CARDINAL Glass Industries

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Most of the products listed on the EPA ENERGY STAR website utilize a single fuel. Example: natural gas for water heaters or furnaces and electricity for light bulbs, televisions, refrigerators, heat pumps, etc. In these product scenarios the use of site energy comparisons works as the efficiency of the energy supply isn't an issue.

EPA's benchmarking discussions recommend using source energy for comparing buildings (see https://www.energystar.gov/buildings/benchmark/understand_metrics/source_site_difference). Like buildings, windows are unique in that the combination of U-Factor and SHGC can affect both heating and cooling energy. For natural gas combustion furnaces and electric compression refrigeration cooling systems the "supply" efficiency of these fuels is radically different. The national supply of natural gas is approximately 90% efficient (mostly pumping losses) and electricity is around 30% (power plant thermal losses plus transmission/distribution losses).

The ENERGY STAR Windows version 7 criteria analysis and report are technically flawed in the usage of "equivalent" and "energy savings" in that disparate energy streams (gas and electric) are added directly at site. This violates two of the guiding principles listed on page 4 of the report:

- Statement 1: significant national energy savings (site ≠ national)
- Statement 3: utility bill savings

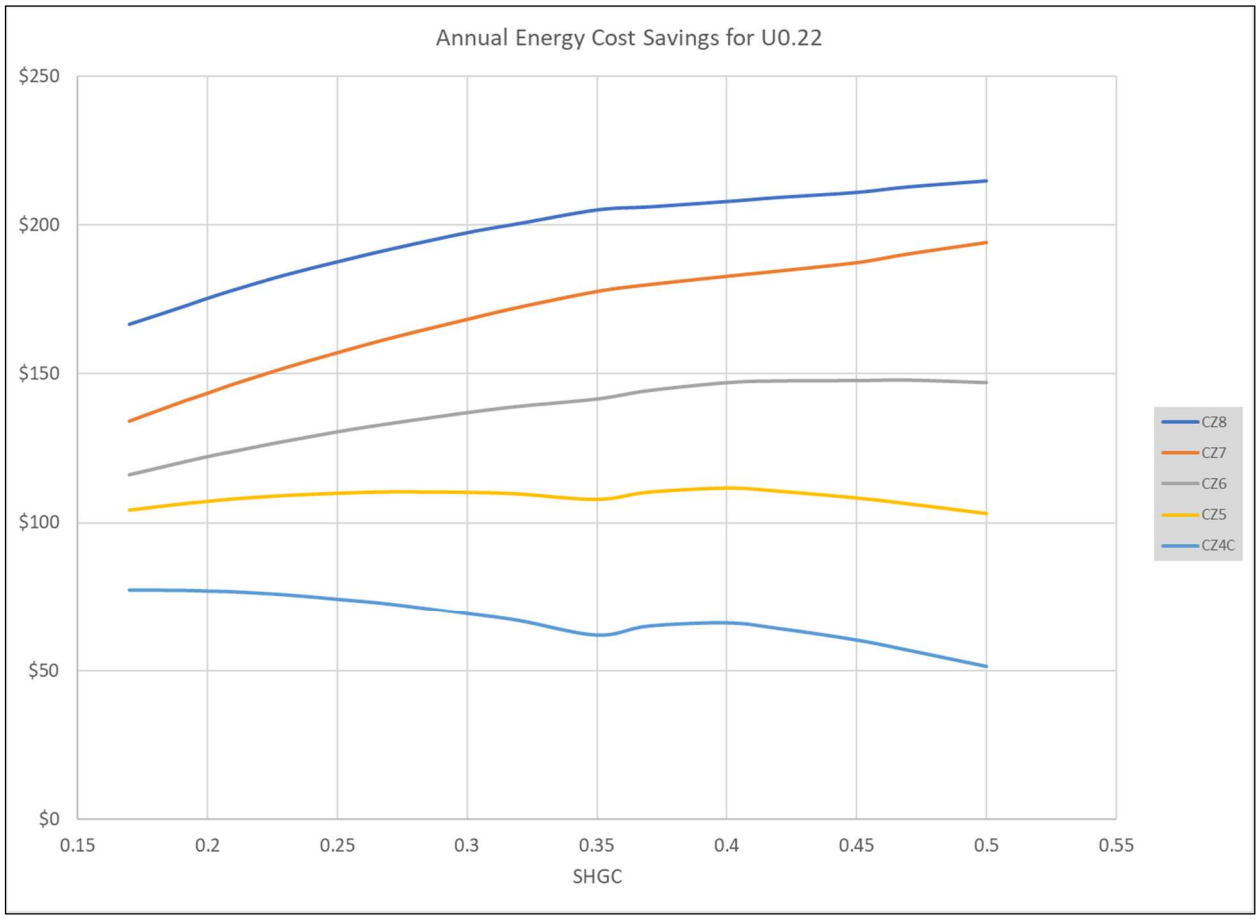
The disconnect in using site energy as an equivalence measure is observable in Table 13. Climate Zone 5 sees a 36% reduction in dollar savings across the "equivalent" steps and CZ6 is shows a 21% drop. How do we explain that to consumers?

Graph 1 (next page) plots the annual energy savings (market baseline) for each climate zone in Northern as presented in the spreadsheet *WDS_V7_Draft 1 Data3a - Results and Assumptions.* Note these dollars are based on the ENERGY STAR energy price assumptions presented in Table 9. We'll use this data as presented but it's my contention that energy prices should be local (state level) and consider time of year pricing fluctuations.

The different slope/direction of each zone line says that the proposed grouping of climate zones 4C through 8 into Northern is wrong.

- The upward slope of the climate zone lines for 6, 7, and 8 suggest a passive benefit with high solar gain (more on this later).
- Climate Zone 6 is about 89% of the population in CZ6-8 and as such will dominate any discussion on potential solar trade-up in this region.
- The slope of the line for climate zone 5 is flat: no change in consumer cost regardless of SHGC (equal cost trades between gas heating and electric cooling).
- The flat line for CZ5 is consistent with the 2021 update to the IECC which set a 0.40 SHGC maximum for the zone. Note to EPA: this update to the 2021 code was missed in the code development discussions.
- The downward slope (reduced savings) in CZ4C reinforces the SHGC cap for zones 5 and 4C.

Graph 1

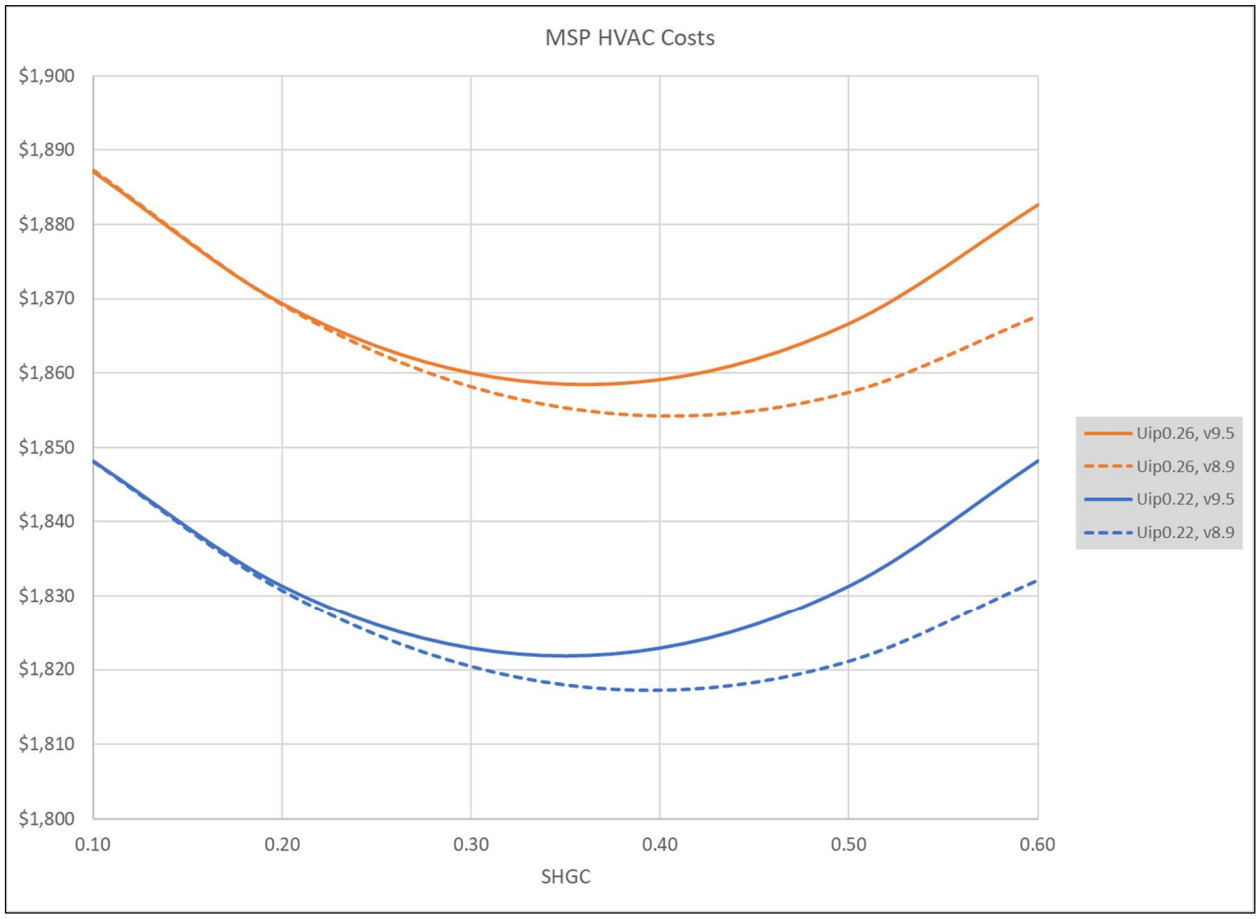


The "bump" in the profile at SHGC around 0.35 is from a modeling error in the Energy Plus program for all versions prior to 9.4 (including version 8.9 used in this analysis). For more background on this see this link: [Fix issue where simple glazing system had negative absorptance at some incident angles by nealkruis · Pull Request #8001 · NREL/EnergyPlus · GitHub]. Note that this update to Energy Plus occurred after the ENERGY STAR modeling was run.

This negative absorptance error led to an over-estimate of heating loads, on the order of 2%, and an under-prediction of cooling that varies by climate zone (from 3% in the south to >10% in the north).

Graph 2 is a visualization of the change in HVAC energy costs as a function of SHGC in Minneapolis with the error correction. Note: these trends were developed from E+ runs I did on (121) window U and SHGC combinations for (1) archetype (gas furnace, slab-on-grade). Percentage wise the modeling change isn't of huge consequence, but the slope of a potential trade-up line will be flatter than the Version 7 Draft (uncorrected) data suggests.

Graph 2



As an OEM supplier to the window industry Cardinal has no experience in retail sales and can't offer any meaningful insights on the payback analysis. I will observe however that the science behind the cost model trend line in Figure 10 is not readily apparent. Once the energy modeling issues are corrected the inclusion of better statistical analysis on costs would be supportive for guiding principle #3.

Even with the window modeling glitch in previous versions we support the switch to the Energy Plus program. E+ is now the de-facto standard for both residential and commercial building energy simulation. In my experience Energy Plus is better suited to handle passive solar gains versus the older DOE2 program.

A large part the ENERGY STAR Windows summaries/conclusions comes from proportioning scalars developed from other datasets. The comments below outline aggregation (and other) concerns we have with this analysis as presented:

- The PNNL Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes (energycodes.gov) provides detail on weighting of foundation and heating system types (see chapter 4 in report on Aggregating Energy and Economic Results). EPA has not shared this information other than blanket statements such as "LBNL consolidated approach" or "utility rates based on population-weighted average".
- The data from the 16 foundation and heating systems has not been released, only the aggregation from the unreleased weighting approach. I would like the chance to evaluate both. It's my contention from previous work that foundation type doesn't matter for window performance, and from this we could greatly simplify future window analysis parametrics.
- Adopt the rolling baseline approach used by PNNL to simplify the output. In essence the last version of ENERGY STAR becomes the comparison point. The confusion of multiple baselines (Market and Code) is not needed.
- The population provided with the windows documentation show 281 million people, about what the 2000 census totals are. Why did we spend all the time and effort to update the climate zone maps with 20-year-old population data? The accuracy of the population weighted utility rates used in the cost analysis are now in question.
- In PNNL's code determination analysis they created 120 state level climate regions to cover the United States. Basically there's one representative weather site for each state level climate zone. I'm questioning the logic of EPA's list of 132 cities. As an example: Minnesota zone 7 per 2019 census is 633,000 people and uses Duluth (the most populous city in the region). EPA has 3 cities in the region totaling 1.1 million people. Nearly double? Not trending right for accurate aggregation summaries!
- The U.S. has grown from year 2000 by nearly 17% to 328 million people. In that same time period, the Northern zone population has increased by only 4%. Zones 6-7-8 from 2019 census numbers show a population decrease of 22% when compared to the numbers in the EPA distributions. Current numbers show zones 6-7-8 are about 5% of the U.S. population.
- Incorporating the 2021 IECC climate zone changes did not affect the building energy modeling. The simulations still use TMY3 weather data, which is 30 years old. The zone proportioning now uses a combination of 20 year-old population data and 30 year-old weather.
- While the aggregation is set up for 120+ localities EPA choose to use the "big" ENERGY STAR regions weighted to the (old) population levels. Why not use local prices? This will better accommodate the guiding principle on consumer utility bill savings.
- Look into seasonal fuel pricing, not just annual average. EIA datasets I've downloaded show heating season gas prices about 20% lower than the annual average, and cooling season electrical prices about 10% higher. This varies from region to region (a likely consequence of state level utility commissions). All the more reason to use the local data.

- EIA shipment data for ENERGY STAR furnaces show about a 40% market penetration. Given the short life span of furnaces relative to windows it seems reasonable to expect some significant penetration of condensing furnaces when windows are being replaced. I suspect, but haven't had a chance yet, to detail air-conditioner penetration in a similar manner. Suggest that EPA include this in the updated analysis.
- Bears reminding that the NFRC product database is a representation of what's offered, not what's sold. Manufacturers include nearly all options in the initial product certification to avoid rework later.
- The Orientation Sensitivity analysis (figure 10, page 38) suggests passive solar benefits are agnostic to orientation? The analysis is flawed for the same site energy deficiencies discussed earlier (no cost data is included for consumer analysis like Graph 1).
- Think about the comfort implications for the suggested Northern zone trade-up: it's okay to sacrifice winter night insulating value on the promise on daytime solar gain, irrespective of orientation or time of year. Sounds like a recipe for colder rooms in the winter night and hot spaces when the sun shines. Is there an equivalence disclaimer for this?
- There doesn't seem to be a technical justification to the 0.17 minimum SHGC in the Northern zone, other than that it's EPA's job to guard against dark glass. Seems like this is a regulation looking for a problem rather than trusting the consumer to make informed purchasing decisions.

The analysis work behind this version is disappointing compared to the regressions/trend analyses used in the last 2 versions. Why would EPA be proud of running 566,000 simulation runs and then publish tabular datasets with **"n/a"** included? Oops, we didn't plan our experiment very well?

As I've mentioned before I think it's time to retire this program. Declare victory. ENERGY STAR Windows has transformed the market for code compliant windows. The Most Efficient program is for all practical purposes the same as this version 7 proposal for northern zones.

What's next? ENERGY STAR for Replacement! The "inventory" of existing windows that will need replaced in the next 30 years is huge and consumers need clear messaging on proper selection. ENERGY STAR could adopt each new code version as it's implemented (the 2021 version would already be in play) without having to do expansive (expensive?) analyses like this. I think good market penetration into this program would save more energy in the long term than a program with the best paper performance. And I much rather see EPA behind this effort as opposed to multiple marketing attempts from the industry.

I'd be happy to assist in any further reviews and provide copies on my background information.

Regards.

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