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Subject: Comments on V7 Discussion Guide
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Attachments: image003.png

First off, let me say congratulations to EPA and ENERGY STAR on the market transformations brought forth by the windows program. In 20+ years the penetration of low-E glass in the residential market has expanded from around 30% to more than 80%. The ENERGY STAR program helped to identify that products were readily available. Today the national model energy codes reflect performance levels that require low-E glass everywhere in the country. DOE field studies on new construction code compliance demonstrated that windows, in all climate zones, were code compliant or better.

The Most Efficient program identifies the next level with a U-Factor of 0.20 Btu/hr·ft²·°F (1.16 W/m²·°K) for all U.S. climate zones, and is roughly in line with the upcoming 2020 ENERGY STAR Windows program for Canada. This U-Factor performance requires a step-change in technology; such as triple pane or vacuum glazing. Participation and sales to this level is limited as products and/or designs don't readily fit in standard windows. I encourage the EPA to keep this program in place, and as is, to enable more market transformation.

The challenge now is for the next version of the "standard" program. Do we need a Version 7 with incremental upgrades (and a lot of analytical analysis to validate the small savings beyond code)? My ***personal*** opinion is that Version 6 can be retired and the program relaunched under the banner of ENERGY STAR Replacement Windows. Most marketing studies put replacement sales at about ½ the national window volume. With the ENERGY STAR brand behind a replacement program this helps ensure that the once in a generation opportunity for replacement gets to a window energy upgrade.

Suggest that replacement program criteria match the latest version of the national code. This will be a great signal for remodelers and big box stores to demonstrate code compliance of their windows. As a replacement these products should definitely be "better-than" the typical single or double pane clear glass windows being replaced. Mapping will follow the current climate zones (zones 1 – 8) and a county level/zip-code database of requirements is easy to produce. Updates to the program will also be easy – criteria updates with the publication of the next version of the IECC. ENERGY STAR doesn't need to expend manhours and resource dollars on energy analyses as any changes/updates will have already been vetted in the public code process.

The criteria in the Version 6 program are pretty much optimized for the current level of technology with double pane glazing. U-Factors could be lowered by about 0.03 Btu/hr·ft²·°F, but that requires the addition of a 4th surface low-E coating, and/or massive changes in frame heat transfer. SHGC values are about as low as possible within the constraints of light transmission. Products that meet the Southern 0.25 SHGC typically use a spectrally selective low-E coating, most often of the triple silver variety. Cardinal's triple silver product has less than 0.01 SHGC outside of the visible spectrum. While there's definitely additional energy savings in the southern markets for SHGC lower than the current 0.25, it will come at the expense of visible light transmission. Rough rule of thumb to consider moving forward is that every 0.01 point of SHGC reduction will reduce light transmission by about 2 percentage points. There is no definition as to where glass becomes "dark" but we do know

that lower light transmission will generally impart more reflected color and move the low-E coating away from the residential preference for "clear" glass.

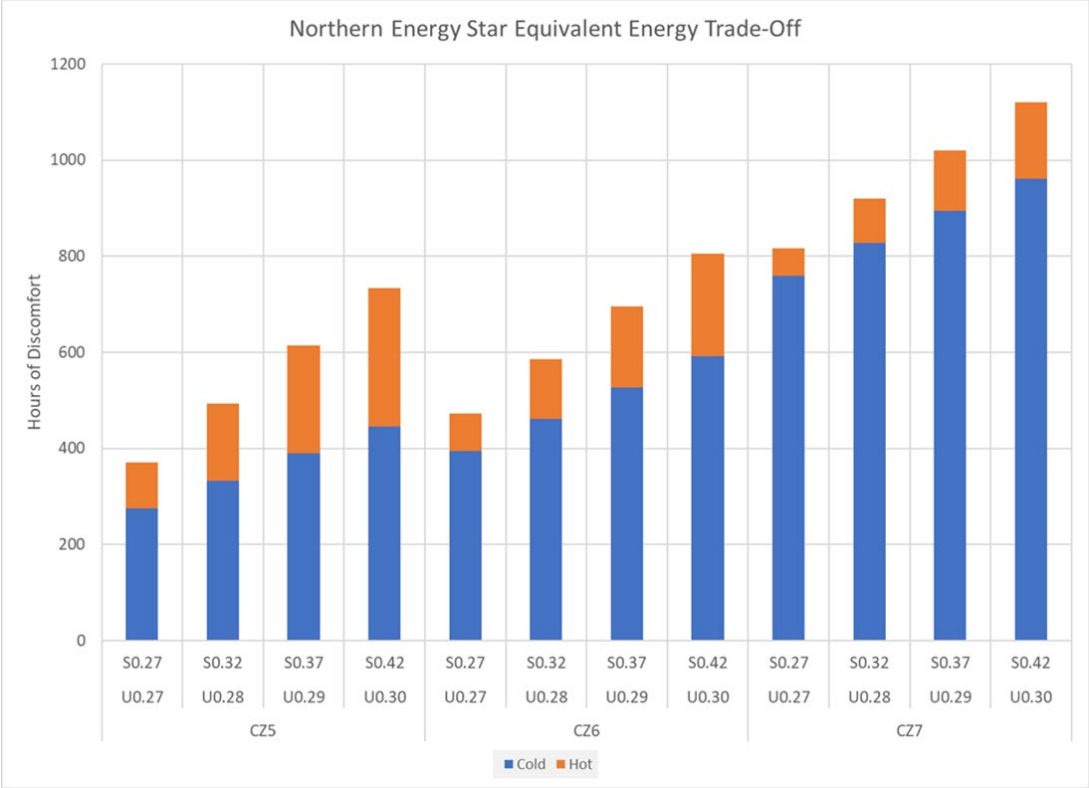
The challenge for a Version 7 program then is that a lot of energy (pun intended!) will be spent to demonstrate what I believe will be small gains in efficiency Previously EPA has stated that the window program needs to be better than code. Therefore, any new analyses should follow the protocols established for code determinations (see https://www.energycodes.gov/sites/default/files/documents/residential_methodology_2015.pdf).

From this, here's my list of modeling details that need to be addressed:

1. Analysis Program. Versions 5 & 6 used analysis from DOE2. New modeling needs to be performed using the Energy Plus program.
2. Weather Data. Analyses for V5/6 used TMY2 weather (1961-1990). While TMY3 data (1991-2005) is readily available for Energy Plus, I suggest that newer weather cycles be considered. ASHRAE Std169, using weather data from more recent times, rearranges the climate boundaries and has already been accepted into the 2021 IECC.
3. Population Weighting. My re-read of the 2008 V5 analysis work is that aggregation was done by regional window sales(??). I don't recall that this data has ever been presented, but I'd suggest a better method of weighting would be to use existing houses by county, in a regional aggregation similar to the discussions outlined in the methodology link above.
4. Calibration. My first impression of this discussion is either you believe in the analysis or you don't. None of the code activities (performance path scoring and PNNL determinations) use calibration. What does this add to the viability of the program criteria?
5. Regional Energy Data. V5/6 summed source energy using one set of national source scalars for gas & electric. Gas is consistent across the country, but electric source scalars vary by region, and have changed significantly since the V5 analyses in 2008. Also, source energy does not track well with consumer costs. My recommendation is to select an appropriate data source for regional gas and electric prices and that these need to be incorporated into the aggregation.
6. Fan Energy. Air-conditioner sizing (capacity) is driven by window SHGC. So too is the size of the air handler (furnace) fan. Window U-Factor has a minimal influence on fan sizing. When considering the energy trade-off between high and low solar gain glazing's it's critical that fan energy be included. Simply stated, the "big" fan needed to handle the extra cooling load from high solar gain windows adds a penalty to winter time performance as well. Winter run times with high solar windows may be shorter, but the "big" fan will draw more total power.
7. Orientation Sensitivity. V5/6 used the logic that the average of a neighborhood's energy performance with windows oriented in all directions can be represented by a modeling simplification using widows equally distributed on four sides (north, east, south, west). Where this fails is in the consideration of U versus SHGC trade-offs in houses with asymmetric window distributions. Let's consider that the typical house has most of the windows on the back and front sides (few windows on the ends adjacent to neighboring houses). For most locations in the northern zone the current trade-off fails for houses with West/East facades (and is marginal for those with a northern exposure). Is the trade-off valid if it fails to produce energy savings on ½ of the orientations? Should a next version of ENERGY STAR consider trade-off's it needs to be based on based on worst case orientation to ensure that all

exposures realize energy savings.

8. Thermal Comfort. Let's revisit the logic of the current Northern zone U:SHGC trade-off for low versus high solar gain windows. Why would it be considered "equal" to provide poorer insulating value (colder window) with a risk of winter daytime overheat and the near guarantee of hot discomfort in the summer? The trade-off subverts good passive solar design principles. The graph below shows three trends:
    - Increasing U-Factor increases hours of cold discomfort
    - Increasing SHGC increases hours of hot discomfort
    - The application of the same criteria across 3 widely different climate zone is questionable.



Put this all together and my analysis work suggests a next generation program something along these lines:

<u>Southern Zone</u>

- Climate zones 1, 2, and 3 (combines current Southern and South Central)
- Represents about 40% of U.S. housing stock
- U = 0.30 and SHGC = 0.25

<u>Central Zone</u>

- Climate zones 4 and 5 (combines current Central and lower 1/3 of Northern)
- Represents about 50% of U.S. housing stock
- U = 0.30 and SHGC = 0.40 (analysis actually suggests that SHGC = 0.30 might have more energy savings)

Northern Zone

- Climate zones 6, 7, and 8 (removes CZ5 from Northern grouping)
- Represents about 10% of U.S. housing stock
- U = 0.30 and SHGC = Any

A lower U-Factor in this new Northern zone would definitely save more energy, but I'll reserve judgement until more detailed payback analyses are performed.

In conclusion, I'm not convinced that the technical limitations of double pane glazing justifies the effort needed to layout a version 7 program. I'd fall back on above code house programs (such as ENERGY STAR Homes) to take care of more detailed window applications and again suggest that the area where ENERGY STAR can influence window selection the most is in the replacement segment.

Thank you for considering my comments.
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