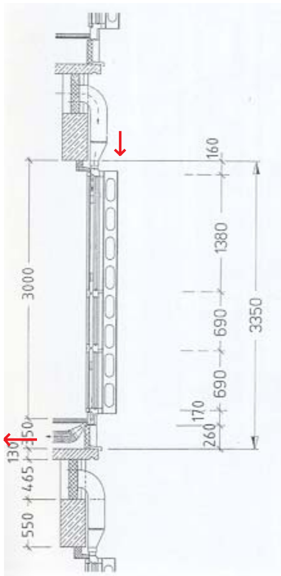

Figure 9*

*Headquarters of the Lloyd's Insurance Company, London by the Richard Rogers Partnership**

*The facade of the office levels has mechanically ventilated windows. The warm air in the room is extracted above the lighting units, so that the air also takes up their additional heat. Then this air is fed via specially shaped ducts at the level of the topmost transoms into the narrow cavity of the story-height ventilated windows. Here the air is warmed further by taking up heat from radiation of the glass; it is then taken out at the bottom of the window and drawn forward to the air conditioning system of the building. The aim in extracting the air via the lighting and then down from the top to the bottom of the cavity, is to utilize the internal heating loads as much as possible in achieving higher temperatures on the surface of the window during colder periods; this improves the thermal comfort in the office space near the windows.**

The integration with the AC system achieves preferred temperatures on the surface of the window. In the proposed addition to Cowgill Hall, heat absorbing glass is proposed to achieve high temperature in the cavity without blocking views.

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Double Glass Facade - Case Study 2

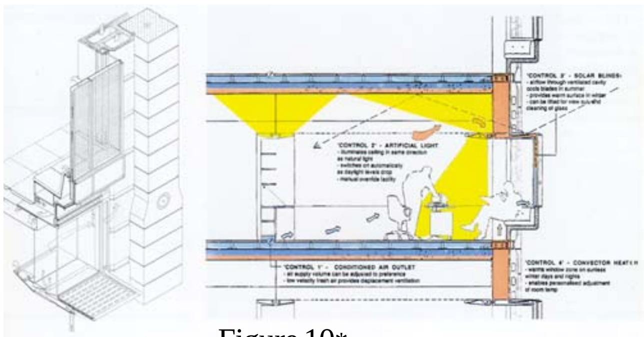

Figure 10*

New Parliamentary Building, Westminster, London by Michael Hopkins and Partners

*In this project, the street facade is composed of loadbearing sandstone piers and glazed bay windows. As these windows are not intended to be opened, for reasons of safety and acoustic insulation, a ventilated cavity facade was proposed. The window construction is composed of an external insulating unit (an external clear laminated glass, an argon gas filling in the cavity, and an internal float glass with a low-E coating), and internally an opening sheet of toughened glass. Solar shading is taken care of by adjustable louvre blinds integrated in the 75 mm wide cavity between the outer and inner skins, and by light shelves positioned above the bays; these shelves shade the area immediately next to the window, and they are designed to reflect daylight into the back of the room.**

It is important to integrate lighting devices with the double glass facade to maximize the benefit of the double glass facade in buildings which do not have an all-glass surface. In case of the proposed addition to Cowgill Hall, the all-glass facade is sufficient for natural lighting.

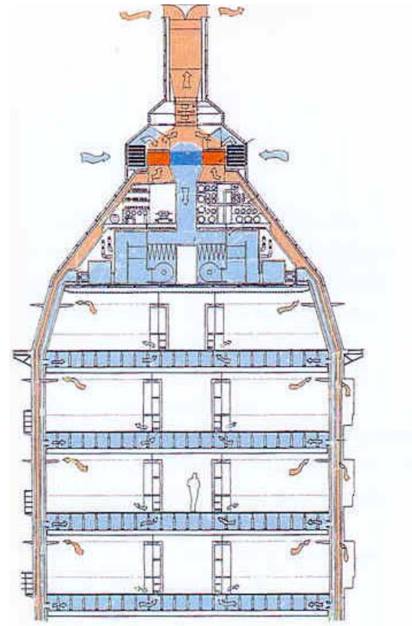

Figure 11*

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*Museum of Art and Crafts, Frankfurt by Richard Meier**

*The Museum of Arts and Crafts in Frankfurt am Main, built 1979-84 by Richard Meier, has a mechanically ventilated cavity facade. The air in the room is drawn out through a slit below the inner frame of the window and then directed upwards along the inside of the outer window to be extracted at the top. This air flow is facilitated by the special design of the transverse glazing bars.**

The box type of double glass window is the most efficient in almost every aspect compared with other types of double glass facade, however it is not as architecturally transparent.

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Double Glass Facade - Case Study 4


Headquarters of the Swiss
*Insurance Company, Basel by Herzog and de Meuron**

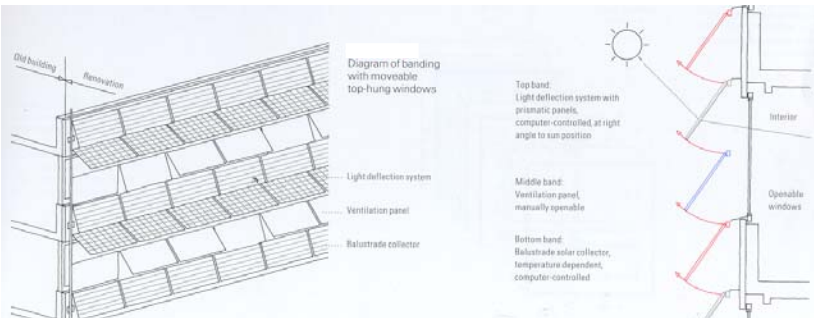

Figure 12*

*The glass skin gives an overall unity to the existing building with its stone facade and its new extension. At each storey level the mullion and transom frame has triple horizontal banding with top-hung windows. The glazing band at window level is of clear insulating glass; these sections can be opened manually for ventilation by the rooms' occupants. The upper band consists of insulating glass with integrated prismatic panels. These glazings are computer-controlled to track the sun across the sky and thus protect the interior of the offices from direct sunlight. The top-hung windows in the lower band at each floor level, however, fulfil a different function in the energy system of the building. In winter they remain generally closed and create a buffer air zone in front of the parapet. In summer they are open, to prevent the stone facade of the old part of the building from overheating and to ensure night-cooling of this facade. This possibility of adjusting the glass panels permits a differentiated approach to respond to changing the weather and climatic conditions and shows how other aspects such as natural ventilation, light deflection, etc., are becoming increasingly important components of facade planning. The increasing complexity in facade requirements high lights the need for new working methods to guarantee optimum interaction of facade and building services.**

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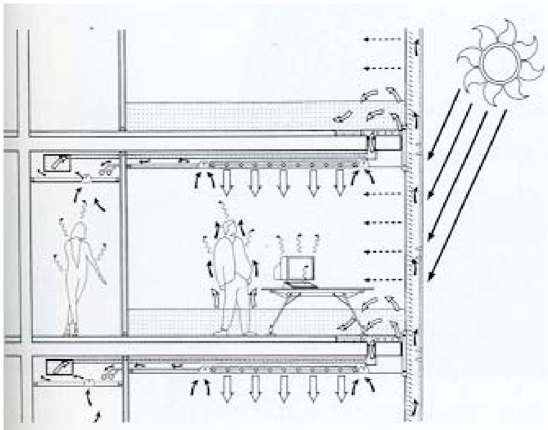

Figure 13*

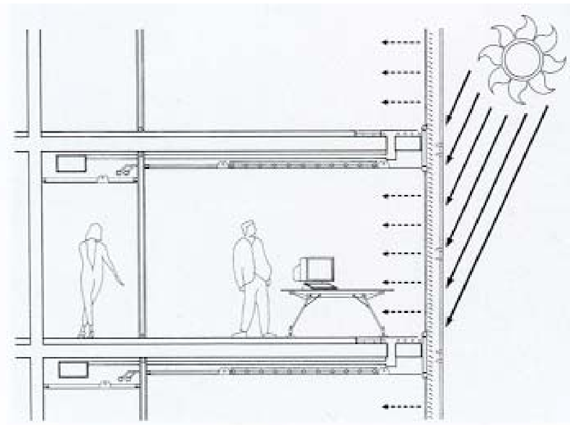

Figure 14*

*Business Promotion Center, Duisburg, Germany by Norman Foster and Partners**

*The curved, double-skin facade of the lens-shaped building at the edge of the complex consists of clear single glazing situated 20cm in front of the full-height insulating glass facade. The single glazing consists of 1.50 x 3.30m toughened, 12mm thick panes suspended in vertical aluminium profiles by means of Planar bolts. The profiles are suspended from the edge of the roof and attached to the intermediate floors for transfer of horizontal loading. The inner facade skin consists of storey-height side-hung windows with thermally broken aluminium profiles and insulating glass units; outside is a 6mm float glass, inside is an 8 mm laminated glass with low-E coating and the cavity between is filled with argon gas. The U-value of the whole double-skin facade is around 1.4W/mxmK. Perforated, computer-controlled aluminium blinds are incorporated into the cavity between the two skins. Air is injected at slightly higher than ambient pressure into the lower part of this cavity and through the effects of warming a natural stack effect results. This air rises and removes heat from the louvre blinds and continues upwards to be expelled into the open air through small openings by the roof edge.**

The idea of combining a suspension structure with the double glass facade is adopted. By applying a double glass facade, this building used a displacement ventilation system; The proposed addition to Cowgill Hall achieves the same result of saving energy by reducing cooling load.

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Double Glass Facade - Case Study Summary

		Natural / Mechanical ventilation	Single / Multiple story	With / withOut insulating glass	Shading reflection property	Cavity depth	Upward / Downward ventilation
	Headquarters off the lloyd's insurance company, London	M	S	W	NA	40mm	D
	New Parliamentary Building, Westminster, London	M	M	W	NA	75mm	U
	Museum of Art and Crafts, Frankfurt	M	S	NA	NA	NA	U
	Headquarters of the Swiss Insurance Company, Basle	N	M	W	NA	NA	U
	Business Promotion Center, Duisburg, Germany	N	M	W	Aluminum	200mm	U

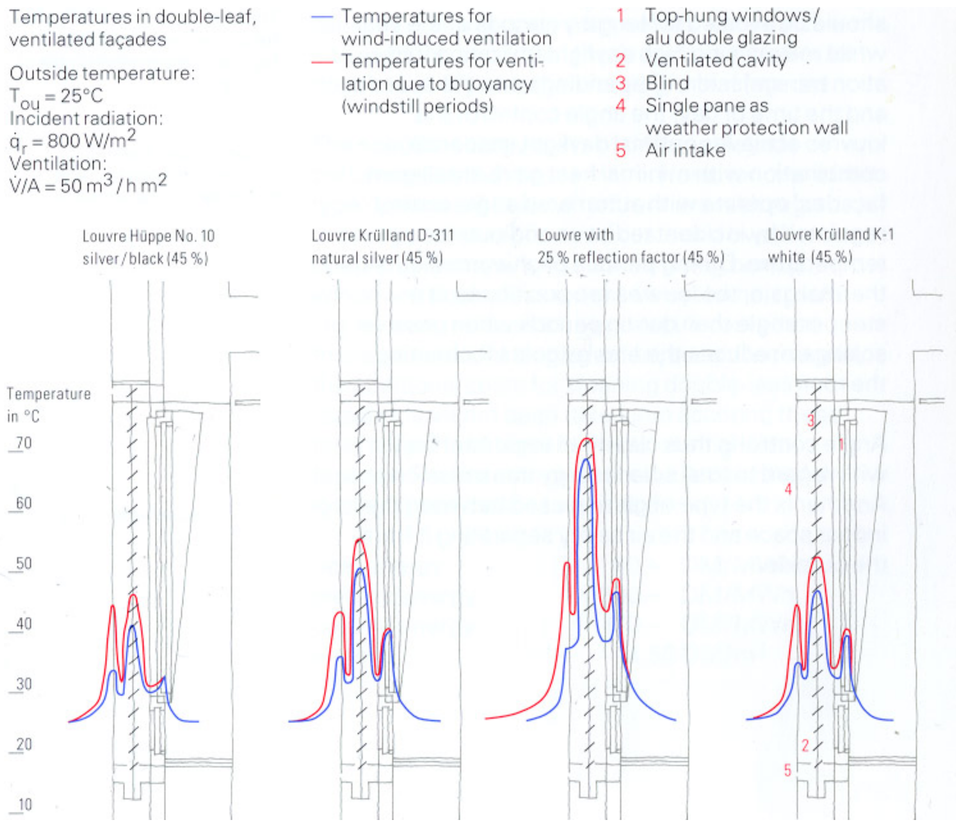
NA: Not Available

Although the double glass facade can be classified in different categories, each of the above cases has specific design and application based on specific context, e.g. weather, site, building type and existing condition.

According to US Department of Energy, in moderate climate regions, all-glass building itself generates enough heat for heating from sun light and indoor electrical usage such as computers in winter. Excessive heat gain in summer is the main contribution to energy cost.

So control of heat gain in summer should be the challenge of double glass facade design in the case of the Cowgill Hall Addition.

Chart of Temperature in transition space for different types of louvre*



*Assuming that fresh air enters a building through the cavity between a double-leaf facade, it's very important, especially during transition periods and when individual occupants want natural ventilation, that no extreme temperature increase occurs in the cavity between the window panes, because the heated outside air would then overload the room temperature. The Figure series compares the temperature in this transition space for different types of shading (reflection quotient). In this example, fresh air enters into the window-pane configuration at a temperature of 25 centigrade and is already heated in the boundary layer region in the outer pane. On this path through the cavity between panes, the temperature rises further. The rise in temperature in this space due to reflection and especially due to light absorption may vary greatly and reach maximum temperature of 70 centigrade. **

Temperatures in different cavities vary considerably. The question of how to remove the heat from the cavity is important. Very little inlet and outlet design has been done. The idea of accelerating ventilation by designing the inlet and outlet seems promising.

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A closer look at double glass facades, physical characteristics

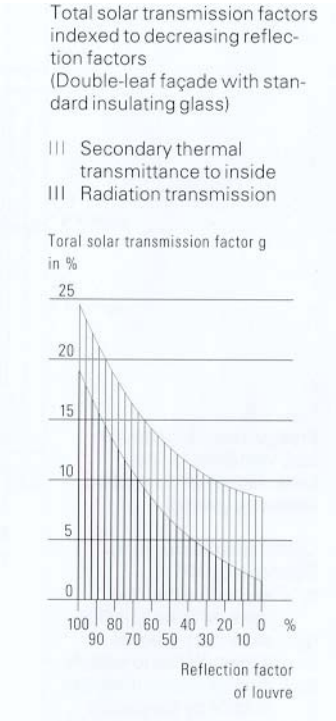

Chart of Total solar transmission factors indexed to decreasing reflection factors*

*The chart presents a calculation of the change in total solar energy transmission per changing reflection quotient. When the reflection quotient diminishes (pollution), the total solar energy transmission does too, because there is less radiation transmission, which is usually positive in terms of heat for the adjoining rooms. On the other hand, the light quality may suffer.**

The quality of the louvre, for e.g., reflection quotient, is worth studying.

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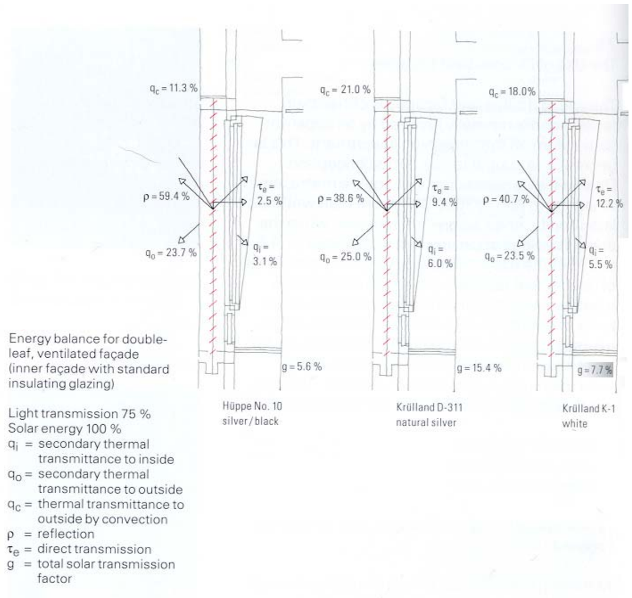
Chart of Energy balance in double facades*



*The energy balance with regard to the radiation transmission quotient, the secondary heat transfer and the total solar energy transmission is shown in the chart. As the comparison of different shading measures in the double-leaf, ventilated facade proves, the total solar energy transmission varies considerably for different types of shading.**

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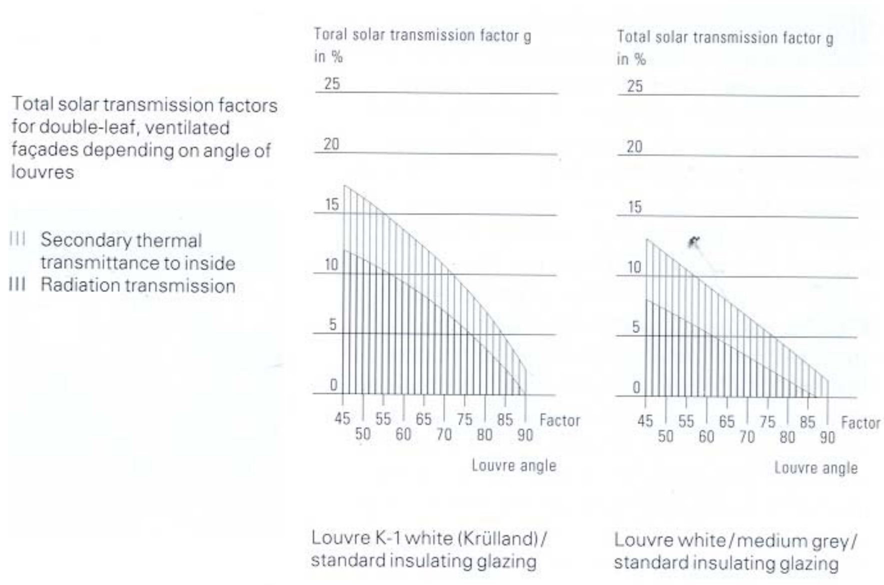

Chart of Solar transmission depending on angle of louvres*

While the surface of the louvre is most important, the angle at which it is placed has an influence as well and changes the total solar energy transmission. The chart shows an example of two different louvres and how the total solar energy transmission changes, depending on the angle. Hence, the correct form of angle control (computer-aided) is key to the optimization of a facade, since direct radiation of office areas should be avoided for lengthy periods of the year while maintaining high daylight utilization (radiation transmission). Depending upon the season and the time of day, the angle control of louvres achieves optimal daylight incidence in combination with minimal heat gain. 'Intelligent facades' operate with automated angle control regulated by incident radiation and outside air temperature. During periods of unwanted thermal gain, the louvres are positioned at a steeper angle than during periods when passive solar gain reduces the energy costs for heating the room.

*Angle control is thus clearly an important factor with regard to total solar energy transmission. Another is the type of glazing used between the indoor space and the air cavity.**

Since direct radiation of office areas should be avoided for lengthy periods of the year while maintaining high daylight utilization, the question is, "how much energy can computer-aided control save and is it a sufficient method to achieve cost efficiency?"

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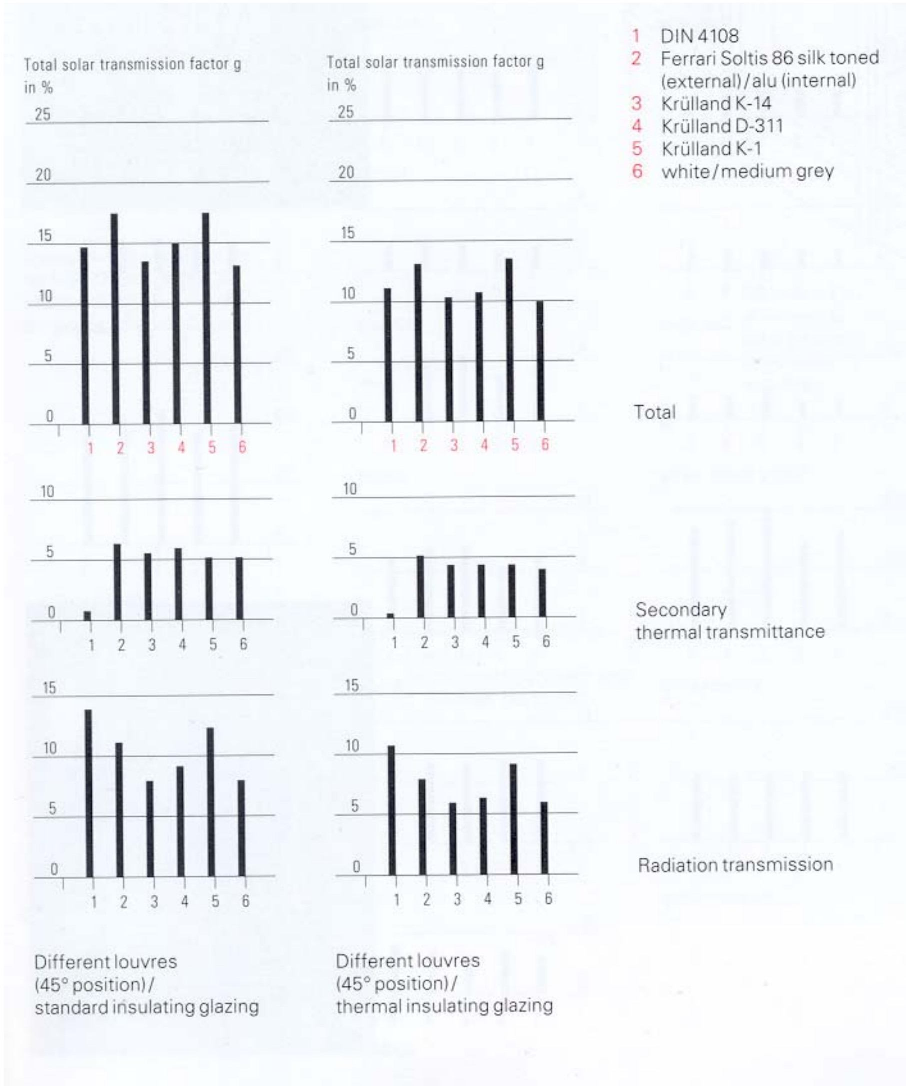
Chart of Total solar transmission with different glazing systems*



If the inner insulating glass has heat-protection qualities, then the total energy coefficient of permeability decreases for the complete shading system. The chart compares two types of glazing with a difference in total energy coefficient of permeability of approx. 15%(box-type window with standard insulating glass g=0.6/box-type window with heat-insulating glass g=0.45). *

Secondary thermal transmission is almost half of the total. Secondary thermal transmission is not linear to the number of glass panes. So it is possible to add a third pane to improve efficiency.

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A closer look at double glass facades, glass property research

Since the properties and physical compositions of various glass materials are highly related to the ecologic performance of double glass facade, it is necessary to take a closer look at glass properties.

Base Glass

Clear-white glass

Body Tinted Glass

The addition of metal oxides to the base glass leads to a stronger tint which produces a higher ratio of absorption and a resulting increase in the temperature of the glass.

Photosensitive Glass

...One example is Louvre, this louvred clear glass combines in a single pane the qualities of transparence and the solar shading effect of narrow slatted blinds.

Photochromic Glass

The properties of body tinted glass are unchangeable, whereas Photochromic glass is self-adjusting, in that the light transmission decreases automatically in response to exposure to ultraviolet or short-wave visible light.

Surface Coating

Reflective and Selective Coatings

Increased reflection properties lead to reduction in the level of transmission. Solar control and reduced emissivity glass is generally used in laminated glass insulating units or multiple glazing units.

Cold Mirror Coatings

The effect of cold mirror coatings is the opposite of that of low-E coatings, because they reflect visible light wavelengths, while admitting the infrared range.

Anti-reflection Coatings

Reduce the reflection of normal glass from 0.09 to 0.02-0.03 and thus increase light transmission.

Dichroic Coatings

The interference effect of these coatings divides the light into spectral colors

Ceramic-Enamel Coatings

Frit-coated glass has a 100-150 nm thick ceramic-enamel layer which is both weather resistant and durable. In recent years more fritted glass panes are becoming available which have various patterns and extents of dots, lines or meshes.

Angular Selective Coatings

Angular selective coatings control the solar and visible transmission according to the selected directions.

Laminated Glass

consists of two or more panes of glass which are bonded together with a plastic material, A number of different materials can be used as an interlayer: transparent, colored or patterned film; thermally insulating, ultraviolet-absorbing or reflecting film; or wired interlayers to meet safety, security or heating requirements.

Angle-Selective Films

In principle they are composed of a microscopic louvered grid structure.

Layers with Photovoltaic Modules

They enable the active use of solar radiation by turning it into electrical energy

Temperature-Dependent Layers

can automatically control light transmission by reversible physical changes which are activated by a change in temperature: Thermotropic Layers &Thermochromic Layers

Electro-Opitic Layers

Influencing the transmission properties in the visible and invisible radiation range by electricity.

Insulating Glass

*Fillings with gas, Insulating Properties, Solar Shading Properties or Light Redirecting Properties**

Possible research topics

Tinted glass---Selective coating---Angle-selective films

The main goal of employing a double glass facade is to maximize the natural daylight while minimizing heat gain. Research on glass may allow this goal to be met cost effectively. The three types of glass all have the potential of utilizing daylight without gaining heat in the application of Cowgill Hall Addition.

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