April 22, 2022

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Subj: Comments on ENERGY STAR Windows Proposed Version 7, Draft 2

Mr. Anderson,

First off let me state that Cardinal Glass has a full portfolio of products that can be used by our window customers to achieve compliance with the proposed Energy Star Windows program requirements (ESW7.2), in all climate zones.

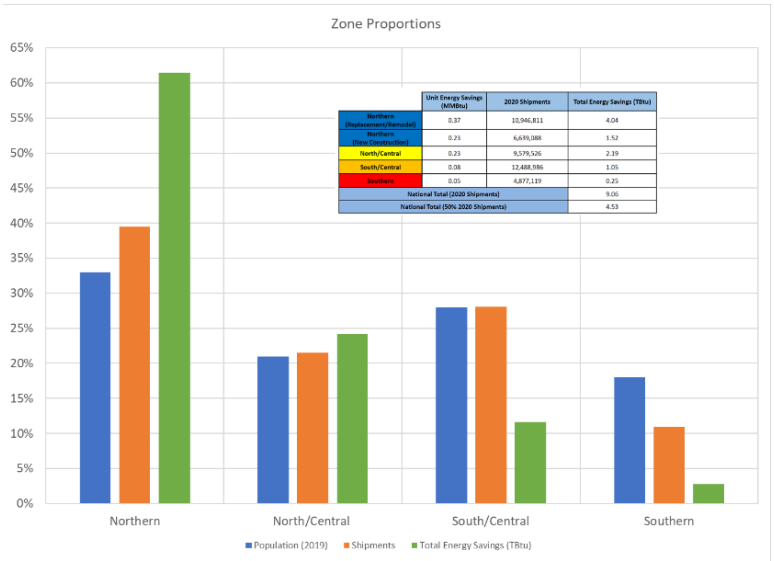
While my comments are being provided past the deadline, I hope you will still review them and take into consideration these concerns:

1. Inconsistency with energy code zones resulting in nearly 60% location error for regional population weighting. When is less than half right considered acceptable?
2. Inconsistency with code requirements for performance comparisons. The code defines the "measure" for proper energy analysis: section R405.2 says ***COST*** is the basis for trade-offs.
3. Zone groupings. North and North Central group differently when errors 1 & 2 are fixed.
4. No consideration for the long-standing Energy Star program objectives on atmospheric pollution prevention. High solar gain and the incipient increase in air-conditioning electric load will increase total emissions.
5. Inadequate consumer protection. Lack of orientation consideration in the Northern zone's proposed U:SHGC trade does not follow mandatory energy code requirements and results in increased consumer risk. IECC Table R405.4.2 states that equal window distribution is used to establish the energy budget which is then compared to actual building orientation. Above code programs like Resnet suggest using a worst-case orientation to qualify all potential orientations. This is essential consumer protection provided in the energy code, as well as in the home energy ratings arena. ENERGY STAR Windows should embrace a similar construct.

As a reminder the ENERGY STAR website states: "energy efficiency means…. cutting energy bills and reducing pollution." The version 7 draft for the windows programs has abandoned the founding principles of consumer costs and atmospheric pollution prevention by adding site heating energy to site cooling energy. This ignores all the process conversion and delivery (in)efficiencies. Consumers don't get this choice – they must pay for the delivered energy cost!

Code Zone Concerns.

The following graphic was developed from summaries presented in the Draft 2 stakeholder webinar on March 1, 2022. Why are the zone savings so disproportionate? The Northern zone is tagged with savings nearly twice its population while the two southern zones skate-by with underwhelming contributions.



	Unit Energy Savings (MMBtu)	2020 Shipments	Total Energy Savings (TBtu)
Northern (Replacement/Remodel)	0.37	10,946,811	4.04
Northern (New Construction)	0.23	6,639,088	1.52
North/Central	0.23	9,579,526	2.19
South/Central	0.08	12,488,586	1.05
Southern	0.05	4,877,139	0.25
National Total (2020 Shipments)			9.06
National Total (50% 2020 Shipments)			4.53

The primary reason for my delay in getting these comments to you is that I took on the task of finishing the analysis that your team failed to address in v7.1 and subsequently overlooked again with v7.2. While the population totals have been updated to data from this century, they are aggregated against "old" climate zone groupings from the previous energy code. The 2021 IECC updated climate zone mapping based on work from ASHRAE Standard 169. Understand that this group used a more recent time frame to update design temps and degree days used for the zone assignments (and hence equipment sizing). ASHRAE did not, however, update the TMY3 weather data used for energy analysis. Therefore, failing to update the regions/population weightings properly means that all the ESW v7 efforts on zone updates has been time wasted.

The PNNL Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes (energycodes.gov) is the backbone for code determinations and was used for ENERGY STAR Windows version 6. In essence, state level climate/moisture zone "regions" are established with 1 representative city (typically the most populous) assigned to each region. In the old (pre-2009) code climate zones there were 120 climate-specific regions at the state level. About 15 of the representative cities selected by PNNL were used for multiple regions (example: Elkins, WV was used for WV_5A and NC_5A) or were out of the state (example: Tucson, AZ class 1 weather used for CA_2B).

Fast forward to the new code, 2021, and there are now 127 regions per the Standard 169 groupings. While it is not shown on the IECC climate zone maps, the Wet-Humid climate delineation still exists, and I've included it my analysis of region grouping. ESW increased the list of locations to 132 weather sites but the locations were **NOT** adjusted to the new climate regions and groupings.

Here is the list of grouping errors in v7.2 that I have discovered:

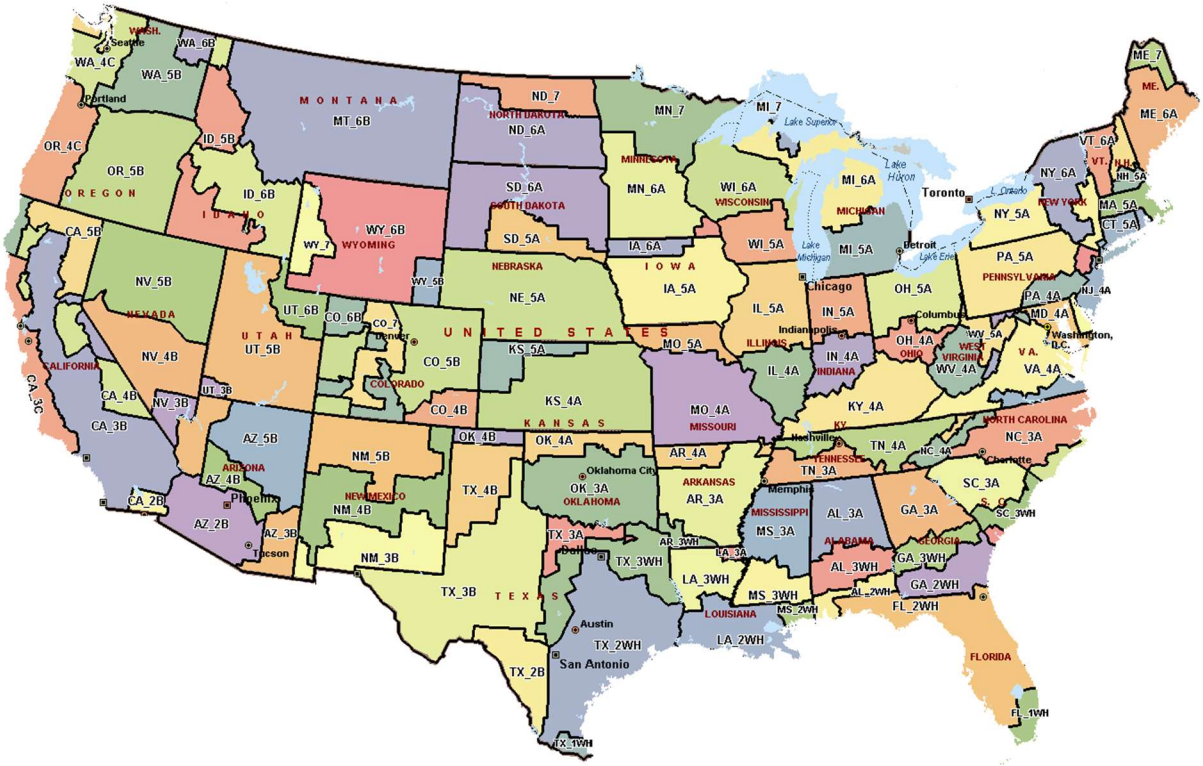
- 32 regions with no representative location (example: North Carolina 4A and 5A)
- 14 regions where population is too high (example: MT_6A is 40% more than census)
- 12 locations assigned to the wrong region (example: Madison for Wisconsin zone 6)
- 8 regions with a low population count (my definition is +/- 10% of census)
- 7 duplicate locations in a region (example: Omaha and Scottsbluff for zone 5A in Nebraska)
- 5 locations that are not the regions' most populous (Pocatello versus Idaho Falls for ID_6B)

This totals 78 errors out of 132 locations in v7.2. No proportioning was done by EPA to include the new Alaska zones 5 and 6. Also, why is it that the "updated" ESW v7.2 map doesn't show anything for California zone 3C?

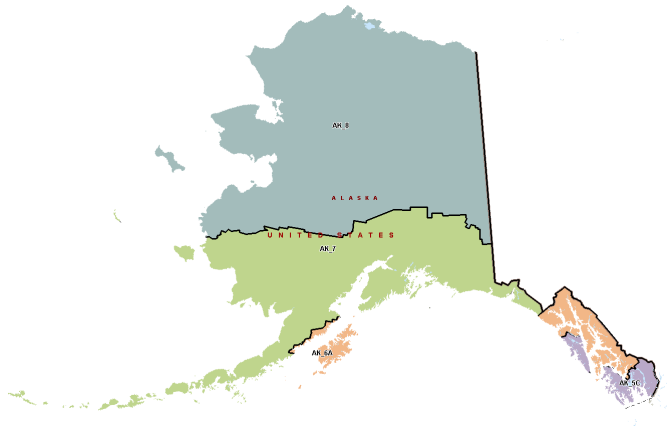
Lastly, all this zone re-alignment effort suggests that ENERGY STAR considers the 2021 code as the basis for proper comparison. If the code is the basis, how can the second proposed trade step in the ESW v7.2 Northern zone be allowed? U=0.26, SHGC≥0.40 is in violation of the SHGCmax for zone 5.

Following is a map of what the new region groupings look like for the Lower 48 and for Alaska. Note there where continuity gaps in NC_4A and NC_5a; I filled these in for better visualization.

Lower 48 Regions



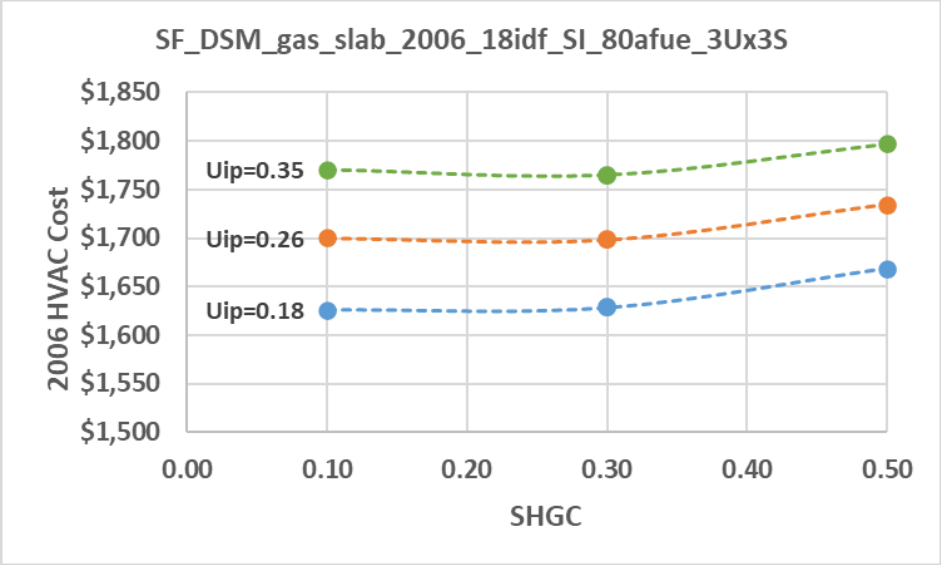
Alaska Regions



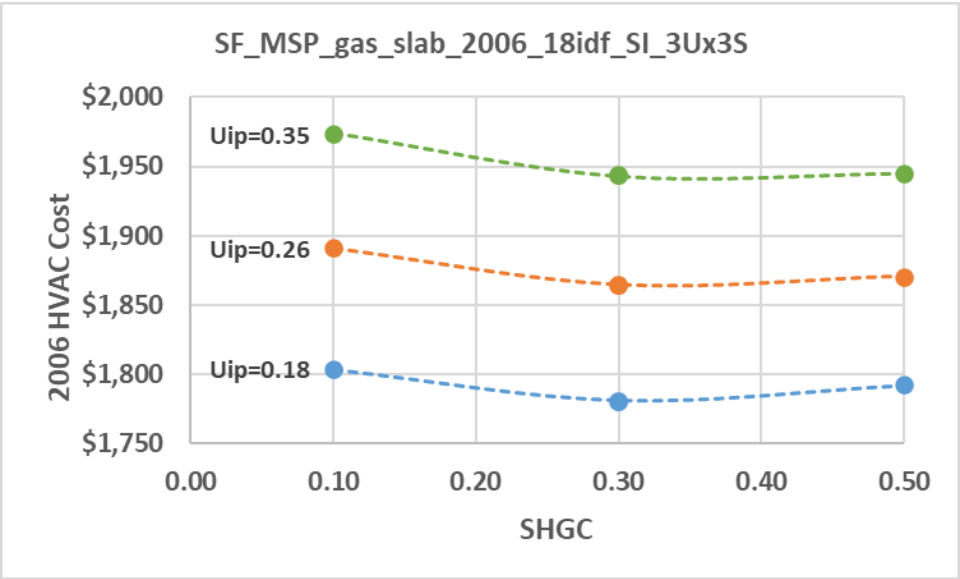
Note that Alaska zones 5C and 6A are new for the 2021 code and where not considered in EPA's population weighting.

<u>Performance Comparison Concerns</u>

The following graph is a parametric analysis for a climate zone 5 example using trade-off **<u>costs</u>** from the ESW7.2 regional fuel prices. The upward slope with increasing SHGC suggests that, from the consumer perspective, high solar gain windows fail the proposed trade-off, for all window U-Factor's.



Moving on to zone 6 notice that the SHGC trend slopes down and that cost is optimized at about 0.30 SHGC. There are no additional savings for increasing SHGC beyond the optimum point.



A two-parameter linear analysis of the zone 6 data give us an equation of the form:

Energy Cost = $1,647 + $914*Uip - $50*SHGC

It's unfortunate that EPA abandoned the proven regression techniques developed by LBNL for use in the version 5 and 6 research. Trend analysis simplifies the number of runs needed (I guess EPA didn't need to save energy when it came to computer run time!) while the magnitude of the U-Factor and SHGC scalars give us insights into regional responses.

The tabulation below shows the regional variation of each regression scalar. The scalar labeled ***b*** is for non-window related portions of the building (think opaque). The magnitude of the ***b*** varies with building insulation level, air leakage, HVAC efficiencies, etc., and the severity of the winter weather. The sign convention on ***m2*** gives us a clue as to how solar gains affect the total HVAC costs. A negative ***m2*** says that passive solar gains are more of a benefit to heat energy savings than a penalty on air-conditioning. A positive sign on ***m2*** says solar gains increase total costs. Passive gains in the winter are always beneficial (up to the point of overheating the building) but a positive value to ***m2*** says the air-conditioning penalty overcomes the winter savings.

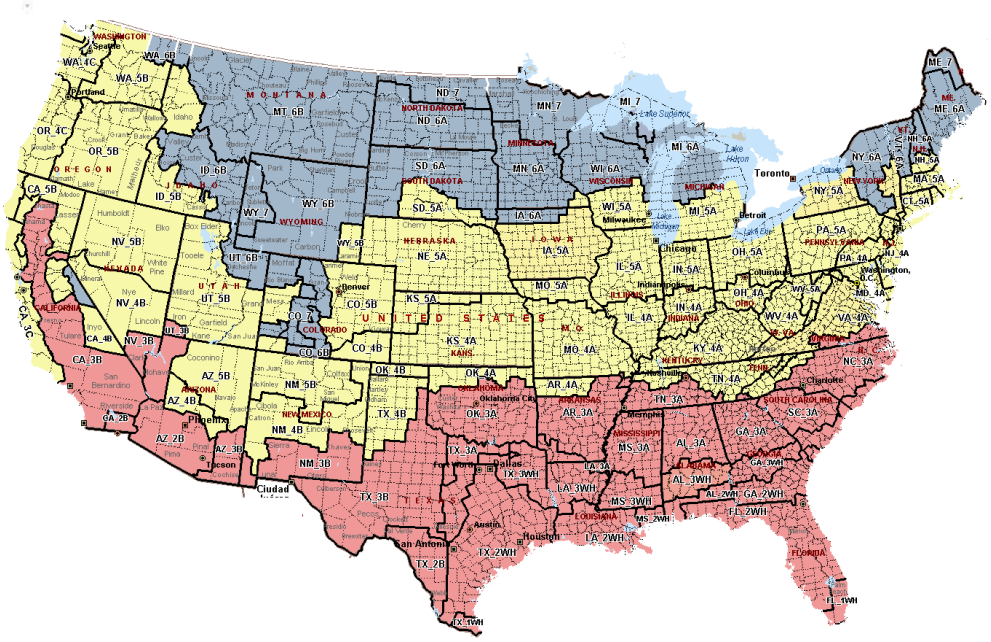
Zone/Furnace Efficiency	Opaque (*b*)	U-Factor Scalar (*m1*)	SHGC Scalar (*m2*)
Zone 4, 80% AFUE	$1248	$602	+ $209
Zone 5, 80% AFUE	$1480	$772	+ $86
Zone 6, 80% AFUE	$1647	$914	- $50
Zone 7, 80% AFUE	$1885	$1136	- $248

Climate Zone Groupings

The colorization of the table above is intentional. Regression coefficients suggests similar window responses for zones 4 & 5; they are colored yellow to match the current North-Central window zone. Zones 6 & 7 get the blue zone coloration of ESW North as the window responses show passive benefits (albeit small in CZ6). When the population proportioning is correctly applied climate zone 5 represents 84% of the existing ESW Northern zone. How can CZ6 and 7, at only 16% of the Northern population, overpower the trade-off as the EPA grouping/analysis suggests? Climate zone 6 should be separated from CZ5 and grouped with CZ7/8. It's not shown in this table but regression coefficients from all locations suggest that the ENERGY STAR Window zones could be simplified to this:

ENERGY STAR Zone	IECC Climate Zones
North	6, 7, and 8
Central	4, and 5
South	1, 2, and 3

Here's a visual of the 3 zones:



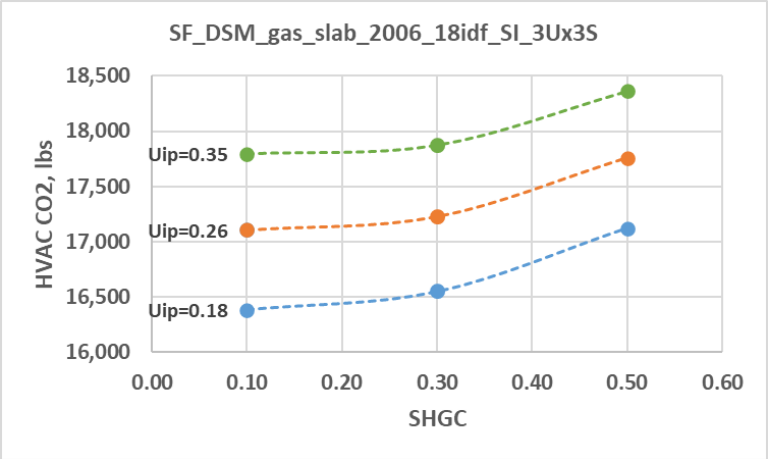
Condensing Furnace

Code protocol is to use DOE minimum equipment efficiencies, but I wanted to point out how the scalars change if equipment changes. Furnaces tend to have a shorter life expectancy than windows and so a homeowner interested in improving window efficiency likely has already faced a replacement decision with their furnace. The yellow highlight in the table below shows that a homeowner in climate zone 6 who has already done an ENERGY STAR furnace will have a cost penalty should they choose (the lower cost) of the proposed ENERGY STAR Northern zone high solar gain trade-off.

Zone/Furnace Efficiency	Opaque (b)	U-Factor Scalar (*m1*)	SHGC Scalar (*m2*)
Zone 5, 92% AFUE	$1329	$676	+ $142
Zone 6, 92% AFUE	$1450	$795	+ $9
Zone 7, 92% AFUE	$1662	$992	- $181

Pollution Prevention Concerns

The next plot further demonstrates that the proposed SHGC trade-up in climate zone 5 fails the ENERGY STAR goal to reduce **emissions**. Compare this to the earlier plot on costs and we see that the upward slope on SHGC is even greater when CO_2 is considered.



The new ESW criteria should be developed recognizing that winter design temperatures drop by about 10°F per climate zone. Does it, therfore make any sense that a location in climate zone 7 (about 40°F colder than CZ4) can install an ES Window with U=0.26 while the southern location must use U=0.24. This is ludicrous!

Last thing on the trade-off analysis I'd like to address is metric (SI) units versus Inch-Pound units. The Energy Plus program only runs with metric inputs (it's not possible to input U-Factor's in units of Btu/hr·ft^2·°F). The EPA results tables showing GJ energy (metric) versus Inch-Pound U-Factor tells me that the metric U-Factor input values (W/m^2·°C) have been converted. EPA displays IP U-Factor's in increments of 0.01 Btu/hr·ft^2·°F . Does this mean that the precision levels for the Energy Plus input was in increments of **0.05678 W/m^2·°C** or was editorial license taken on the rounding protocols? This conversion has been a continual angst for NFRC on addressing cross border unit precision and I want to be certain that we're not re-introducing conversion problems into ENERGY STAR Windows.

<u>In Conclusion</u>

In the ESW v7.1 discussions there was a response stating: "EPA plans to advise consumers of the potential for cooling energy losses when selecting high gain windows and provide guidance on how cooling energy can be reduced with common window attachments or other solutions". So, the consumer protection advise of EPA is buy an ENERGY STAR attachment to "fix" the problem created with an ENERGY STAR Version 7 Window?

While the proposed trade for the Northern zone does makes it *<u>easier</u>* for Cardinal's customers to comply, and as stated earlier we have all the glass products needed, I don't believe this fits the ENERGY STAR program mantra of encouraging and promoting leading edge technology. Sounds more like bait-and-switch as opposed to product improvements.

Regards,

Jim Larsen

Jim Larsen
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