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LOW-E GLASS
(LOW-EMISSIVITY)

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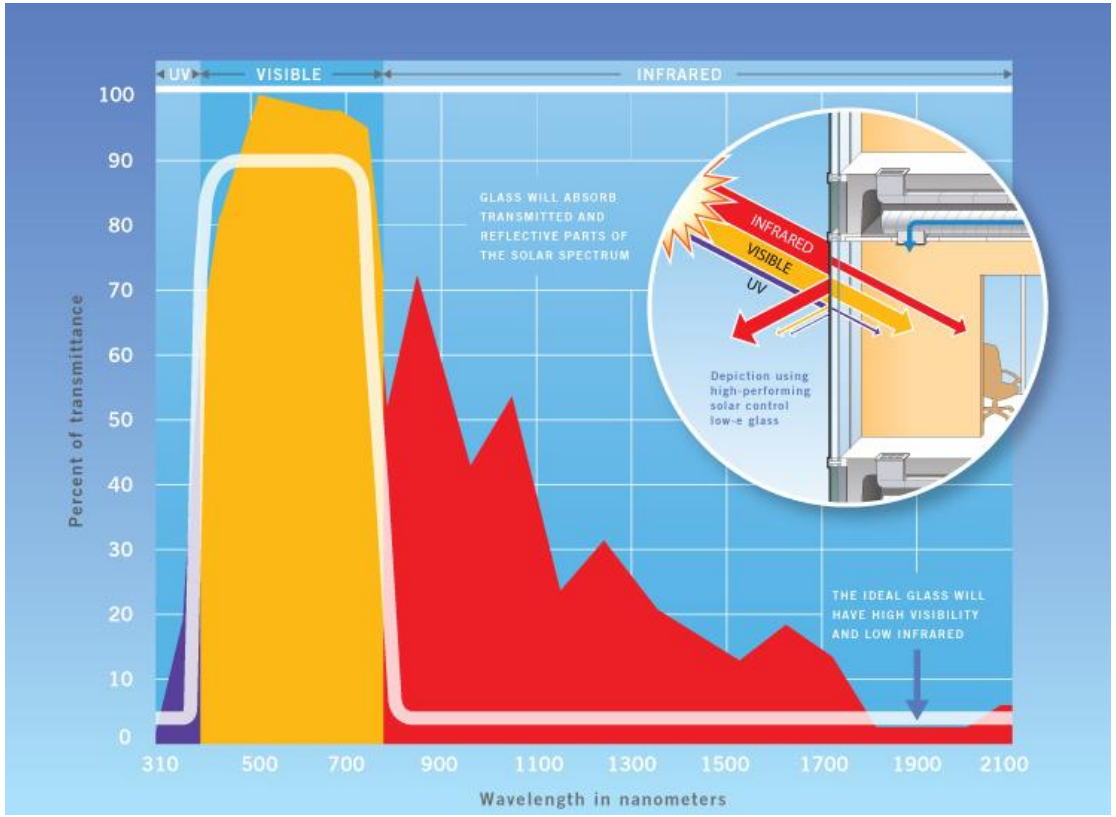
Low-Emissivity Glass

Understanding the concept of low-emissivity glass would benefit from reviewing the Solar Energy spectrum and Emissivity terms:

Solar Energy Spectrum with three different wavelength ranges is involved in the low emissivity concept:

- **Ultraviolet light** (3% of the solar energy spectrum) is what causes interior materials such as fabrics and wall coverings to fade, has wavelengths of 310-380 nanometers when reporting glass performance.
- **Visible light** (44% of the spectrum) occupies the part of the spectrum between wavelength from about 380-780 nanometers.
- **Infrared light** (or heat energy which is 53% of the solar energy spectrum) is transmitted as heat into a building and begins at wavelengths of 780 nanometers . Solar infrared is commonly referred to as short-wave infrared energy, while heat radiating off warm objects has higher wave lengths than the sun and referred to as long-wave infrared.



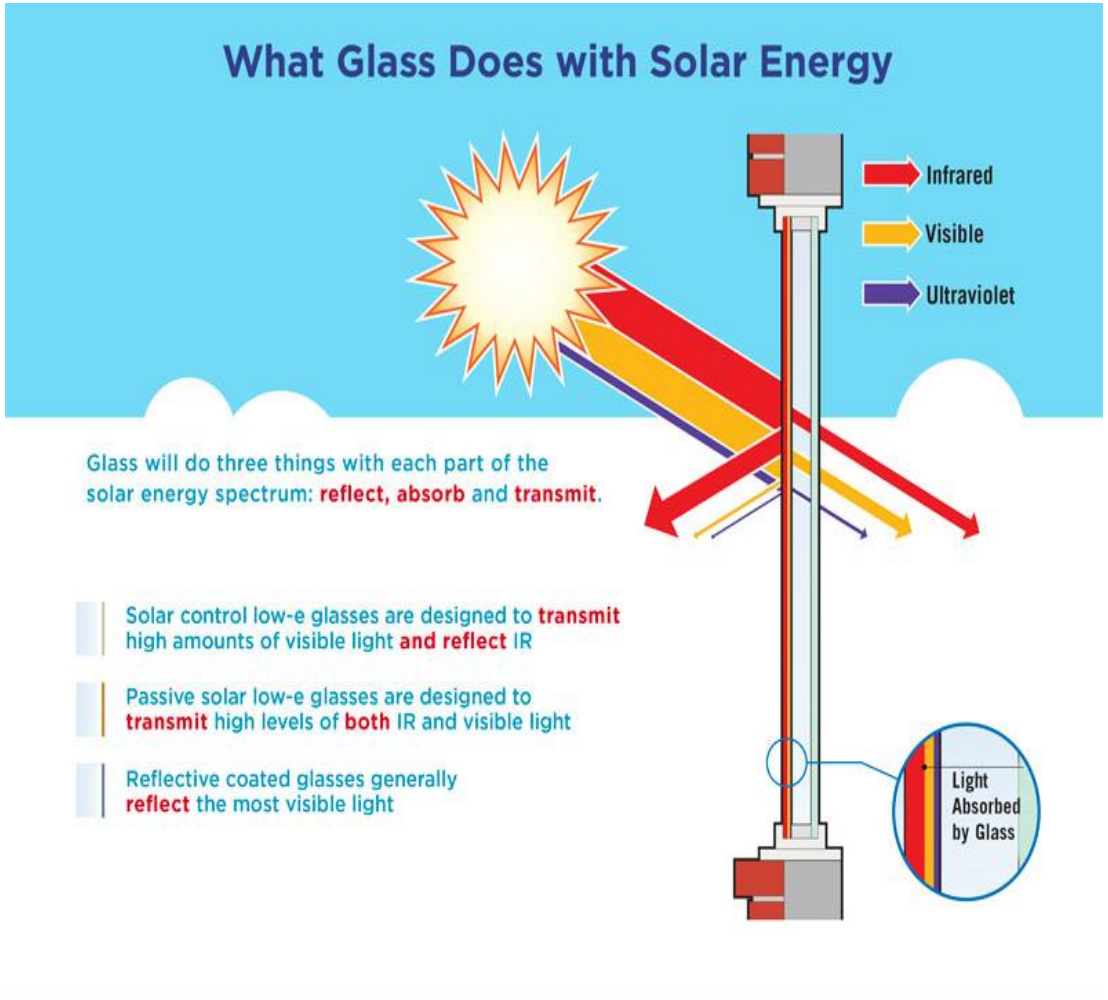
Emissivity

The ability of a material to radiate energy is known as emissivity. In general, highly reflective materials have low emissivity and dull darker colored materials have high emissivity. All materials, including windows, radiate heat in the form of long-wave, infrared energy depending on the emissivity and temperature of their surface. Radiant energy is one of the important ways heat transfer occurs with windows. Reducing the emissivity of one or more of the window glass surfaces improves a windows insulating properties.

Low-Emissivity Glass

Low-Emissivity glass (or low-E glass as commonly referred to) is a type of energy-efficient glass designed to prevent heat from escaping through windows to the cold outdoors. It is created to minimize the amount of infrared and ultraviolet light that comes through the glass, without reducing the amount of light that enters the room.

Low-E glass has a microscopically thin coating that is transparent and reflects heat. The coating is even thinner than human hair! The low-E coatings keep the temperature of the room consistent by reflecting the interior temperature back inside.



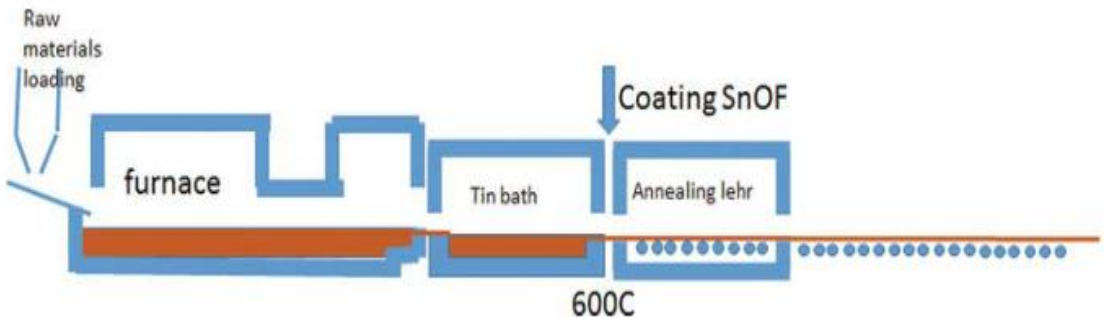
Low-E Coatings

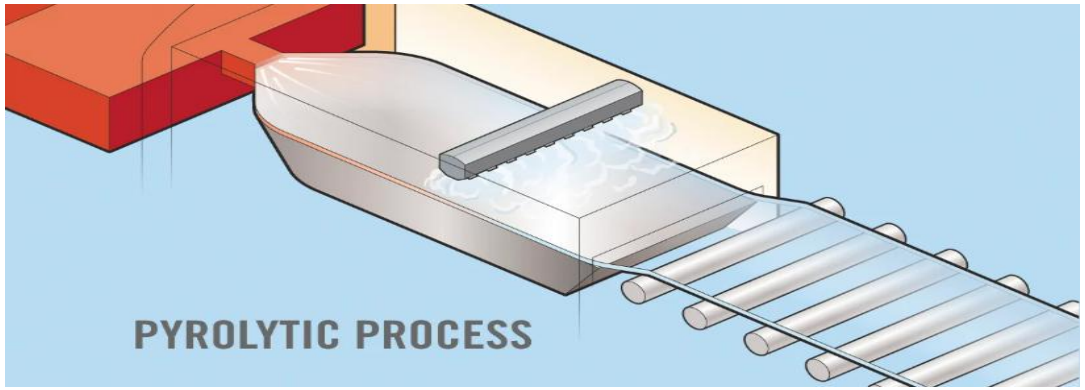
Low-E coatings are comprised of microscopically thin chemical layers organized in a stack or fused to the glass surface which contribute significantly to the performance properties of the glass.

Types of Low-E Coating:

Passive Low-E Coating (Hard-coat or Online Low-E glass)

The passive low-E coatings are manufactured using the pyrolytic process which became common in 1970's. The coating , typically tin oxide [SiO2], is then applied to the upper surface of the glass ribbon while it is being produced on the float line, which causes the coating to "fuse" to the hot glass surface . This fusion creates a strong band, or 'hard-coat" that is very durable. Passive low-E coatings are designed to maximize solar heat gain into home or building to create the effect of "passive" heating and reducing reliance on artificial heating.

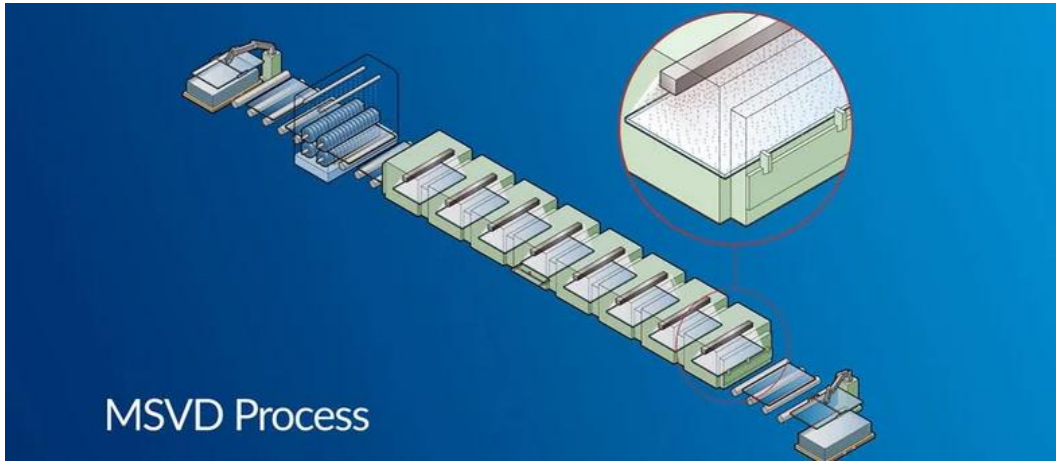


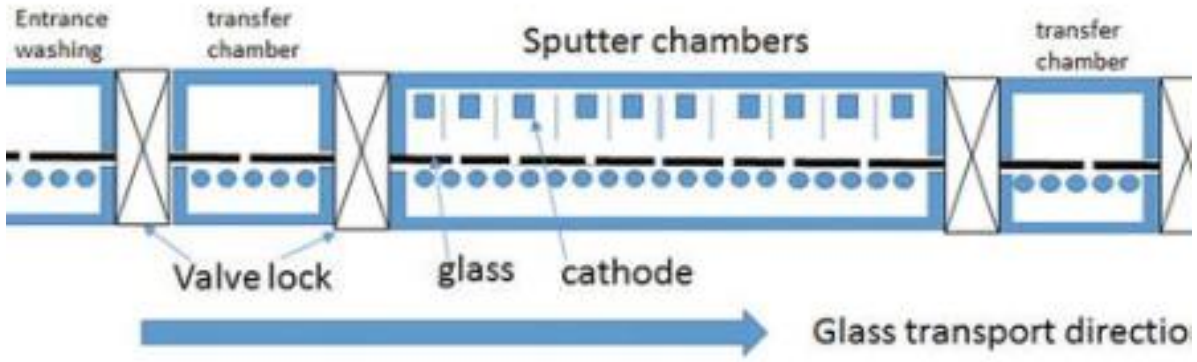


Solar Control Low-E (Soft-Coat or Offline Low-E glass)

The solar control low-E coatings are manufactured using the Magnetron Sputtering Vapor Deposition (MSVD) process, introduced in 1980's, which means the coating is applied offline to precut glass in a vacuum chamber at room temperature.

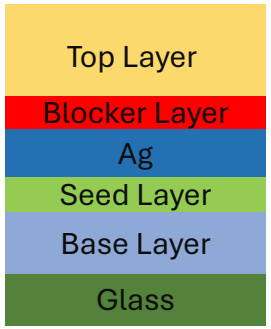
The fully formed glass travels along a conveyor system through a long vacuum chamber where a range of materials are sequentially accumulated on the glass surface. In this method silver(Ag) and other metals and metal compounds are uniformly sputtered on the glass surface. It consists of at least four-layer films with pure silver film between two metal oxide films. The metal oxide film provides protection for the silver layer and acts as an intermediate layer to adjust the color appearance and light transmittance. This coating which is referred to as "soft-coat ",is approximately 1/500th of the thickness of a paper sheet and it needs to be sealed in an insulated glass unit. The soft-coat has lower emissivity and superior solar control performance.



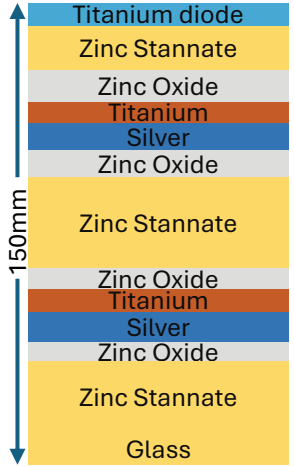


The influence of silver

Depending on the performance requirement of the coating , as many as 15 layers may be added to achieve the desired performance. Of the materials that comprise a sputter low-E coating , silver is the most influential in enhancing energy performance. As more silver layers are added to the composition of the coating , the better the spectral selectivity of the glass will be.



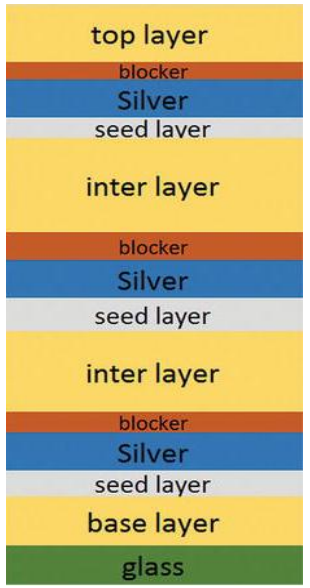
Single-Silver Coatings: The earliest low-E coatings were composed of one layer of silver and two dielectric (ceramic) layers in a five-compound stack. The single layer of silver enabled the coating to block heat by reflecting infrared and ultraviolet light, while the dielectric layers in the base coat and topcoat protected and anti-reflected the reflecting properties of the silver layer, enabling visible light to pass through.

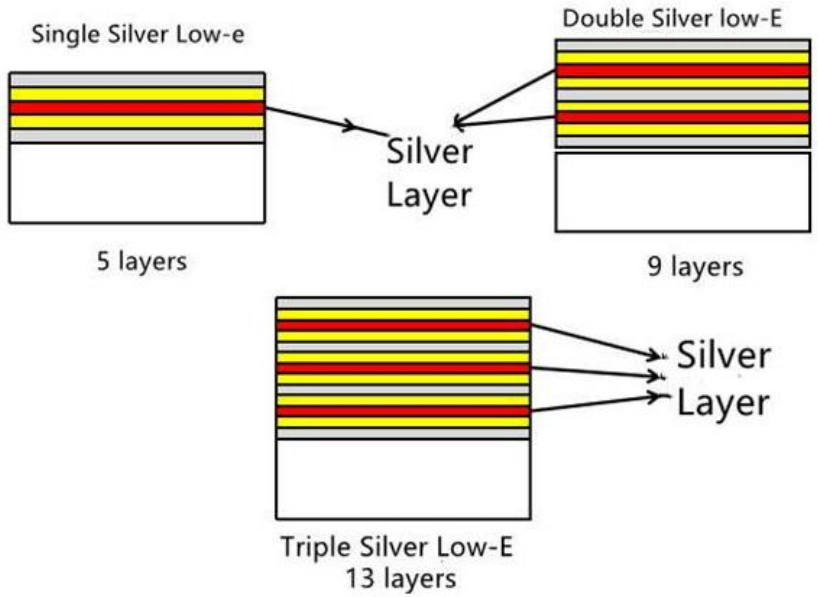


Double-Silver Coatings: In the early 1990's, the first double-silver-coated-glasses were introduced and transformed low-e glass fabrication. These glasses featured two layers of silver and multiple micro-thin layers of active/proactive performance materials. Double-silver coatings enable this generation of low-E glasses to maintain the same levels of visible light transmittance as single silver low-E coatings while increasing their ability to block solar heat gain by more than 30 percent.

The influence of silver

- **Triple-Silver Coating:** In 2005, glass manufacturers introduced the modern, state-of-the-art low-e coatings, which feature three layers of silver and material in over 12-layer stacks as thin as 300 nanometers. Triple-solver low-E coated glasses can transmit nearly 70 percent of the sun's available light into a building while blocking up to 75 percent of its infrared and ultraviolet energy.
- **Quad-Silver Coatings:** Finally, quad-silver coatings, which are state-of-the-art advancements introduced in 2016, can block nearly 80 percent of the sun's radiant energy while transmitting more than 50 percent of available sunlight.

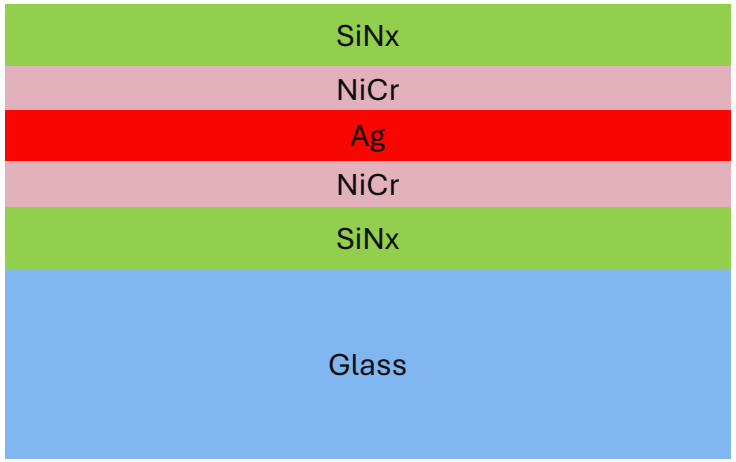




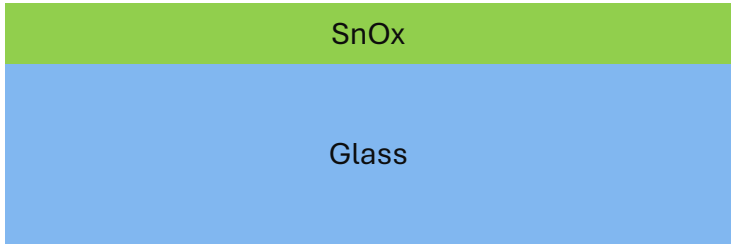
coating layer-single-double-triple silver lowe coating

Hard-coat (online) vs. Soft-coat (offline) Low-E Glass

- **Processability:** The hard-coat low-E layer is hard with good firmness and wear resistance. It can be stored, processed, cut as ordinary glass, tempered and bent. It is usually used as a single piece or laminated , insulated glass. In soft-coat low-E glass some films are soft, and the wear resistance and firmness are not very high. It is also sensitive to humidity, has short storage periods and high production costs. Some offline membranes cannot be used singly when imposed to air. They should be processed into composite products such as insulated glass units.
- **Glass color and reflectivity control:** Hard-coat low-E glass has not many choices of colors and performances . The parameters such as transmittance and reflectance are not adjustable. Soft-coat low-E glass has a variety of options, such as high , medium and low transmissions according to different climate characteristics. Soft-coat low-E glass has rich and varied colors , parameters such as transmittance and reflectivity can be adjusted according to design requirements. The soft-coat low-E glass film layer is more uniform , the color is more natural ad it presents different visual effects when reflected against the sun by different weather.



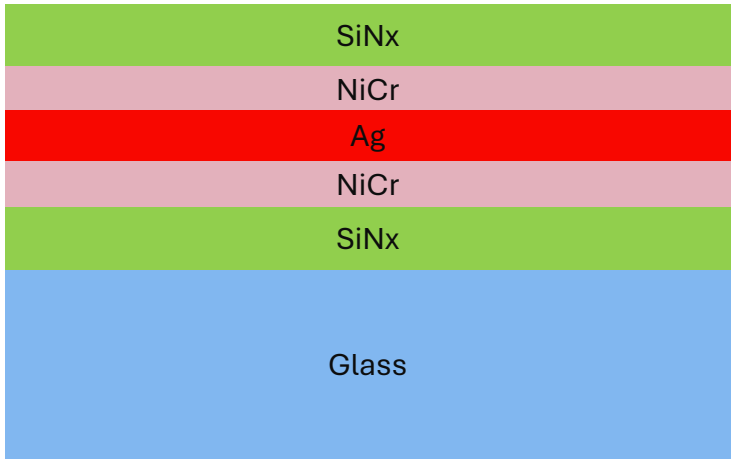
Offline Low-E



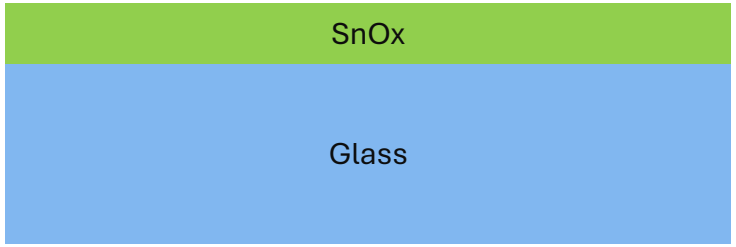
Online Low-E

Hard-coat (online) vs. Soft-coat (offline) Low-E Glass

- **Optional specifications**: The offline low-E glass can use any thickness of float glass. But the price will be higher if it is more than 15mm in thickness . But the thickness of online low-E is generally 4,5,6,8,and 10 mm.
- **Cost:** According to the experimental calculation results, using offline low-E glass saves an average of 8% more than using online low-E glass under normal circumstances.
- **Product application:** In many countries, online low-E glass is mainly used for low rise buildings. This is because online low-E lass can be used in a single panel, and the price is relatively cheaper. The offline low-E glass mostly will be adopted as insulated glass or other compound products with excellent performance and relatively high price, which is used in high-end buildings such as commercial buildings.



Offline Low-E



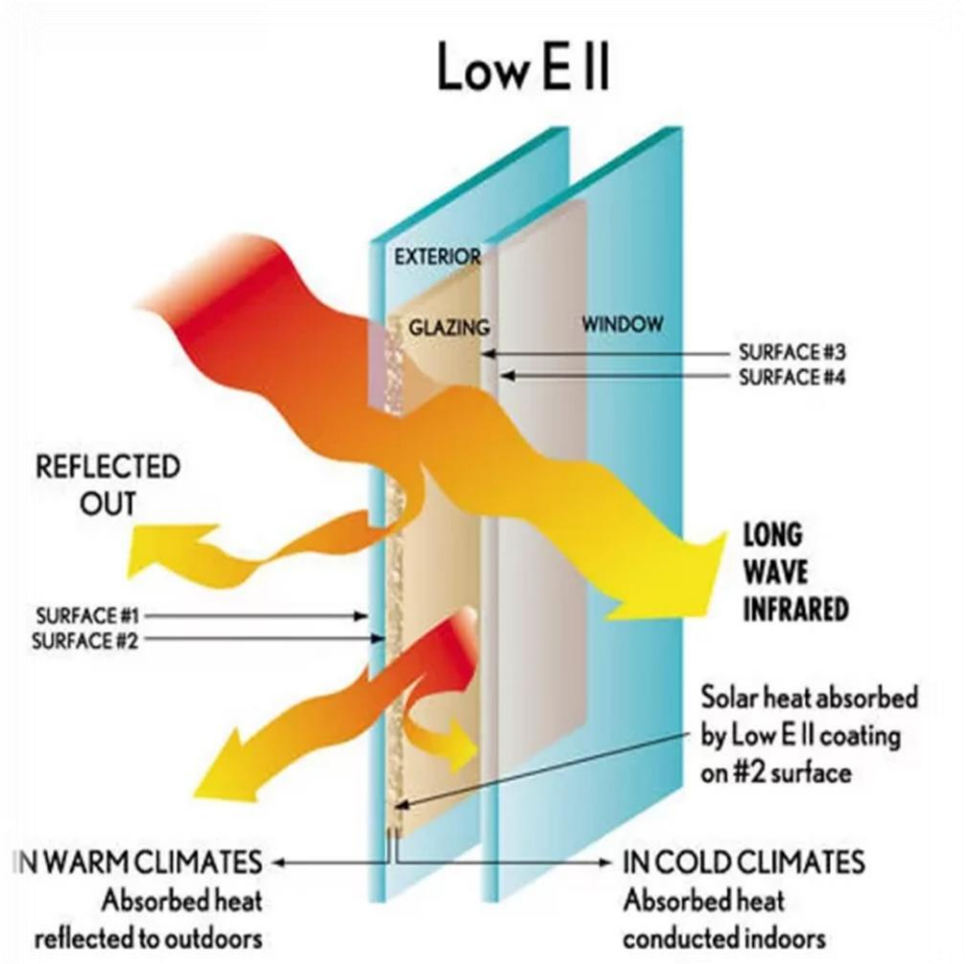
Online Low-E

Factors used to measure the low-E glass effectiveness

- **Solar Heat Gain Coefficient (SHGC) :** This is the fraction of incident solar radiation that is admitted through the glass. This can be either directly transmitted and absorbed or radiated inward. This factor is also nearly the same as **" solar factor** or **g-value**" , the coefficient used to measure the transmittance of solar gain through glazing.
- **U-value:** This is the rating that is given to a window based on how much heat loss it allows.
- **Visible Light Transmittance (VLT) :** The measure of how much visible light passes through the glass.
- **Light to Solar Gain (LSG):** The ratio between the window's visible light transmittance to its solar gain coefficient rating.

How Effectiveness factors are influenced by various Low-E coatings

Low-E, ½" airspace, ¼" clear	U-Value	VLT	SHGC	LSG
Pyrolytic	0.33 – 0.37	54% – 74%	0.45 – 0.66	1.09 – 1.25
Double-Silver MSVD (High VLT/Low Reflectance)	0.29 – 0.29	53% – 70%	0.28 – 0.39	1.76 – 1.98
Triple-Silver MSVD (High VLT/Low Reflectance)	0.28 – 0.29	61%	0.27 – 0.30	2.17 – 2.37



Technical considerations in low-E glass selection

- Windows with **hard-coat** low-E glass allow more solar energy to radiate through, which means they're less good at insulating but better for passive heating. For large and south-facing windows in colder climates these might be a good option because you'll be able to use some solar energy to heat your home when you need it the most.

- **Soft-coat** low-E glass (solar control coatings)are better insulators because they let less radiant energy through. If hot summers are an issue, or if windows aren't ideally sized or located for passive heating , this option might be worth considering because you'll lose less conditioned air.

- In addition to the type of low-E coating, the placement of low-E coating itself plays a big role in how the window performs. Manufacturers can apply the coating to different glass surfaces of a double or triple pane window to change the way the window operates. With a double-pane window, for example, a passive low-E coating (hard-coat) on the interior surface of the interior pane would maximize the radiant energy the window allows through. A solar control low-E coating (soft coat) placed on the interior surface of the outmost pane would better block solar energy and improve insulation.

Applications

Low-E glass is essential for rooms or buildings with a high portion of windows or glass doors such as

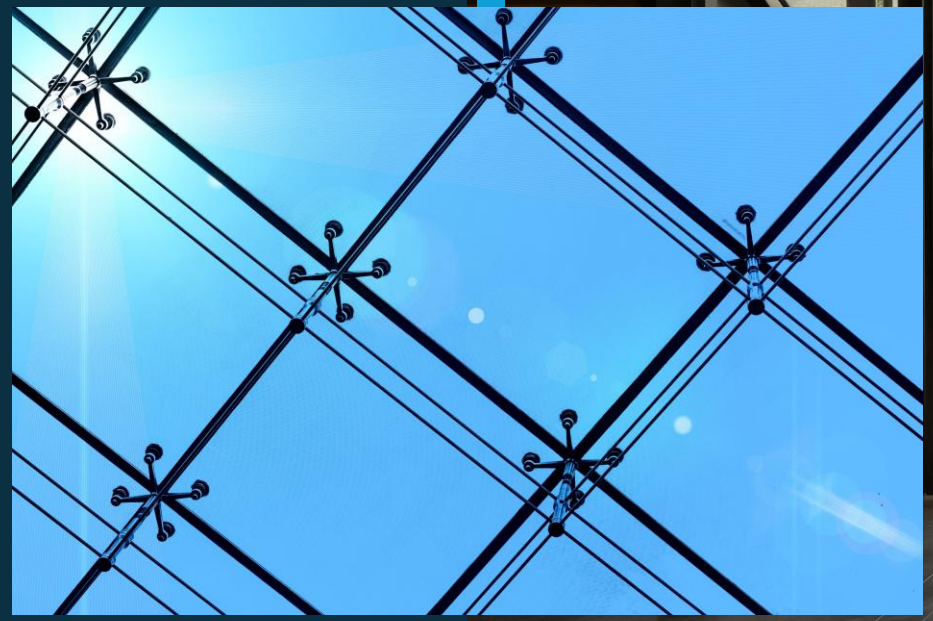
- **Conservatories**
- **Sunrooms**

Applications

- Windows and curtain walls
- Spandrel glass

Applications

- Door glazing
- Skylights



Performance Table for Soft Coat Low-E glass (Non- Temperable /Neutral)

- **Explanation:**
- **Light to Solar Gain (LSG):** The ratio between the window's visible light transmittance to it solar factor.
- **Daylight Transmittance (LT %):** The ratio of the visible spectrum (light) that is transmitted through glass.
- **Daylight Reflectance Outdoor (LR %):** The percentage of the visible spectrum (light) that is reflected outside by glass.
- **Solar Factor (g value %):** The percentage of total solar radiant heat energy passing through the glass. The lower solar factor means better solar control.
- **U value (W/m²k) :** A measure of the rate of the heat loss of a building component. The lower U value means better heat control and more comfort in winter.

ITEM	LSG	LT %	LR %	SF %	U value W/m^2k
1	79/63	79	12	63	1.1
2	80/64	80	12	64	1.1
3	73/43	73	11	43	1.1
4	70/40	69	11	40	1.1
5	70/37	69	13	37	1.0
6	66/44	66	25	44	1.1
7	62/44	63	23	43	1.1
8	50/33	49	31	33	1.1
9	50/25	50	15	25	1.0

Performance Tables for Soft Coat Low-E glass (Temperable/Neutral)

- **Explanation:**
- **Light to Solar Gain (LSG):** The ratio between the window's visible light transmittance to its solar factor.
- **Daylight Transmittance (LT %):** The ratio of the visible spectrum (light) that is transmitted through glass
- **Daylight Reflectance Outdoor (LR %):** The percentage of the visible spectrum (light) that is reflected outside by glass.
- **Solar Factor (g value %):** The percentage of total solar radiant heat energy passing through the glass. The lower solar factor means better solar control.
- **U value (W/m²k) :** A measure of the rate of the heat loss of a building component. The lower U value means better heat control and more comfort in winter.

ITEM	LSG	LT %	LR %	SF %	U value W/m^2k
1	80/64	80	12	64	1.1
2	71/53	72	19	53	1.1
3	63/29	63	13	29	1.0
4	62/44	63	23	43	1.1
5	50/33	49	31	33	1.1
6	43/28	44	34	28	1.0
7	41/27	42	36	27	1.1

ITEM	LSG	LT %	LR %	SF %	U value W/m^2k
1	70/40	69	11	40	1.1
2	70/37	69	13	37	1.1
3	58/32	58	21	32	1.1
4	51/28	50	23	29	1.1
5	50/27	49	16	26	1.0
6	50/25	50	15	25	1.1
7	40/22	40	19	22	1.1

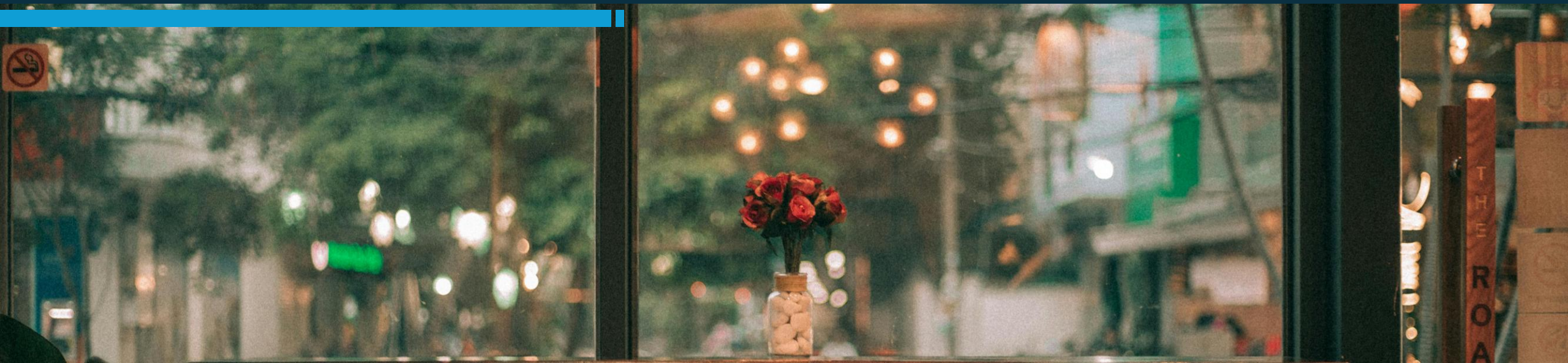
Performance Table of Hard-coat Low-E glass (Temperable/Neutral)

- **Daylight Transmittance (LT %):** The ratio of the visible spectrum (light) that is transmitted through glass
- **Daylight Reflectance Outdoor (LR %):** The percentage of the visible spectrum (light) that is reflected outside by glass.
- **Solar Heat Gain Coefficient (SHGC) :** This is the fraction of incident solar radiation that is admitted through the glass. This can be either directly transmitted and absorbed or radiated inward. This factor is also nearly the same as **" solar factor** or **g-value**" , the coefficient used to measure the transmittance of solar gain through glazing.
- **U-value:** This is the rating that is given to a window based on how much heat loss it allows.

item	Thickness mm	LT %	LR %	SHGC	U value
1	3.2	83	11	0.74	0.66-0.51
2	4	83	10	0.72	0.66-0.50
3	5	82	11	0.70	0.65-0.50
4	6	82	10	0.69	0.65-0.50

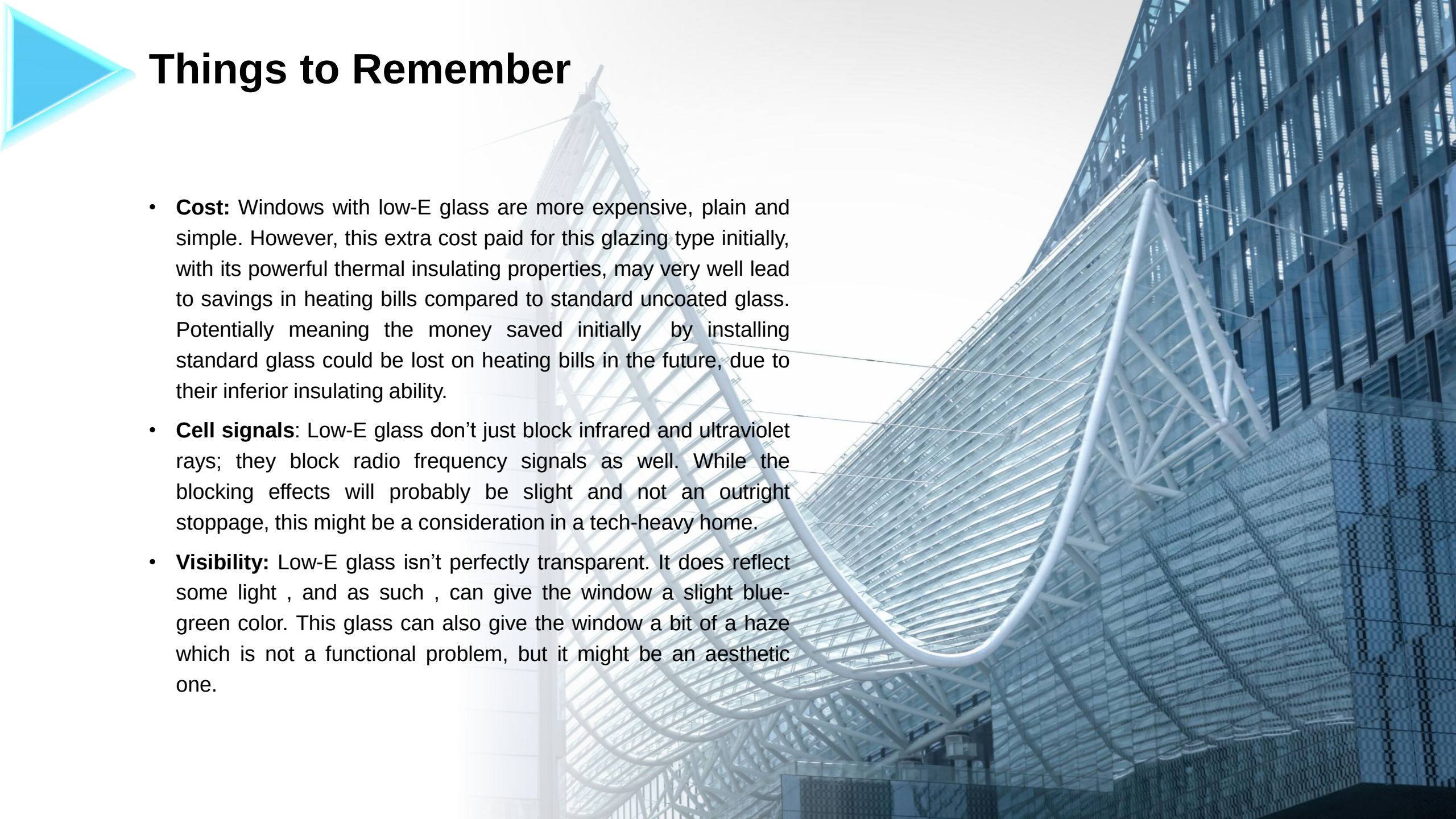
Properties

- **Energy efficiency:** The biggest advantage of investing in low-E glass is energy efficiency. Heat transfer though an ordinary window is like a two-way street. The sun's rays can warm a room, but heat can also escape from that room by warming the glass which will allow that energy to pass through to the outside. Thanks to the low-emissivity film coated on the glass, low-E glass has higher insulative properties than standard uncoated glass. So, when combined with other insulating technologies, such as warm-edge spacer bars and argon-gas-filled-cavities, low-E glass can be used to create an insulated glass unit (IGU) to prevent energy passing through to the outside and maintain energy efficiency.
- **UV light blockage:** Excessive UV rays are harmful for people, and they aren't great for fabrics or finishings either. Over time, exposure to UV light can fade interior furnishings like rugs, curtains, sofas, chairs and artwork. Since low-E glass reduces the amount of UV light that enters a home, furnishing especially those made of fabric should see a longer life and less fading and damage.
- **Long-term cost savings:** Low-E windows will reduce energy bills, which could save money in the long run. The U>S Department of Energy Efficiency and Renewable Energy states that low-e windows "can reduce window energy use by 30-40% ". Given that windows , doors and skylights can be responsible for up to 25% of the energy loss of a home, according to Natural Resources Canada (NRCan) that might make this a worthwhile purchase, depending on the age and condition of the current windows.



Things to Remember

- **Cost:** Windows with low-E glass are more expensive, plain and simple. However, this extra cost paid for this glazing type initially, with its powerful thermal insulating properties, may very well lead to savings in heating bills compared to standard uncoated glass. Potentially meaning the money saved initially by installing standard glass could be lost on heating bills in the future, due to their inferior insulating ability.
- **Cell signals**: Low-E glass don't just block infrared and ultraviolet rays; they block radio frequency signals as well. While the blocking effects will probably be slight and not an outright stoppage, this might be a consideration in a tech-heavy home.
- **Visibility:** Low-E glass isn't perfectly transparent. It does reflect some light , and as such , can give the window a slight blue-green color. This glass can also give the window a bit of a haze which is not a functional problem, but it might be an aesthetic one.



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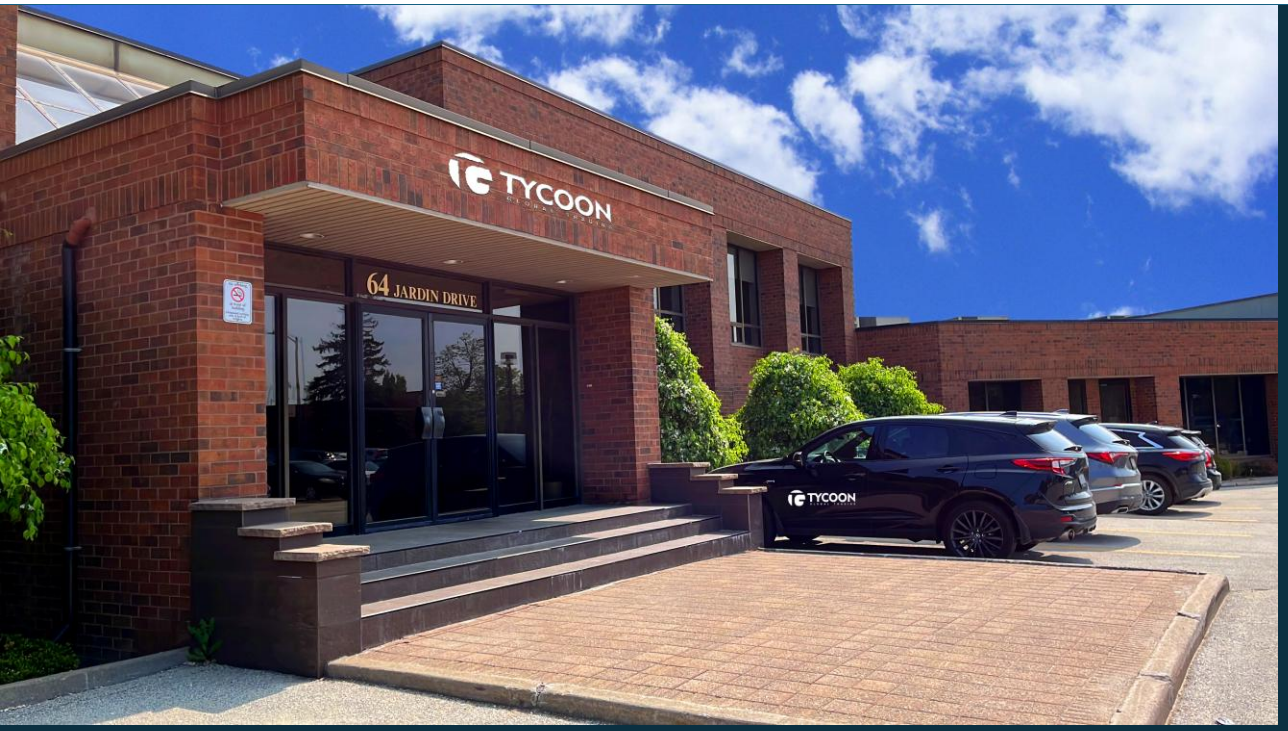

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