

The MSVD Low E 'Premium Performance' Myth

– Actual energy conservation performance of different types of Low E glazings in residential windows

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The current market for low emissivity (Low E) glazing is primarily supplied by two types of technology: 1) On-Line Chemical Vapor Deposition (CVD) and 2) Off-line Magnetron Sputtered Vacuum Deposition (MSVD). MSVD technology is employed to produce a transparent metallic 'soft' Low E coating (single or multi-layer) on the glass surface which requires special equipment and handling procedures to fabricate this glass into an Insulating Glass Unit (IGU). This coating is applied by special 'off-line' equipment after the glass has been formed, cut to size and removed from the floatline. CVD or 'pyrolytic' technology is employed directly on the floatline to produce a transparent conductive tin oxide (SnO₂) coating on the glass surface as the glass is being formed. This 'hard' Low E coating is covalently bonded to the glass, hence this product is actually more durable than uncoated clear glass.

Historically, the focus of the energy efficient fenestration industry has been the promotion of a window's ability to minimize heat transfer. Hence, Low E glazing has been predominantly marketed as an effective element to significantly reduce heat loss from a building through a window. More recently, solar selective Low E glass has equipped windows in warmer climates with the ability to minimize the amount of solar energy transferred into a building while allowing significantly more daylight to enter than allowed by reflective and tinted glass.

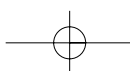
This focus on reducing energy transfer to maximize a window's thermal insulating performance has had the following significant impacts on the Low E marketplace in the United States and Western Europe:

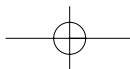
1. Building codes and standards that promote energy efficient residential fenestration in heating dominated (cooler) climates require only maximum allowable U-factors;
2. Codes and standards for cooling dominated (hotter) climates require maximum allowable U-factors and maximum allowable solar heat gain coefficients (SHGCs); and

For moderate or heating-dominated climate zones, the 'High Performance' characterization of low solar heat gain sputtered Low E coatings is a MYTH!! In fact, available glazing products with slightly greater U-factors and significantly higher SHGCs (Pyrolytic Low E), deliver significantly and drastically superior energy performance in heating dominated climate zones.

3. Creation of the widely held market perception that, in a heating dominated climate, 'high performance' Low E coatings are those possessing the lowest emissivity (ϵ), regardless of the SHGC provided by the coating.

The emissivity of pyrolytic Low E glass typically ranges from 0.15 to 0.20. The emissivity of MSVD Low E glass ranges from 0.04 (double stack) to 0.08 (single stack). Focusing solely on emissivity, it appears that the MSVD product is clearly superior from a thermal performance standpoint. The double stacked





Surface Treatment

GLASS	REPRESENTATIVE PRODUCT	WINDOW U	WINDOW SHGC
Clear glass	--	0.42 BTU/ hr-ft ² -°F 2.40 W/m ² -K	0.55
MSVD 1: Low SHGC MSVD Low E 'High Performance Low E'	Cardinal LoE ²	0.28 BTU/ hr-ft ² -°F 1.61 W/m ² -K	0.31
MSVD 2: Moderate SHGC MSVD Low E	AFG Comfort Ti-PS	0.28 BTU/ hr-ft ² -°F 1.62 W/m ² -K	0.43
Pyrolytic 1: Low SHGC Pyrolytic Low E	Pilkington SolarE	0.31 BTU/ hr-ft ² -°F 1.77 W/m ² -K	0.35
Pyrolytic 2: High SHGC Pyrolytic Low E	Pilkington Energy Advantage	0.31 BTU/ hr-ft ² -°F 1.77 W/m ² -K	0.51

Table 1

MSVD coating enables the window to achieve a U-factor of 0.28 BTU/hr-ft²-°F (1.61 W/m²-K) when applied on 3mm glass in an argon filled vinyl framed window. Employing a pyrolytic Low E coating instead of the double stacked MSVD coating in this same window provides a product with a U-factor of 0.31 BTU/hr-ft²-°F (1.77 W/m²-K). Solely due to this U-factor distinction, the current US and W. European market perception is that the double stacked MSVD (DS MSVD) Low E glass is the 'premium product,' and that pyrolytic Low E glass provides inferior energy conservation performance.

Although the U-factor is a critical element, especially in a climate where a significant temperature difference exists between a building's interior and exterior, it is not the sole characteristic upon which the overall energy performance of a window should be based. An equally important metric is the window's solar heat gain coefficient (SHGC or g). For cooling dominated regions of the United States (below 3500 Fahrenheit Heating Degree Days – HDD°F), a window's SHGC is viewed as a critical energy performance element by the building codes, government sponsored 'encouragement' programs (Energy Star), as well as the marketplace. Hence, these codes and voluntary programs require a window's SHGC to be below some maximum limit (<=0.4) in these climatic regions.

In heating dominated regions as well as in moderate climates (>3500 HDD°F, or approximately 1000 HDD°C), the impact of a window's SHGC on overall energy performance is not considered by the codes. In fact, the codes, as well as a majority of the marketplace, are solely concerned with heat losses, especially above 6000 HDD°F (approximately 2400 HDD°C). Energy losses are primarily driven by a window's U-factor. Therefore, this focus on U-factor currently results in the 'premium' marketplace status of the DS MSVD over pyrolytic Low E coatings.

However, a residential window's actual energy performance in a heating dominated climate is strongly influenced by both its ability to minimize energy losses (U-factor) and its ability to maximize the transfer of passive solar energy into the household (SHGC). A simulation study employing the Lawrence Berkeley National Laboratory's (LBNL) RESFEN 3.1 program was conducted to evaluate the

impact of various types of glazings on the annual energy consumption of a residential dwelling in various cities across the United States. The objective of this study was to demonstrate the significance and importance of both a window's U-factor and SHGC on its actual energy conservation performance.

Computer simulations to determine the annual energy consumption impact of various types of glazings in a single family residence were performed for twelve cities across the United States. Five of the cities are located in what is deemed as the North (>6000 HDD°F: Boston, Chicago, Seattle, Denver & Salt Lake City), another five cities are located in the Central (3500-6000 HDD°F: New York, Philadelphia, Washington DC, Kansas City & Albuquerque) and the final two cities are in the South (<3500 HDD°F: Phoenix & Miami). These calculations were done in accordance with NFRC 901, 'Guidelines to Estimate Fenestration Annual Energy Performance in Single Family Residences,' by using RESFEN 3.1 software which is based upon the US Department of Energy calculation method (DOE 2.1E). The window properties employed in the study, including angular dependence data, were calculated with Window 4.1 and imported into the RESFEN 3.1 program.

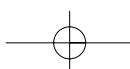
The following basic assumptions were employed and held constant for each run in the simulation study:

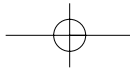
House

- Single story, new frame, 2000 ft² (186 m²) floor area
- Window Area: 300 ft² (27.9 m²), equally distributed on the North, South, East and West walls
- 'Typical' shading as defined by RESFEN 3.1 (interior shades, overhangs, trees and neighboring buildings)
- 'Typical' foundation and envelope insulation for each location as listed in NFRC 901 or RESFEN 3.1 manual

Windows

- 2 ft x 4 ft (0.61 m x 1.22 m) Casement
- Vinyl Frame
- 0.3 cfm/ft² (0.1 m³/min/m²) air infiltration rate
- Argon filled Insulating Glass Unit, butyl/metal spacer, 1/2' (12.7mm) gap
- 3mm glass with coatings as described in Table 1.





The full assumptions underlying the simulations are listed in NFRC 901, RESFEN 3.1 manual and the Window 4.1 manual.

The method employed in this simulation study was as follows:

The total annual site energy usage for a home without windows in each of the twelve cities was calculated. Five additional simulation runs to calculate the annual site energy consumption for this home with the windows described above were performed for each city (60 total). The only distinction between each of the five runs with windows was the type of glass employed in the windows, which was varied as described in Table 1.

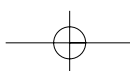
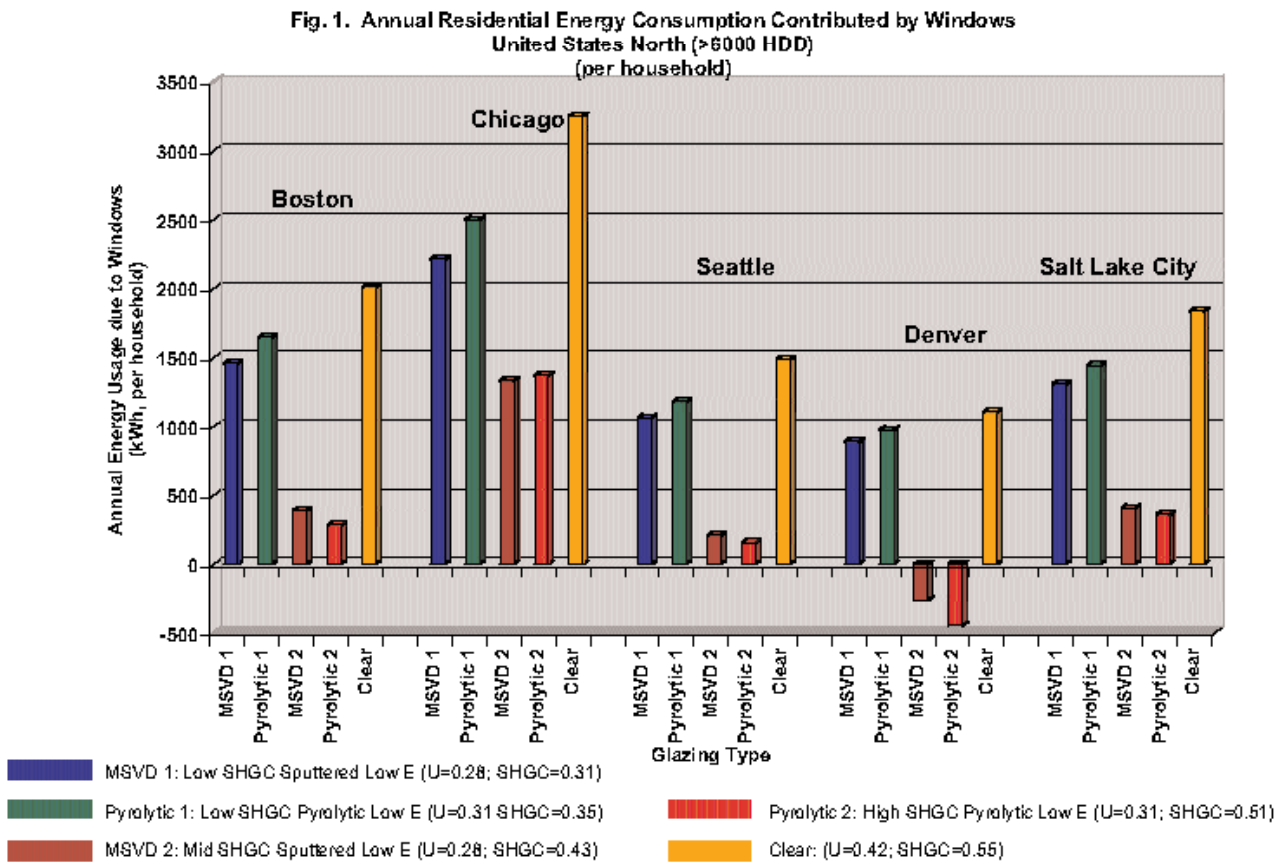
To determine the individual impact of each glazing type on the home's annual energy consumption (heating + cooling), the energy usage of the home without windows was subtracted from energy usage of the home with windows for each of the window types described above, in each of the cities. Positive values for this difference represent the relative increase in home energy consumption contributed by the windows with the various types of glazing products. Negative energy values indicate that the employment of the corresponding window/glazing combination actually decreases the annual energy consumption of the home in that particular location.

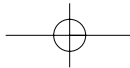
The results of this simulation study are represented by the bar charts in Figures 1-3. Each of the glazing types evaluated, in each of the cities studied, are represented on the x-axis. The values on the y-axis (height of each bar) represent the annual increase (or decrease, if a negative value) in the home's energy consumption (kWh, heating + cooling) contributed by the window employing the corresponding glazing type (x-axis). In other words, the best performing products in each city

correspond to the shortest positive value or the largest negative value bars. The baseline value of 0 kWh on the y-axis represents the results of the simulation run for the house without windows.

Figure 1 summarizes the relative energy performance of the different glazing types in the five northern cities. A significant performance distinction between the different glazing types is quite evident. In all of the cities, two of the five products, the Low E coatings with higher SHGCs (g), consistently require much less additional energy consumption than the other three. For example, in Boston, employing the high solar heat gain pyrolytic glazing (Pyrolytic 2) instead of clear glass, reduces the home's additional annual energy consumption due to the presence of windows by 86%. Employing the higher SHGC MSVD glazing (MSVD 2) in lieu of clear glass reduces additional annual energy usage by 81%.

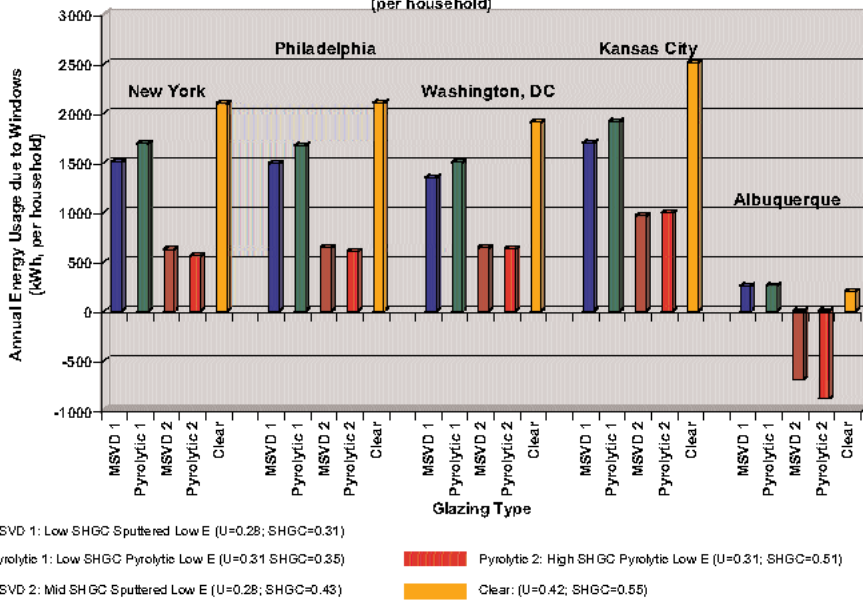
The calculated performance of these higher SHGC Low E products versus clear glass is what the current market perception would predict, as the U-factors of these Low E windows are significantly lower than that of a window employing clear glass. However, the relative energy performance of these higher SHGC Low E products is also consistently and considerably better than that of the low SHGC Low E products, MSVD 1 and Pyrolytic 1, which also possess low U-factors. Focusing again on Boston, employing the high SHGC Pyrolytic 2 glazing saves the home an additional 1173 kWh and 1364 kWh compared to the low solar heat gain MSVD 1 or Pyrolytic 1 glazing. As represented by Figure 1, the superior energy performance of the higher SHGC Low E products is consistent for all five cities evaluated in the northern US.





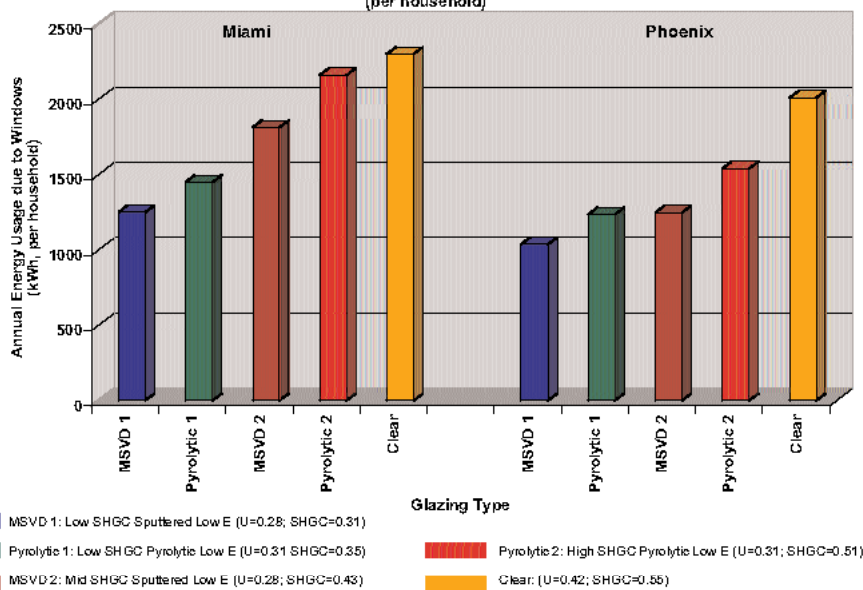
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Fig. 2. Annual Residential Energy Consumption Contributed by Windows United States Central (3500 - 6000 HDD) (per household)



Source: RESFEN 3.1; DOE-2

Fig. 3. Annual Residential Energy Consumption Contributed by Windows United States South (<3500 HDD) (per household)



Source: RESFEN 3.1; DOE-2

As the 'traditional' performance characteristic (U-factor) for all four Low E products is of the same magnitude, the superior performance of the Pyrolytic 2 and MSVD 2 glazings in this region is due to their higher SHGC. This characteristic enables a home employing either of these types of glazing to receive 'free heat' from passive solar energy. As the heating season is significantly longer than the cooling season in this region, this free energy drastically reduces the overall annual energy consumption of a household contributed by the presence of windows. In fact, a window with either Pyrolytic 2 or MSVD 2 glazing actually provides a greater energy benefit than an insulated wall in Denver.

Figure 2 summarizes the relative energy performance of the

various glazing types in the five Central region cities. Once again, the higher SHGC Low E products greatly outperform both the clear glazing and the low SHGC Low E products in all five of the cities studied. In Philadelphia, employing the high SHGC Low E product (Pyrolytic 2) instead of clear glass reduces a home's additional annual energy usage due to windows by 71%. On the other hand, using the low solar heat gain Low E products (MSVD 1 or Pyrolytic 1) instead of clear glass only reduces the additional energy usage by 29% or 20%, respectively. This superior performance of the high SHGC products is due to the longer duration and the greater energy transfer intensity of the heating season versus the cooling season. In this Central region, energy losses via windows during cold weather are greater than heat gains during warm weather as the average outdoor-indoor summer temperature differential (85°F - 68°F = 17°F) is significantly lower than the winter temperature differential (30°F - 68°F = 38°F). Passive solar heat gain in the winter helps to offset these energy losses as 'free heat.'

Figure 3 illustrates the performance of the various glazing types in a cooling dominated climatic region, the United States South. In this region, the current market perception that the low SHGC Low E products are superior is correct. For a home in Miami, employing the MSVD 1 glazing instead of clear glass reduces the home's additional annual energy consumption due to windows by

46%, more than the higher SHGC Low E products (MSVD 2 or Pyrolytic 2). This negative impact of a high SHGC in this region is currently recognized by both the codes and the marketplace.

In conclusion, for moderate and heating-dominated climate zones, the 'High Performance' characterization of low solar heat gain sputtered Low E coatings is a MYTH !! Although these glazings enable the production of windows with very low U-factors, their correspondingly low SHGCs greatly hinder their energy performance in cities such as New York, Chicago, Denver and Seattle. In fact, available glazing products with slightly greater U-factors and significantly higher SHGCs (Pyrolytic Low E), deliver significantly and drastically superior energy performance in heating dominated climate zones. ■

