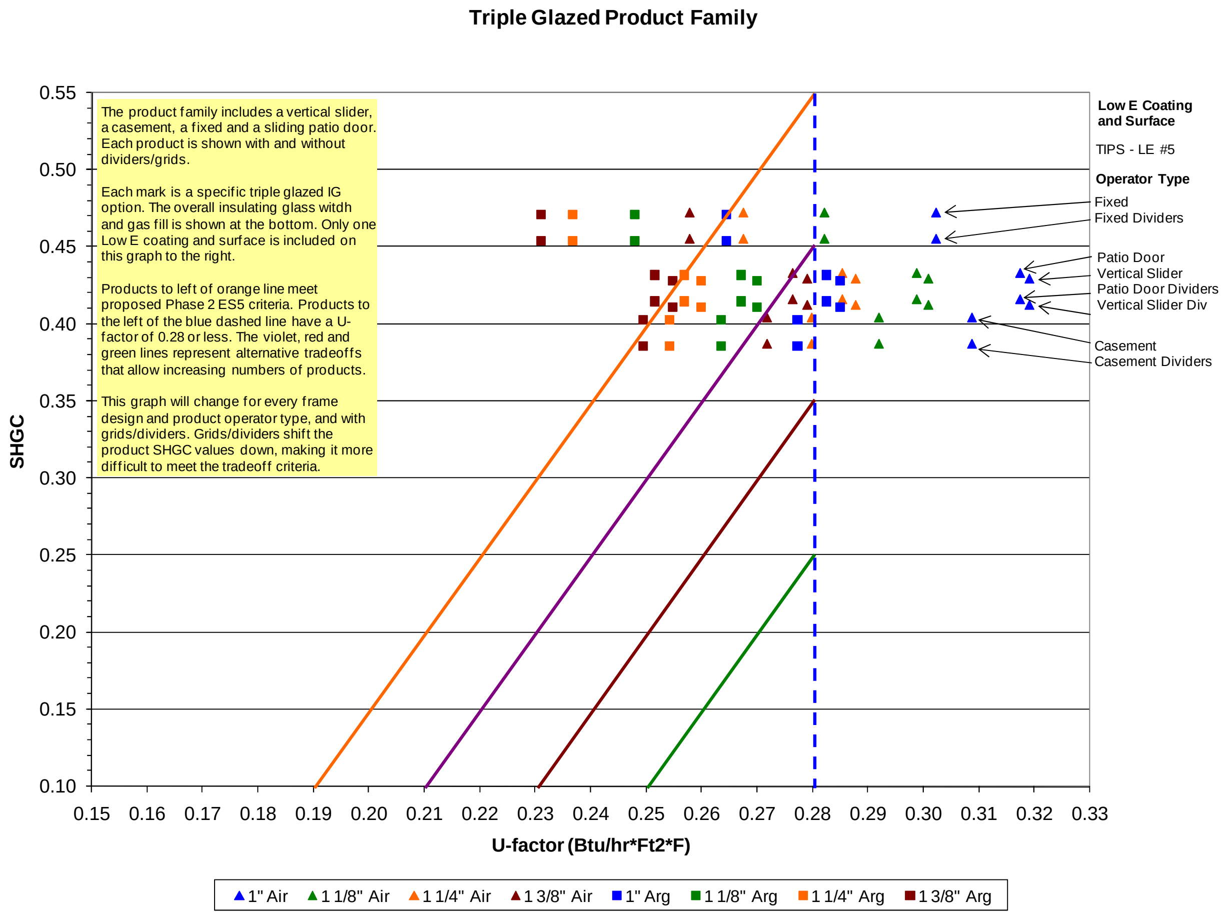
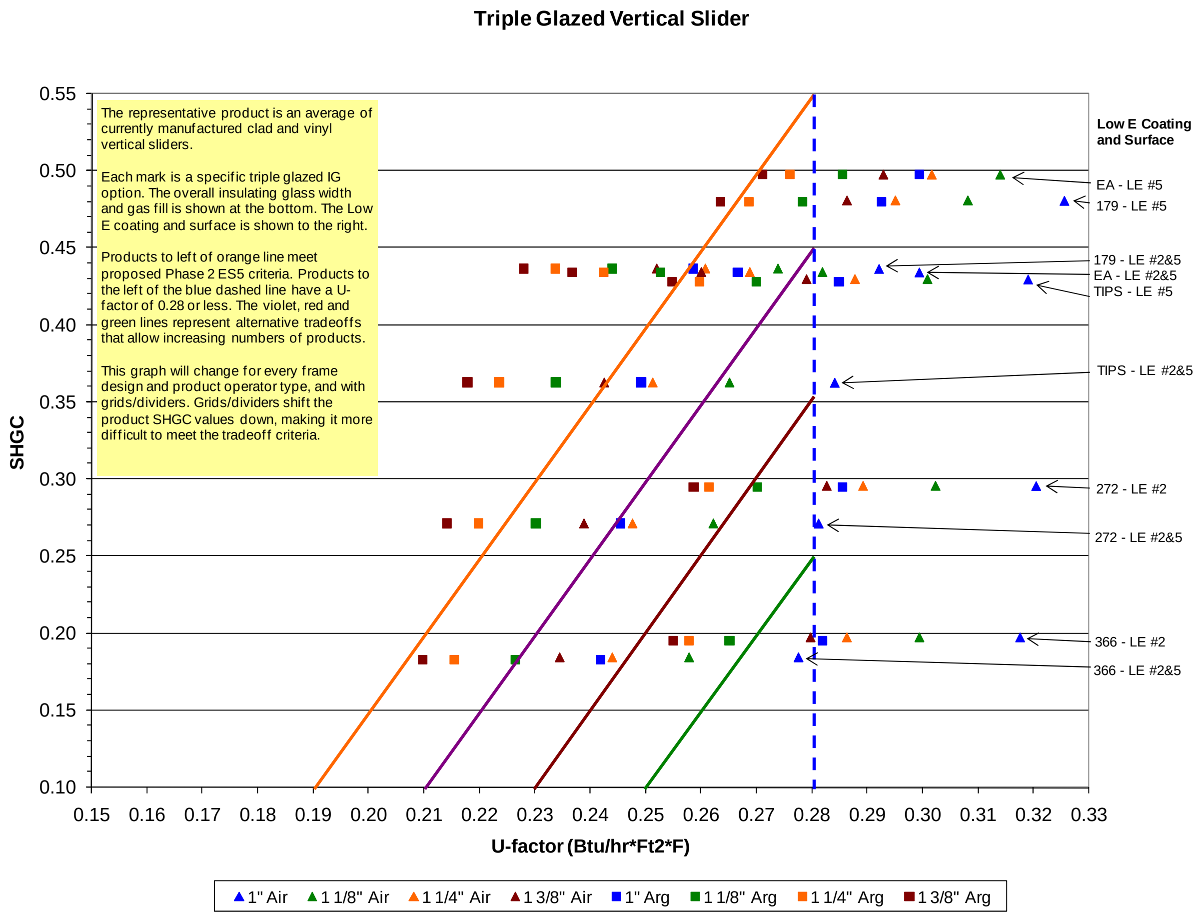


Figure 2 shows a number of triple glazed options for a representative vertical slider compared to the criteria for climate zone ES5. The representative product is an average of currently manufactured clad and vinyl vertical sliders. Each mark is a specific triple glazed IG option. The overall insulating glass width and gas fill is shown at the bottom. The low emissivity coating and surface is shown on the right. For a given glass option, the various IG widths form a horizontal line. The lines on the graph are the same as described for Figure 1. It should be noted that while this is a representative product, of course actual products will vary somewhat. However, this representative product does illustrate the issues with drawing the critiera so tightly.

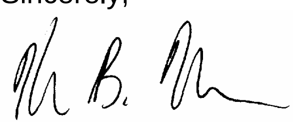
Limiting the product choices to only those to the left of the orange line will often lead to a less economic product that one to the right of the orange line based on the impact of peak demand, time-differentiated energy prices and the actual characteristics of individual homes. Again, there are several possible solutions to this problem. One is to move the trade-off criteria to one of the other lines such as the red or green lines in this case with a cap of 0.28 U-factor shown with the blue dashed line. This would also ease concerns about any unknowns related in switching to triple glazing on a large scale.

Figure 2



I would be happy to discuss any of my analysis with you and answer any questions.

Sincerely,



Ken Nittler, P.E.
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