Energy Conservation Benefits of High Performance Commercial Glazing

Through technological innovation in the flat glass industry, more and more energy efficient windows and architectural glass products are developed not only to address energy conservation concerns, but also to offer architects and building owners with a wide array of performance and color options.

This article examines the energy efficiency impact of different commercial glazing options by using DOE-2, a sophisticated building energy simulation program developed by the U.S. Department of Energy to model the energy consumption and energy costs for a 6-story building with 20,000 sq. ft of glazing distributed equally around the building. The model simulated different climate conditions in four cities: Chicago, IL; Miami, FL; Tokyo, Japan, and Bangkok, Thailand. The glazing options include the Sun-Guard® series of new high performance solar control glass products from Guardian Industries.

COMMERCIAL GLAZING

The multitude of commercial glazing product options can be overwhelming. Architects can choose almost any color and performance options such as reflective, patterned and low emissivity (low-E) glass. All of these products affect the energy use in a building. Whether the glazing unit is single glazed or an insulating unit can also have different impacts on energy performance, comfort and noise attenuation.

Table 1 lists different glazing options and their energy performance values. The energy transfer through a window is expressed by the U-value; the lower the U-value, the lower the energy loss. Insulating units (IG) reduce the energy loss through a window by at least half when compared to single glazed units. In commercial buildings, the energy loss through a window is important to consider in cold climates, along with solar radiation. In moderate and warmer climates, the solar heat radiation through windows is very important to consider in improving energy conservation and occupant comfort.

Table 1: Glazing units

Glazing Unit	VLT%	SHGC	SC	U-Value
Single, Clear	89	0.82	0.94	1.1
Clear IG	80	0.71	0.82	0.48
Tinted Green IG	67	0.46	0.52	0.48
Sun-Guard Silver-20 Clear IG	18	0.20	0.23	0.41
Sun-Guard Silver-20 Green IG	15	0.18	0.20	0.41
Sun-Guard Silver-32 Clear IG	28	0.29	0.34	0.43
Sun-Guard Silver-32 Green IG	24	0.23	0.26	0.43
Sun-Guard LE-40 Clear IG	40	0.31	0.36	0.33
Sun-Guard LE-40 Green IG	33	0.23	0.27	0.33
Sun-Guard LE-50 Clear IG	50	0.39	0.45	0.34
Sun-Guard LE-50 Green IG	42	0.27	0.32	0.34
Sun-Guard LE-63 Clear IG	63	0.50	0.59	0.35
Sun-Guard LE-63 Green IG	52	0.33	0.38	0.35

SHGC: Solar Heat Gain Coefficient; SC: Shading Coefficient
VLT: Visible Light Transmittance; IG: Insulated Glass

The solar energy coming through a window is typically characterized by the shading coefficient or solar heat gain coefficient. The amount of solar heat gain through a window can vary significantly depending on the glass type. The lower the solar heat gain coefficient, the less solar energy entering a space. Historically, the industry has used shading coefficient to refer to the amount of solar heat gain through a window. Shading coefficient is the ratio of the solar heat gain coefficient of a glazing system to that of a 3 mm lite of clear glass.

The last value listed in Table 1 is the visible light transmittance. The visible light transmittance is the percentage of the sun's visible light coming through a window. In addition to aesthetic value, the visible light coming through a window can be used to light the interior space so that electric lighting can be reduced. Electric lighting is a major contributor to a building's energy use; turning off the lights reduces cooling loads and energy use, and saves money. However, very few buildings have active daylighting controls to dim or turn off lights in response to incoming sun light even though such controls typically pay for themselves in a few years or less.

Glazing Options Comparison

The glazing units in Table 1 represent the different types of glass and their respective U-values, solar heat gain coefficients and visible light transmittance. They also offer varying levels of energy efficiency:

- <u>Single, Clear glass</u>: Single-pane uncoated glass, is the least energy-efficient, and is declining rapidly in use in many commercial buildings.
- <u>Clear IG glass</u>: Two panes of single, clear glass separated by an air space within an opening to improve insulation against heat transfer and/or sound transmission. The initial effort to raise energy efficiency in commercial buildings started with the introduction of double pane insulating glass, which dramatically reduced thermal heat gains and losses by as much as 50% over single-pane uncoated glass. Double-pane insulating glass is now widely adopted in Europe and the North America.
- <u>Tinted Glass</u>: Although double-pane insulating glass reduced conductive heat gain and losses through the glass, it did not solve the problem of direct solar heat gain through clear glass. The heat energy that was absorbed through clear glass was reradiated to both the exterior and interior surfaces. To control solar heat gain, heat-absorbing tinted glass was introduced. Green, gray and blue tinted glass could absorb as much as 50% of the solar energy that would normally be transmitted through clear glass.
- <u>Reflective & Low-E Coated</u>: Advanced glass coating technology made possible much greater

reductions in solar heat gain than what was possible with tinted glass. This is achieved by applying heat-reflective metallic coatings to the glass either "online" during the original float glass production process or through an "offline" vacuum sputtering coater. The result is lower solar heat gain coefficient and greater energy-efficiency. In general, much higher solar control performance can be achieved using the offline vacuum sputtering process than is possible with the "online" or "pyrolytic" process. A commonly cited disadvantage of offline vacuum sputtered glass is that unlike the online pyrolytic glass, it cannot be heat-treated after the coating process. This is now largely overcome by a new line of sputter-coated glass products developed and marketed by Guardian Industries under the "Sun-Guard®" brand, of which many can be heat-treated, tempered or further processed without compromising the appearance or durability of the coating. The Sun-Guard series offers excellent performance. For example, Sun-Guard Silver-20 and Silver-32 offer very low solar heat gain coefficients, while Sun-Guard LE-40, LE-50 and LE-63 provide low U-values in addition to very low solar heat gain coefficients.

Building Energy Performance

A detailed simulation was conducted to determine the effect that each of the glazing units in Table 1 have on energy use in a 120,000 ft^2 (11,150 m^2) office building. DOE-2.2 building energy simulation program was used to model the same building in Chicago, Miami, Tokyo and Bangkok. The 6-story building has a 100 ft by 100 ft (30 m by 30 m) floor plate with 12 ft (3.7 m) high walls and 20,000 ft^2 (1,860 m^2) of glazing distributed equally around the building.

Figure 1: DOE-2 model of office building

The DOE-2 office building model is shown in Figure 1. The missing floors are the intermediate floors identical to the second floor. DOE-2 calculates the energy use for all six floors. Table 2 lists the assumptions used in the simulations.

Table 2: Office building assumptions

Factors	Assumptions	
Use Type	Office Building	
Total Floor Area	120,000	Sq.ft
No. of Stories	6	
Floor-to-Floor Height	12	Ft
Floor-to-Ceiling Height	9	Ft
Perimeter Depth	15	Ft
Foundation	Slab-on-Grade	
Window-to-Wall Ratio	0.5	
Window Type	Strip	
Window Height	5	Ft
Shading	None	
Lighting Power Density	1.3	W/Sq. ft
Plug Loads	1.0	W/Sq.ft
Occupant Density	175	Sq ft/per
Occupancy Schedule	12 am-7 am	0%
	8am-6pm	90%
	6pm-12am	0%
HVAC	Packaged VAV (perimeter electric reheat)*	
Cooling Setpoint	75 F/85 F	
Heating Setpoint (U.S.)	70 F/ 55 F	
Heating Setpoint (Tokyo, Bangkok)	68 F/ 55 F	
Cooling System	DX Packaged Unit	
Cooling Efficiency	8.5 EER	
Outside Air	20	cfm/per

*In Chicago where the heating load is significant, hot water coils served by an 80% efficient boiler are assumed.

The design temperatures and insulation levels for each location are given in Table 3. The focus was on the impact of the glazing on the building and minor changes in the insulation levels should not affect the results.

Table 3: Insulation levels in office building

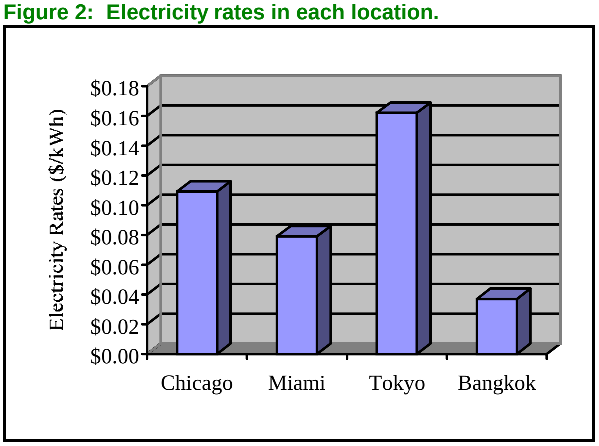
	Chicago	Miami	Tokyo	Bangkok
Heating Design Temperature	-1 F (-18 C)	50 F (10 C)	32 F (0 C)	68 F (20 C)
Cooling Design Temperature	88 F/74 F (31 C/ 23 C)	90 F/77 F (32 C/ 25 C)	88 F/77 F (31 C/ 25 C)	97 F/79 F (36 C/ 26 C)
Ceiling Insulation	R-19 (R-3.3)	R-15 (R-2.6)	R-15 (R-2.6)	R-15 (R-2.6)
Foundation Insulation	R-0	R-0	R-0	R-0
Wall Insulation	R-13+R-3.8 (R-2.3+R-0.7)	R-13 (R-2.3)	R-13 (R-2.3)	R-13 (R-2.3)

Table 4: Energy charges

City	Electricity	Natural Gas	Source
Chicago, Illinois	Summer (Jun-Sep): $14.24/Kw Non-Summer: $11.13/kW <30,000 kWH $0.04247/kWH Next 470,000 kWh $0.03167/kWh Over 500,000 kWh $0.03118/kWh	$0.665/ therm	ComEd Rate 6 (elect)
Miami, Florida	$8.14/kW $0.0363/kWh		Florida Power and Light
Tokyo, Japan	$0.162/kWh		Tokyo Electric Power
Bangkok, Thailand	$0.037/kWh		EGAT

The electricity and natural gas rates were based on information from utilities serving each of these cities. Table 4 gives the energy charges for each location and references the source, and Figure 2 compares the electricity rates. Electricity costs in Tokyo are double those in Miami and quadruple those in Bangkok.

Figure 2: Electricity rates in each location.

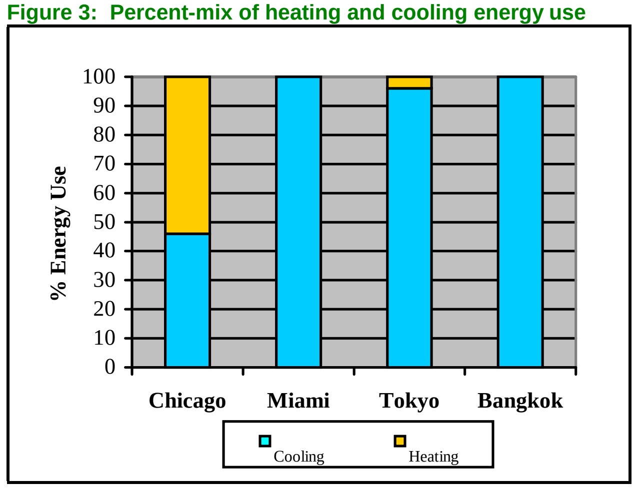


Energy Savings from High Performance Glazing

The energy savings from the use of high performance glazing are the result of reduced heating and cooling energy use. Figure 3 shows the percentage of heating and cooling energy use relative to total energy use for each location based on a commercial building with single-glazed, clear windows. Miami and Bangkok have warm climates and require cooling all year round. Chicago has both heating and cooling requirement, while Tokyo's needs are primarily cooling with modest heating in winter.

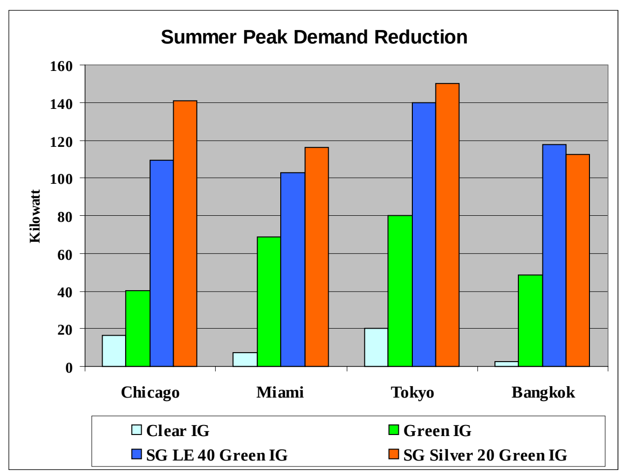
The detailed results of the DOE-2.2 building energy simulation are shown in pages 24-27. What follows is a summary analysis of what the simulation results reveal about energy consumption, peak demand reduction, equipment size reduction, and overall energy costs.

Figure 3: Percent-mix of heating and cooling energy use



Reducing summer peak demand for electricity is often as important if not more important than annual energy reduction. Figure 4 shows the potential scope of summer peak demand reduction. Sun-Guard Silver-20 Green IG, which has a SHGC of 0.18 provides the highest summer peak demand reduction in Chicago, Miami & Tokyo. Sun-Guard LE-40, which has a SHGC of 0.23, also performs very well compared to non-coated green IG and clear IG.

Figure 4: Summer peak demand reduction compared to single glazed, clear glass

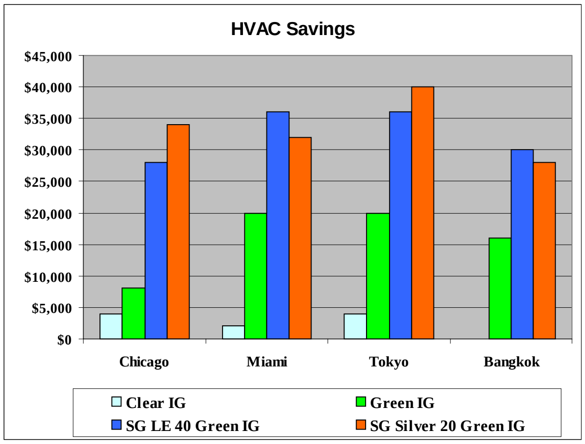


The related benefit from limiting the solar gains through windows is the potential scope for reducing the size of the cooling or HVAC equipment. The first year, one-time cost savings from this is significant, even though the year-to-year energy savings attributable to thermal efficiency are less significant because the part-load efficiency of cooling equipment has improved.

Figure 5 shows the cooling ton reduction or HVAC cost savings that can potentially be achieved for different glazing options, assuming that the avoided cost for a ton of cooling is $400. Sun-Guard Silver-20 Green IG provides the highest cost savings of all the glazing options

in Chicago and Tokyo, while Sun-Guard LE 40 Green IG performs the best in Miami and Bangkok.

Figure 5: Savings from reduction in cooling tons compared to single glazed, clear glass



While reducing summer peak demand for electricity and cooling tonnage has significant benefits, if annual energy consumption is of greater interest, the best performing product is determined by how much heating and cooling are required and which system is used.

Figure 6 shows the annual energy savings for each glazing unit type. In Chicago, which is heating-dominated, Sun-Guard LE-40 Green IG provides the highest annual savings due to its exceptionally low U-value of 0.33 in addition to a low SHGC of 0.27. In Miami, Bangkok and Tokyo, which are mainly cooling dominated, Sun-Guard Silver-20 Green IG offers the highest annual savings due mainly to its very low SHGC of 0.20.

Figure 7 calculates the total first year savings that can be achieved for each glazing type, from both one-time reduction in cooling tons and annual energy savings from increased thermal efficiency. In all climate locations, both Sun-Guard Silver-20 Green IG and Sun-Guard LE-40 Green IG provide substantially higher total first year energy cost savings compared to Clear and Green IG units.

Figure 8 shows that the total first year cost advantages of Sun-Guard Silver-20 Green IG and Sun-Guard LE-40 Green IG over other non-coated Green IG are rather significant. The highest cost advantage is found in Chicago, due to much higher thermal performance benefits and higher costs of cooling and heating. But even in Miami, Tokyo and Bangkok, the energy cost savings over Green IG are at least 73% higher for Sun-Guard LE-40 Green IG and at least 67% higher for Sun-Guard Silver-20 Green IG.

Figure 6: Annual energy savings associated with each glazing unit as compared to the single, clear unit

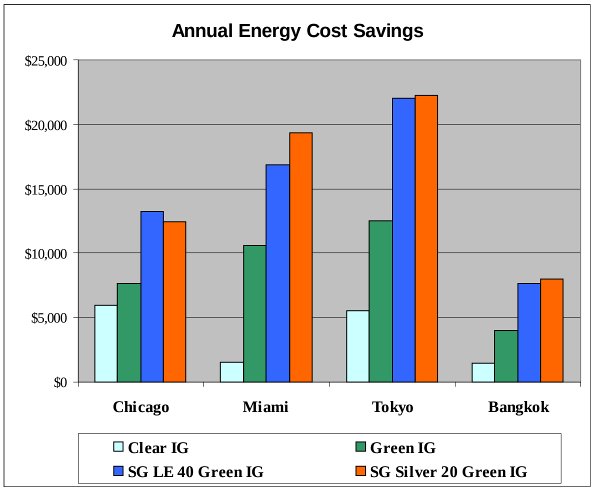


Figure 7: Total first year energy savings associated with each glazing unit as compared to the single, clear unit

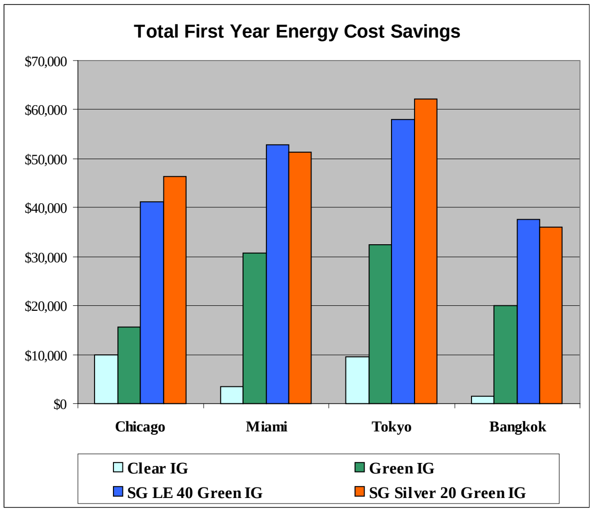
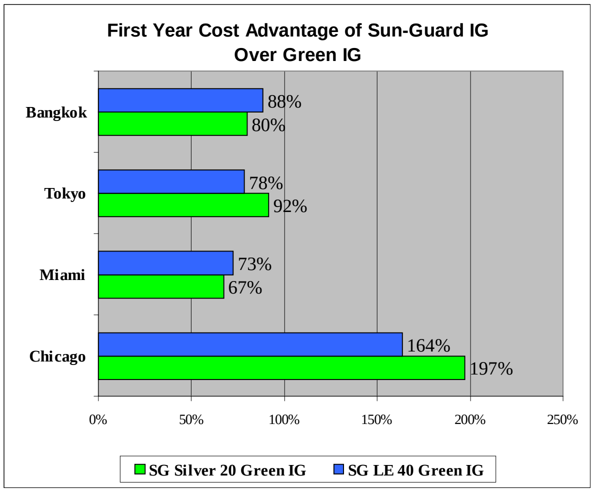


Figure 8: Total first year cost advantage of Sun-Guard Silver 20 and LE 40 as compared to the single, green IG



Financial Payback From Energy Conservation

The outstanding energy conservation and cost saving benefits of sputter coated, high performance reflective glass such as the Guardian Sun-Guard series make it not only an environmentally friendly choice of glazing for commercial building owners and architects, but it is a financially worthwhile choice as well.

Sputter-coated high performance reflective glass such as Guardian's Sun-Guard product series generally cost more to manufacture than uncoated glass. But the energy cost savings from utilizing the more energy-efficient coated glass far outweighs the higher initial cost. Based on Guardian's estimate, the financial payback from adopting Sun-Guard glass products can be less than one year for a commercial building with both heating and cooling requirements (e.g. Chicago) with 20,000 sq. ft of glazed area. The lifetime savings over an expected product lifespan of 20 years will be many times higher than the incremental glass costs compared to uncoated clear IG. The decision for selecting coated glass is hence an economically justified investment for building owners, architects and glazing contractors

GUARDIAN SUN-GUARD®

The Sun-Guard® Series is a family of revolutionary solar control glass coatings produced by the Silacoat™ Technology pioneered by Guardian. Each coating has its own unique color, distinct solar performance, and excellent color uniformity.

Sun-Guard products provide the highest quality and performance of sputtered coatings coupled with excellent durability and flexibility in shipping, handling and fabrication.

Reduced energy consumption, which is the biggest benefit of Sun-Guard solar control glass, will deliver energy efficiency that will meet or exceed local energy code requirements. The product series offers a variety of aesthetically pleasing colors preferred by design professionals around the world. A range of shading coefficients and U-values supports most specifications.

Check out our web site http://www.sun-guardglass.com for more product information.

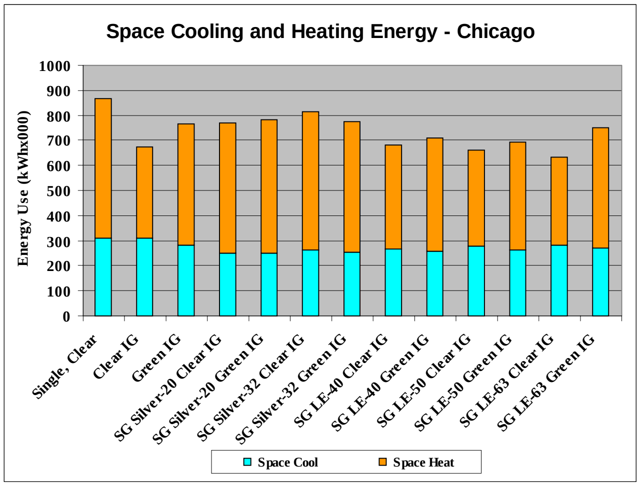
Sun-Guard Project I – J.K. Financial Center

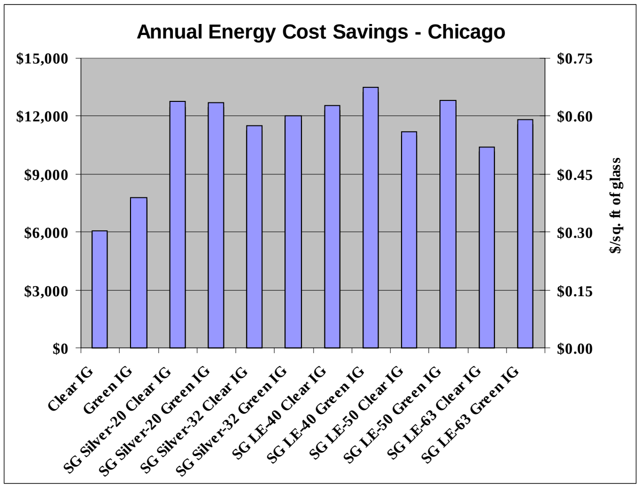
Location: Sao Paulo, Brazil
Glass Coating: 6 mm Sun-Guard Silver-20 on Green
Architect: Skidmore, Owings & Merril LLP, New York and Collaco & Monteiro Architects, Sao Paulo

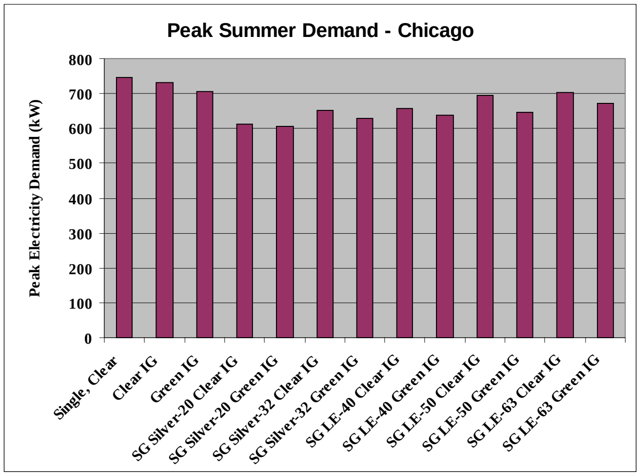
Sun-Guard Project II – Sheraton Foxhead Hotel

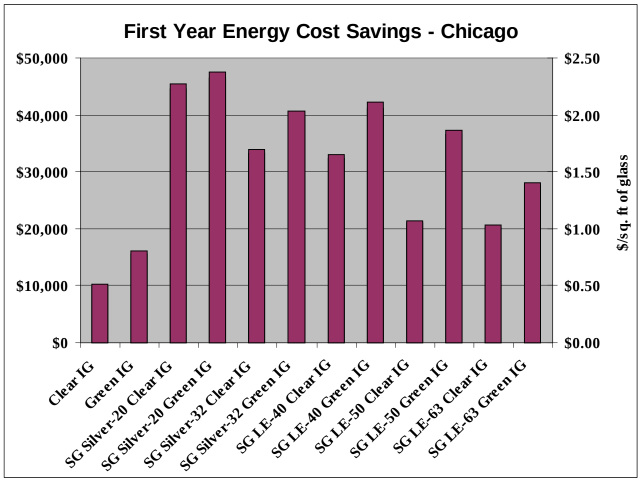
Location: Niagara Falls, Ontario, Canada
Glass Coating: 6 mm Sun-Guard Silver-32 on Green
Architect: Archway Associates, St. Catherine, Canada

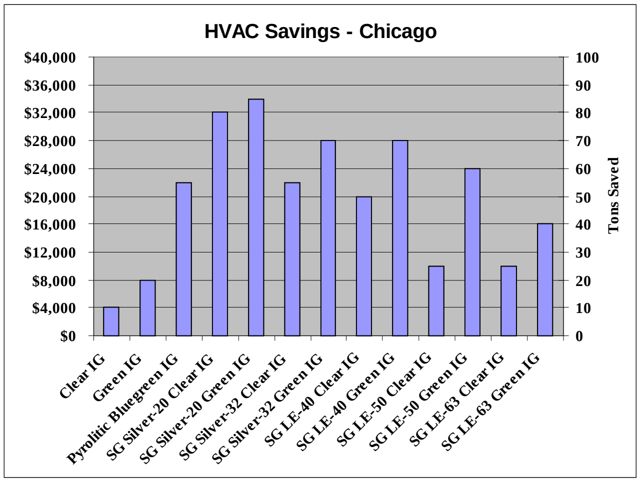
ENERGY SIMULATION RESULTS
Chicago Office Building

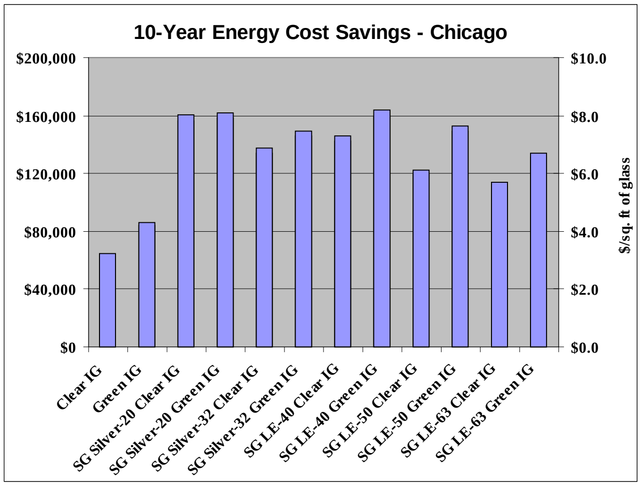




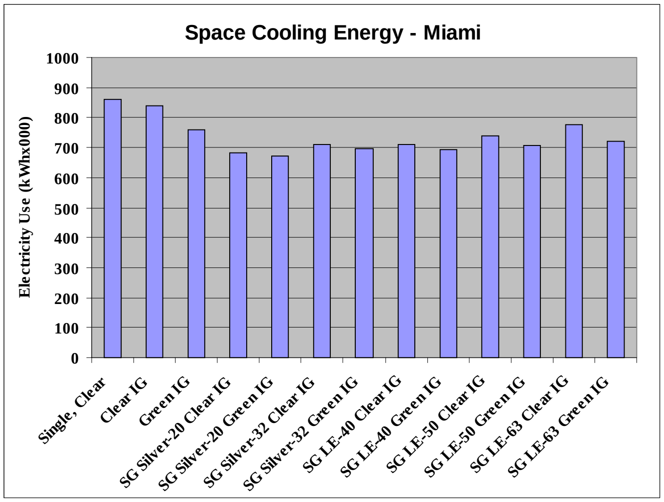


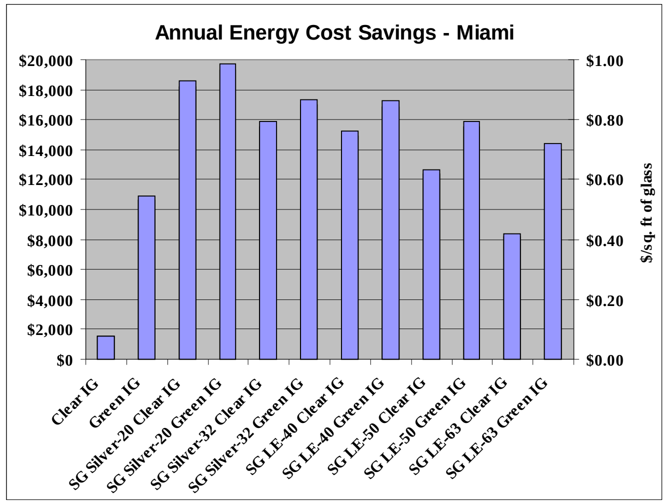


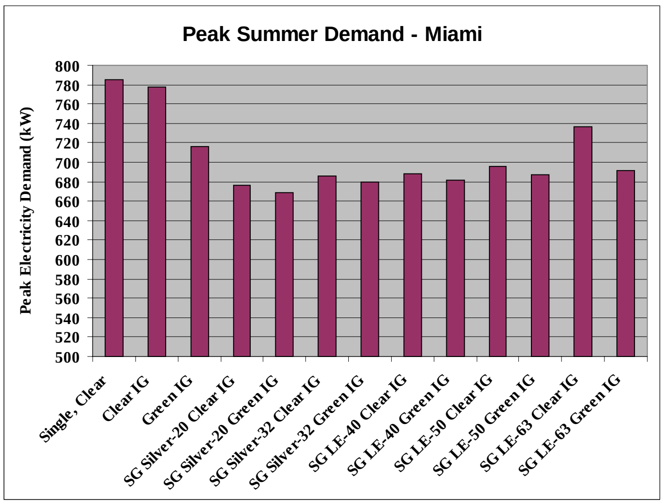


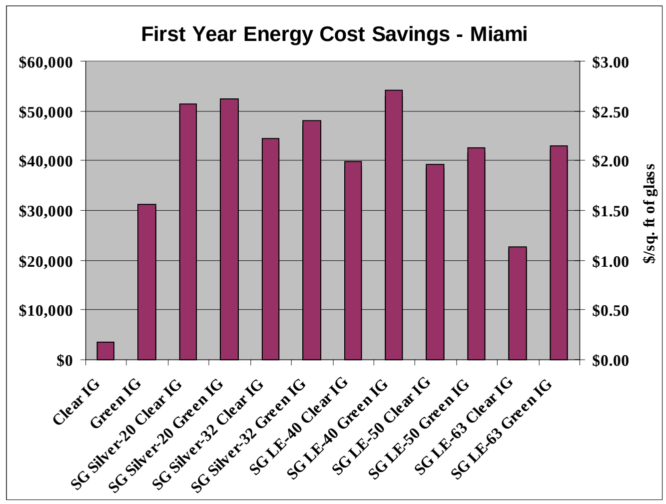


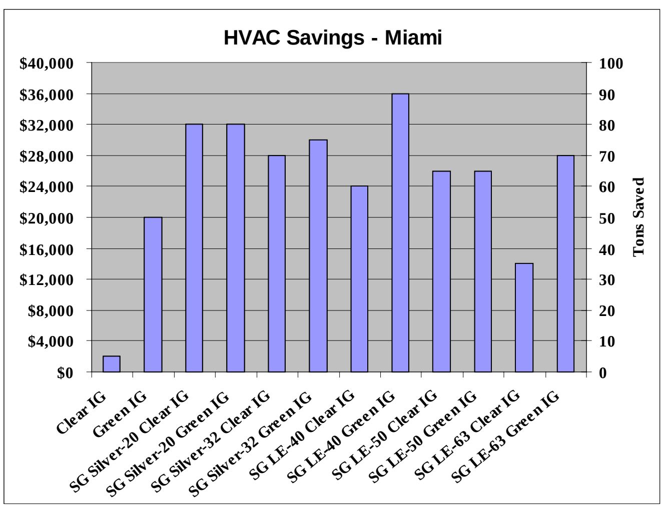
ENERGY SIMULATION RESULTS
Miami Office Building

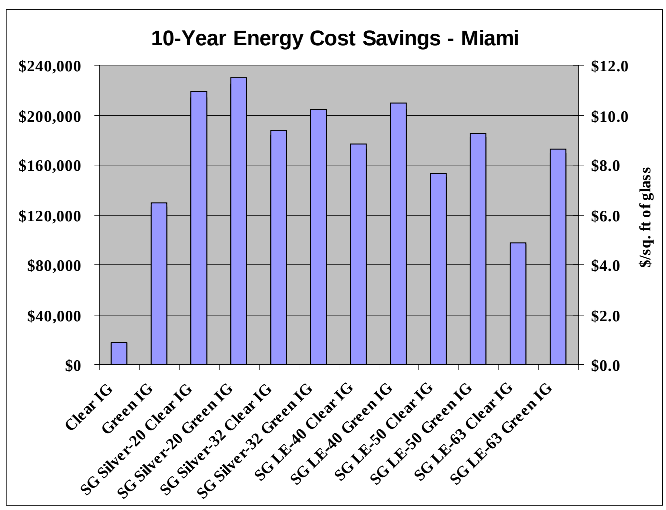






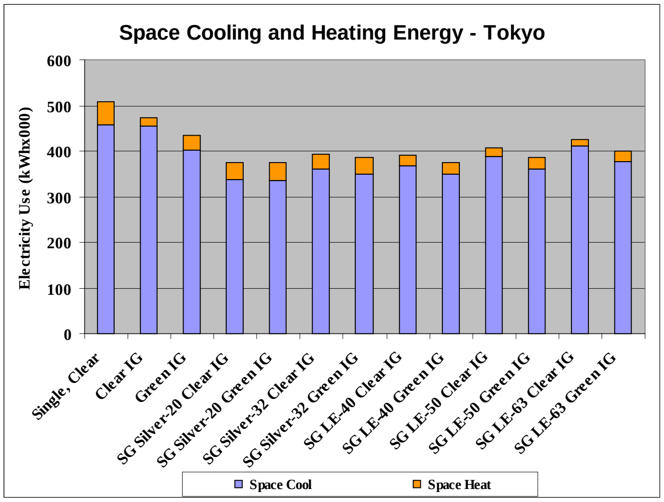


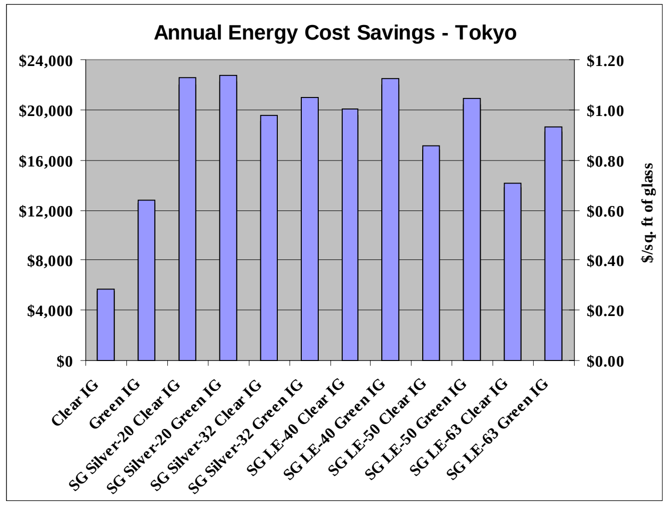


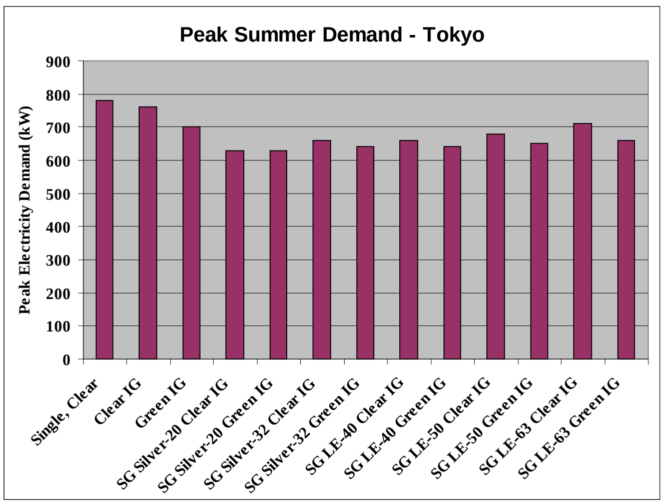


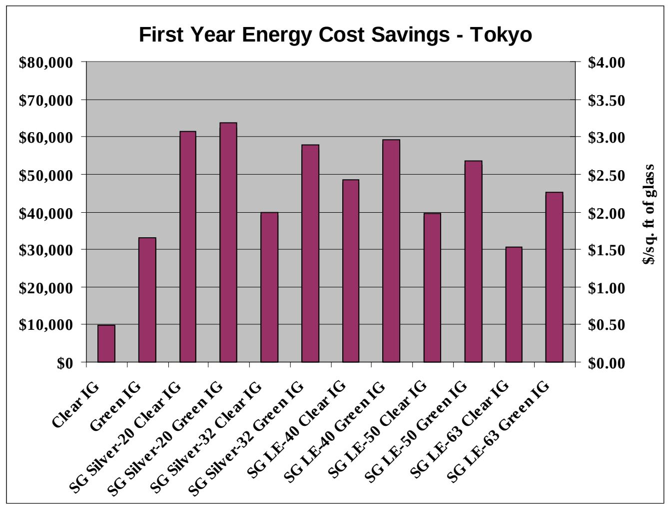
ENERGY SIMULATION RESULTS

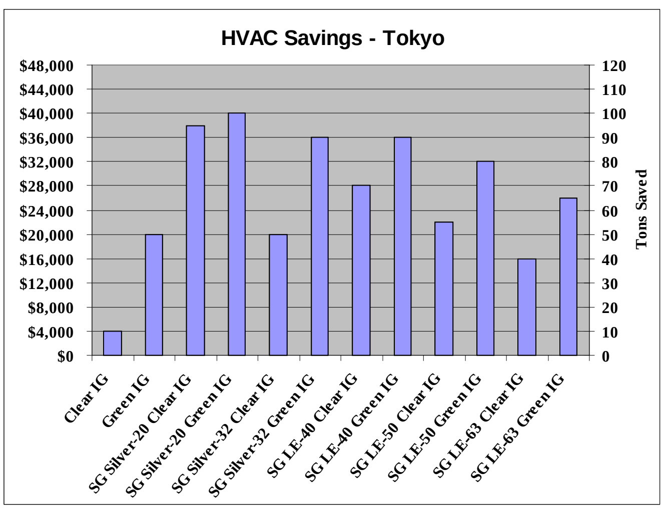
Tokyo Office Building

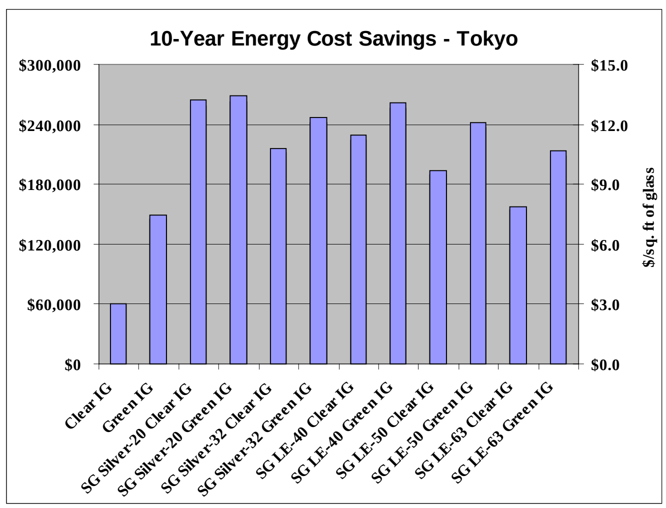












ENERGY SIMULATION RESULTS

Bangkok Office Building