DESIGNING GLASS FACADES FOR NEAR ZERO ENERGY BUILDING

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BUILDING GLASS POLAND

SAINT-GOBAIN

SPECIFICATION FOR BUILDING SIMULATION

In 2019 the Energy Performance of Buildings Directive (EPBD) of the EU enters a new face – all new constructions should be "near zero energy" from then on. We have seen some new legislation in this direction in the Baltics. In Estonia legislation has been adopted demanding "Zero Energy Buildings" from 2020. This has caused a building boom, nobody really knows what the legislation will mean, only that new construction will probably become more expensive.

DESIGNING GLASS FACADES
INTRODUCTION

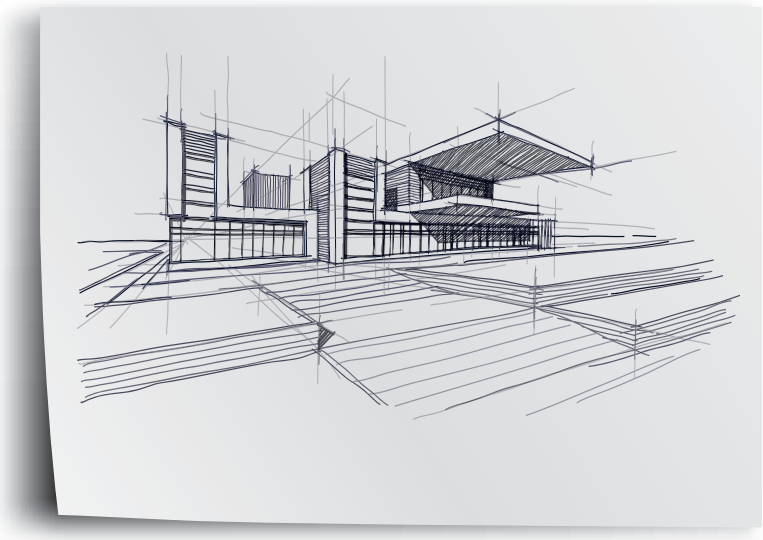
One critical factor to reduce energy consumption in buildings is the solar energy transmitted through the façade, causing problems of overheating in the summer. Some countries have tried to solve this problem by adding a number into legislation. Norway set the g-value demand for sun exposed facades to 0,15, thinking that it would create a need for dynamic facades. Instead it led to extensive use of triple glass with Suncool 30/17 in places like Bergen – glass with 25% light transmission in the rainiest city in Europe. Poland more recently adopted a rule of g-value 0,35 and triple glass units. Now all towers in Warsaw go up with the same class of light solar control glass and no shading, creating massive air conditioning needs.

NEARLY ZERO ENERGY BUILDING

We can see that adding a number immediately warps the market into sub optimization. When in fact there are so many factors to consider before putting a g-value demand on a building – the relation between floor surface and window surface maybe being the most important factor. A Swedish expert has told me that for a larger room like an office landscape a g-sys value of 0,20 is often sufficient, whereas a cellular office with a big window might need a g-value down to 0,08. With a high inflow of energy through the windows it is not possible to design a HVAC (ventilation and air conditioning) system that can maintain a comfortable working environment if not remarkably low g-values are achieved.

To get an idea of what way the market will move it is a good idea to look at Sweden. Because according to Swedish legislation, investors need to prove the climate comfort and energy performance of buildings before even receiving a building permit. This has strengthened the tradition of building simulation in Sweden.

The first computer program to simulate ventilation and façade performance in a building was written before there were even computers in Sweden to perform calculations. Today nearly 2000 consultants work full time in the dominating software IDA ICE. In Sweden we hence have a pretty good grip on what is needed to achieve “nearly zero energy” buildings.



In Sweden the dominating certification system Miljöbyggnad could also give an indication on the direction of the market. It has a daylight requirement for a table surface one meter from the wall in the centre of the room and a limit for solar gain set as W/m2 floor surface. During large parts of the building process it can often not be said with certainty how big the rooms will be, so there is a need for flexible solutions, we call them dynamic facades. In the following we try to sketch the façade evolution in Sweden.

First it is necessary to take a look at the effect of increased u-value demands down to and sometimes under 0,5 for the whole façade. These demands put some strains on the design of the entire façade.

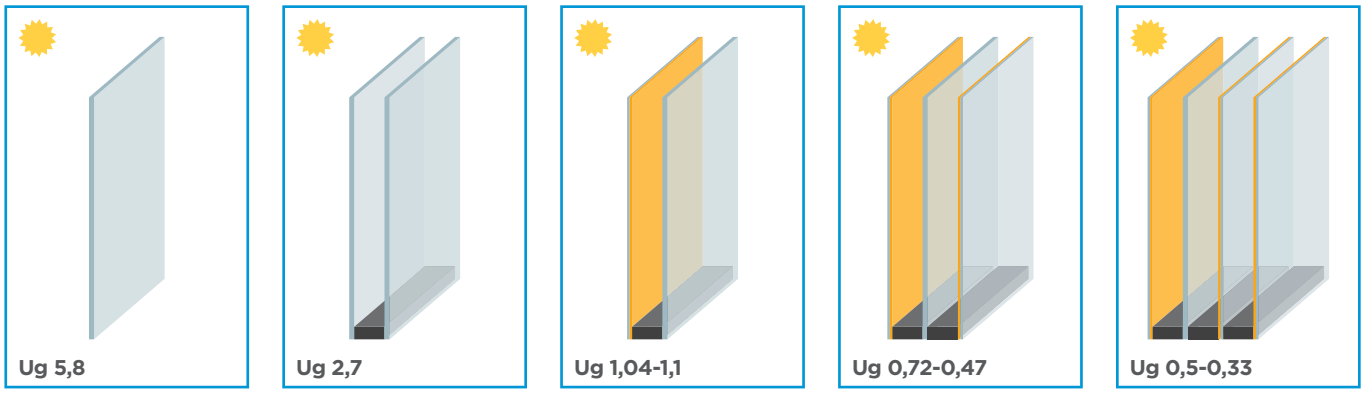
DESIGNING GLASS FACADES

U-VALUE IN FAÇADE

It is common to supply u-values for different materials. those materials are combined into the façade that has been designed. If the total façade u-value required is not met, often we try to improve the u-value for different materials. This has lead to the re-introduction of quadruple glass, for instance.

WINDOW DESIGN

The u-value for a single glass is 5,6. Some 40% of buildings in Europe are still equipped with single glass, and the replacement with double glass and triple glass solutions is the most important factor in reducing the energy consumption of buildings. Between 2000 and 2014 the energy consumption in Swedish buildings was lowered by 14%. The main reasons (the only mentioned) were replacement of poor windows and doors by better ones. The standard of IGU stated double and triple non-coated units with u-value 2,7-1,8 before 2000, was improved by double glass units (DGU) with one coated glass (1,1) 2000-2010 and after 2010 the trend is towards present standard of triple glass units (TGU) with 2 coated glasses (0,7-0,5).



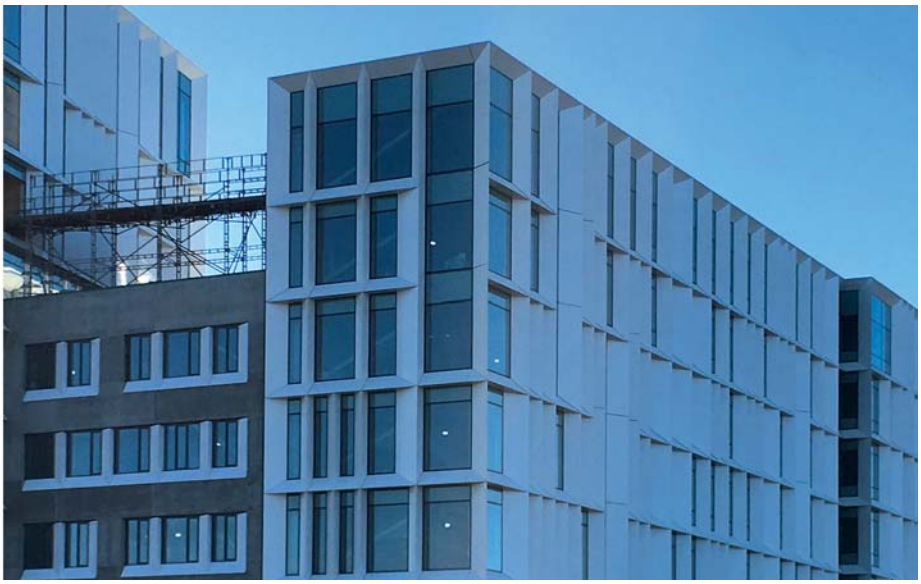
U-value Evolution, spacers for DGU 16 mm, for TGU and quadruple 12-18 mm

For very low u-values, it is necessary to focus on the the design of the entire façade. The shape of the glass will influence the amount of running meters of spacer and frame, and the percentage of edge zone. There is a clear disadvantage for tall and narrow windows compared to more rectangular windows. Decreasing the u-value of glass is not sufficient, especially since we create bigger climate loads inside the units with every increase in spacer width. Especially on narrow windows these stresses create problems of poor aesthetics (bulging glass) and doubtful technical lifespan (stress on sealants). The shape of the window and the frame, and if it is openable or non-openable, will have a bigger influence.

In the table below u-value for the whole window is analyzed in a program called Caluwin, to focus on the effects of different window widths, assuming windows from floor to ceiling 2,4 meters high. The is a difference of almost 0,4 W/m2K in u-value depending on window width. It is not advisable to use glass more narrow than 1 meter. This fact is further underlined by increased thickness of insulation material. A narrow window in a thick wall brings little daylight and even less views to outside, because of the deep wall setting of the frame.

DIMENSION GLASS	Ug	Uf	SPACER	Uw
300 X 2400	0,6	1,0	Swisspacer Advance	1,16
500 X 2400	0,6	1,0	Swisspacer Advance	0,97
700 X 2400	0,6	1,0	Swisspacer Advance	0,88
900 X 2400	0,6	1,0	Swisspacer Advance	0,84
1100 X 2400	0,6	1.0	Swisspacer Advance	0,81
1300 X 2400	0,6	1.0	Swisspacer Advance	0,79

Ug=U-value Glass center point, Uf= U-value frame, Uw= U-value window



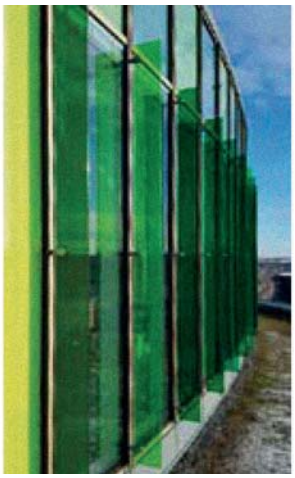
Regionens Hus in Gothenburg and Axis head office in Lund are both based on TGU u-value glass Ug <0,6. Regionens Hus windows are 1250x2400, the U-value for window Uw can be calculated to 0,84 assuming warm edge spacer and frame u-value 1,0. The same assumptions for an example widow at Axis at 400x2700 mm should give Uw approximately 1,10 Uw 1,20.

COLD BRIDGES

In addition to window design comes the problems caused by cold bridges. These come in many different shapes, and need to be dealt with individually. In Norway, the Glass- & Fasadeforening has made a booklet called "Koldebruer" that deals with the subject in great depth. An attempt at translating the table of contects give a clue to what it is all about:

3.1 Facade u-value calculation
3.2 Internal cold bridges into u-value calculation
3.3 Spandrels
3.4 Tall and narrow windows
3.5 Glazed corners
3.6 Seal between facade unit and wall
3.7 Inside floor meets outside facade
3.8 Components mounted on facade after unit mounting
3.8.1 Locks on doors and windows
3.8.2 Fixing of solar shading and decorative items on facade
The points 3.3-3.7 are based on geometry, edge zone problems; between window and spandrel, in corners, in joints between units of a unitized facade and in joining the curtain wall to the heavy structure of the building.

The point 3.8 is material based divided into 2 where the façade focus is point 3.8.2: To hold decorative items and/or solar shadings correctly fixed to the façade, steel structures sometimes need to go straight through all insulation, causing heat exchange between inside and outside.


Cold bridges caused by fixing of solar shadings and decorative items on facade.

To reach very low u-values we risk limiting the creativity of architects in the façade expression. The Regionens Hus Building features TGU top to bottom, horizontal window bands, inside shadings and quite big and homogenous spandrels. The façade u-value could be 0,3 W/m2K lower than Axis head office or even more. We can argue about if these buildings are beauties or beasts, but for better or for worse, future buildings will definitely look more like Regionens Hus than Axis head office.

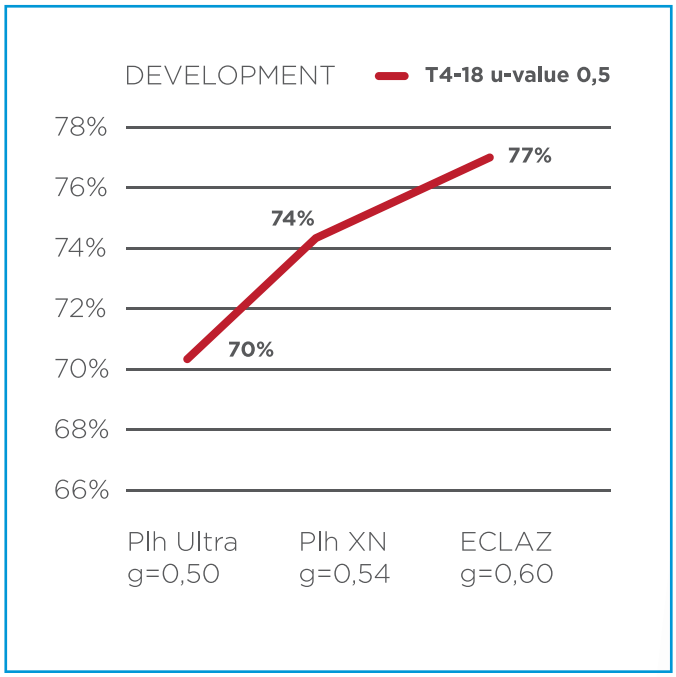
DESIGNING GLASS FACADES
GLASS TYPES IN SSF ESBO

Before drilling deeper into the dynamic facades it is good to stop and make an overview of the different glass types easily at hand in SSF ESBO tool and what they are there for. This presentation takes a strict triple glass (TGU) perspective:

LOW E GLASS

Planitherm XN: this is the standard low e glass from Saint-Gobain since 2014, light transmission in TGU is max 74%. It is coated on the lighter float glass Planiclear, also introduced in 2014 to replace Planilux. Before 2014 there was a different low e glass called Planitherm Ultra. Ultra had lower light transmission of 70% and also lower g-value. Many consultants are not updated, they use too low g-value when they specify low e glass, making it tricky to maximize light transmission.

ECLAZ: the premium low e glass is the first low e coating to be light enough and low reflective enough to actually increase the light transmission in the glass it is coated on. Shifting from XN on Planiclear to ECLAZ on Planiclear is more efficient from light transmission point of view than shifting from XN on Planiclear to XN on low iron substrate Diamant. ECLAZ on Planiclear as inner pane also shifts the color of a white curtain less than XN on Diamant. Planitherm XN and Planiclear has replaced Planitherm Ultra and Planilux. ECLAZ exist parallel to Planitherm XN. Their relation is described in the diagram below.



Development of light transmission and g-value for TGU with two pieces low glass low e glass 2013-2018. When adding 1 mm of glass or 0,38 mm of PVB light transmission decreases by 0,23 and 0,22 percentage points respectively.

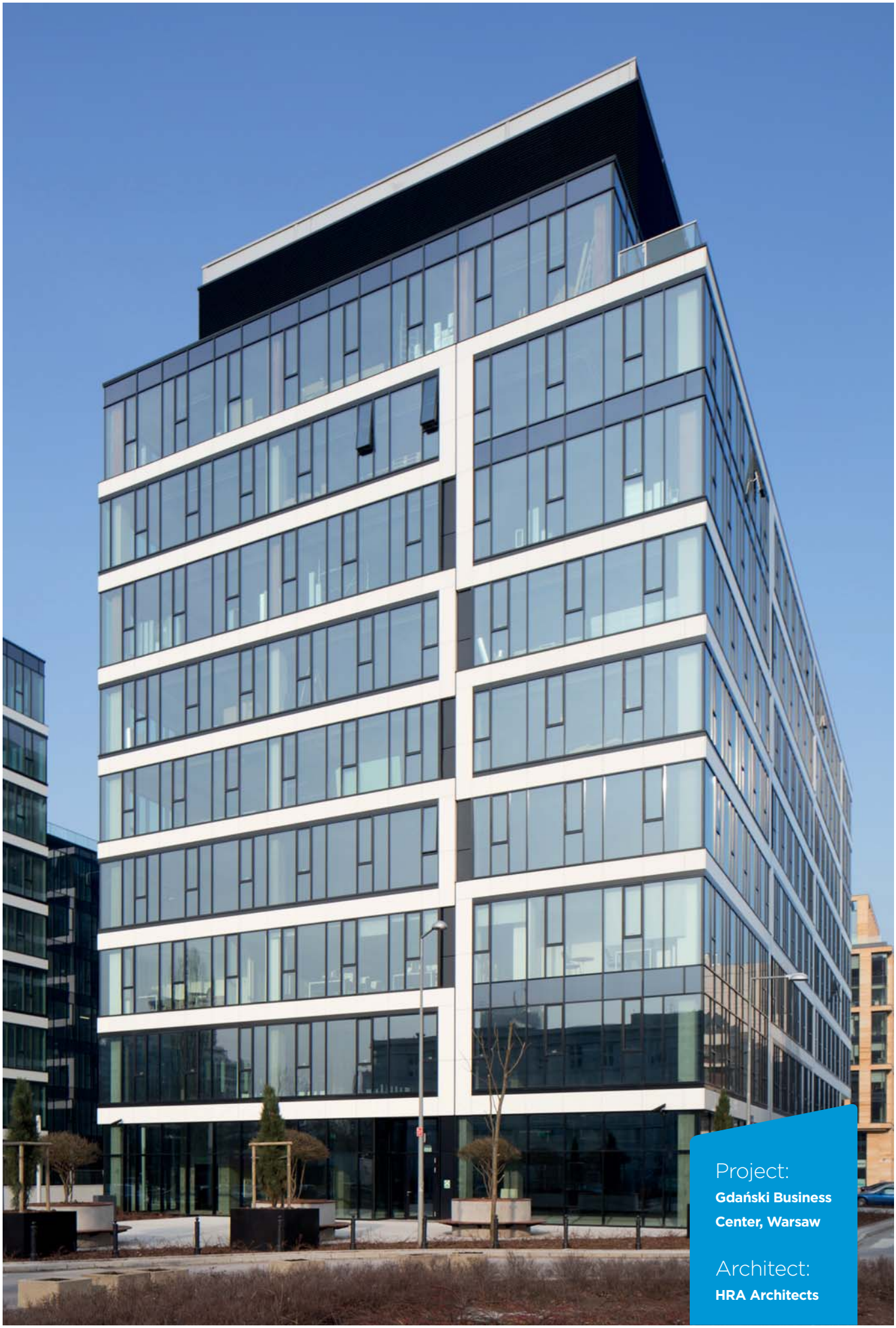
Solar control glass Xtreme 70/33 with inner glass XN left and ECLAZ right.

The reflection of low e glass is held as low as possible and is actually very close to zero. This causes a TGU with 2 low e coatings to have more or less the same reflection as a DGU with 2 uncoated glasses. Both build-ups have four standard float glass surfaces each reflecting 4%, ending up with about 15% reflection. This reflection can be called "natural reflection". Since daylight factor in a room is generally only one percent of daylight on the outside a window will look very dark. The lower the reflection and the smaller the window, the darker the glass looks.

COOL-LITE SKN 176

All solar control glass from Saint-Gobain start the name with "Cool-Lite". In the rest of this text that prefix is avoided. SKN 176 is the first step if the g-value of the low e glass is insufficient to provide a good indoor climate. There are many suppliers for this glass type. The group of glass is known as "70/37" glass types. The name comes from light transmission and g-value properties in double glass units DGU.

In TGU the values are 64/35. The reflection of the SKN 176 is nearly as low as for standard low e glass. They look equally dark in perpendicular view to a window. In some angles and lights a blueish note can be found in the reflection.



Project:
Gdański Business Center, Warsaw

Architect:
HRA Architects

XTREME 70/33

If the SKN 176 is not sufficient to meet g-value demands, the Xtreme 70/33 gives a lower g-value without affecting the light transmission. Xtreme 70/33 has the values 64/31 in TGU. The reflection of the Xtreme 70/33 is the lowest among solar control glasses. From the outside it will look darker than the SKN 176. The low reflection makes the glass suitable in shop fronts, that subject is treated later.

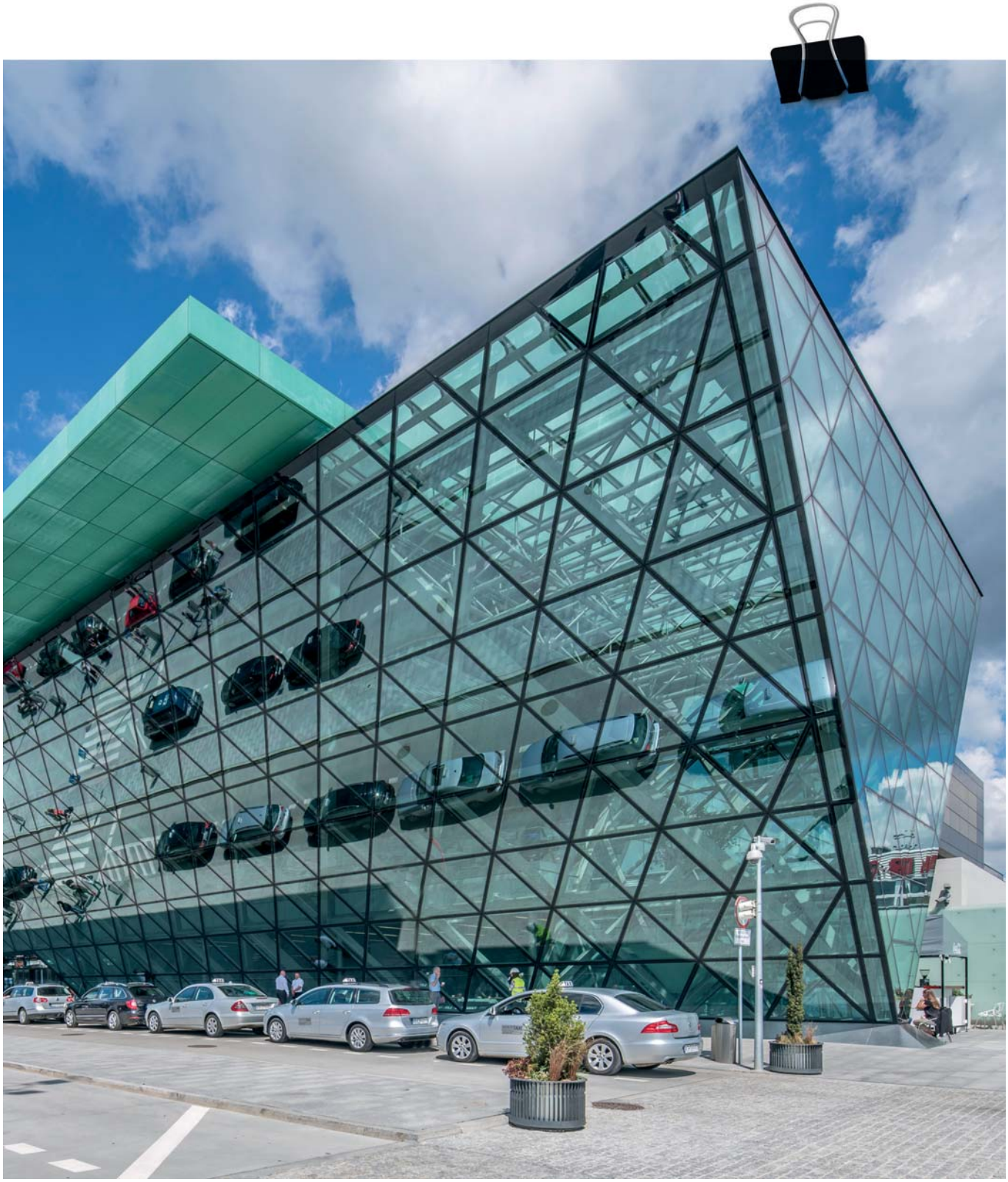
Project:
Mennica Residence

Architect:
BBGK Architects
Jan Belina-Brzozowski
Konrad Grabowiecki
Wojciech Kotecki

Photo:
Bartosz Makowski

XTREME 60/28

The g-value drops further, in TGU the value pair is 55/26. The transmission is still very neutral. The reflection increases a little and becomes a bit greenish. Now it starts looking like a solar control glass.



Project:
Balice Airport

Architect:
APA Kraków Czech, Duliński, Wróbel

Photo:
Bartosz Makowski

XTREME 50/22

The lowest g-value we actively market. It is for lobbys and other places where shading devices are easily damaged. 50/22 is not high in reflection, but the light in transmission becomes a bit sterile. Below a summarizing table.

PRODUCT	TL%	g-value	Selectivity	Outside reflection	Ra transm.	Color reflection
TGU ECLAZ	77%	0,60	1,28	14%	98%	neutral
TGU XN	74%	0,55	1,35	14%	97%	neutral
TGU SKN 176	64%	0,35	1,83	15%	95%	neutral blue
TGU Xtreme 70/33	64%	0,31	2,06	13%	93%	neutral
TGU Xtreme 60/28	55%	0,26	2,11	16%	92%	neutral green
TGU Xtreme 50/22	43%	0,19	2,26	17%	83%	neutral blue

DESIGNING GLASS FACADES
DYNAMIC FACADES

The cheapest way to reach a certain level of solar control is the solar control glass. These have as we know developed into more and more neutral products. If I sit in the sky bar at Scandic Adriadne the sea looks very sterile since the 1990's solar control glass warps the colors, the experience is not pleasant. A great contrast is the Skepps-brohuset in Gothenburg. I visited an office of architecture situated in this new building with big windows. We discussed solar control glass Xtreme 60/28 for a hospital building as the darkest option. "60/28 is what you have in this building" I said. "I did not know we have solar control glass here" he replied, having sat in the building for over one year.

SOLAR CONTROL GLASS

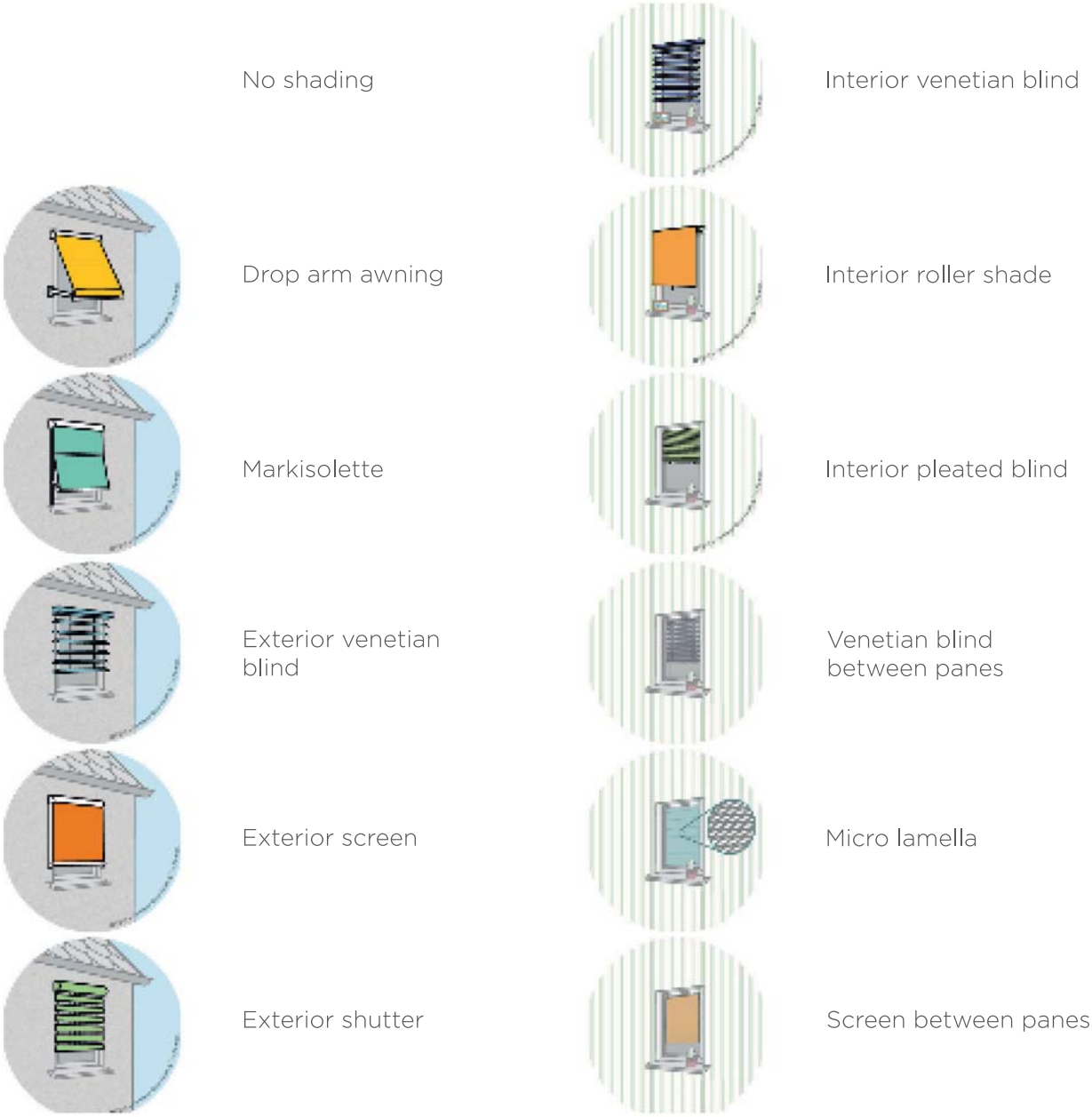
It is very important to point out that a solar control glass should be part of any solar exposed façade. The reason for this is that solar control glass is the only ingredient in the façade soup that has selectivity over 1. And with the triple silver coatings like the Xtreme family we have brought the selectivity above 2 even. This makes solar control glass the most effective tool in the façade tool-box. Selectivity is calculated as the division between light transmission and energy transmission in glass or facade.

With a solar control glass we bring down the light transmission some, but we also drastically bring down the amount of time that other shading devices need be active, and so get more hours of good daylight. For instance; with outside shading like zip screen the screens must be down also on cloudy summer days because of the background radiation, if combined with low e glass only. But if combined with a solar control glass the screens only need to be down during times with direct sunlight on the glass, and then need some sort of glare control is needed anyway.

This argument is connected to Useful Daylight Illuminance – looking at what periods there is sufficient daylight to turn off the artificial lighting. UDI is not part of any rule, regulation or certification, it is a "soft" argument often killed by the hard extra cost of solar control glass.

But the g-value demands we meet in Sweden today down to 0,08 or lower cannot be met with really neutral solar control glass, we need to combine the glass with dynamic shading systems to achieve the desired building comfort. There are a lot of different methods to achieve a dynamic façade with the possibility to adjust the inflow of light and heat. If we look at the Swedish freeware SSF ESBO (or the European ESSO ESBO) there is a palate of solutions to choose from.

Lower u-value demand decrease windows surface. With increased focus on daylight in research and certifications increased g-value demands cannot automatically be met by darker solar control glass, dynamic facades become an important option.



In this booklet we take the IGU supplier perspective and focus on the threat of the exterior screen and the benefits of Interior roller shade, Venetian blind between panes and Micro lamella (Microshade). And of course Sageglass. Building simulation is so important to show the benefits of Sageglass that they are investing into their own version of ESBO called Sageglass ESBO.

In a facade combining glass and shader the g-value is called g-sys and calculated with the ISO 15099 norm instead of the EN 410 used for glass alone. The g-value and TL-value for the glass will differ slightly in the two calculation modes, and the difference appears because of the difference in calculation mode. It is as simple as that.

Dynamic facades come with a cost. And here it is important to point out that a comfortable indoor climate is essential for the profitability of the office workers. In an office building normally 80% of the total cost to a company consists of salaries and employee related costs, 10% are building costs and as a part of building cost only around 0,5% is energy cost. Research has established a link between office temperature and number of dissatisfied users (too hot or too cold). It is called PPD (Predicted Percentage of Dissatisfied) Even a one percent increase in worker efficiency can offset the whole energy cost for a building.

EXTERIOR SCREEN

So now we have established a need for dynamic facades and have also made the extra cost seem more feasible. The first conclusion of the building business in Sweden became a threat to solar control glasses: The heat from the sun must be stopped as early as possible. Let us use outside shaders (blinds or zip screens) and glass with the highest possible light transmission. When I started in specification 4 years ago a lot of buildings were fitted with outside shadings and low e glass.

HS Hansen of Denmark said it was the only way to make a façade. In Denmark there is an Eref value rewarding buildings with a very high g-value because of the heating contribution through glass in winter time. Newer research has proven this way of thinking to be wrongful, but the tradition is strong.

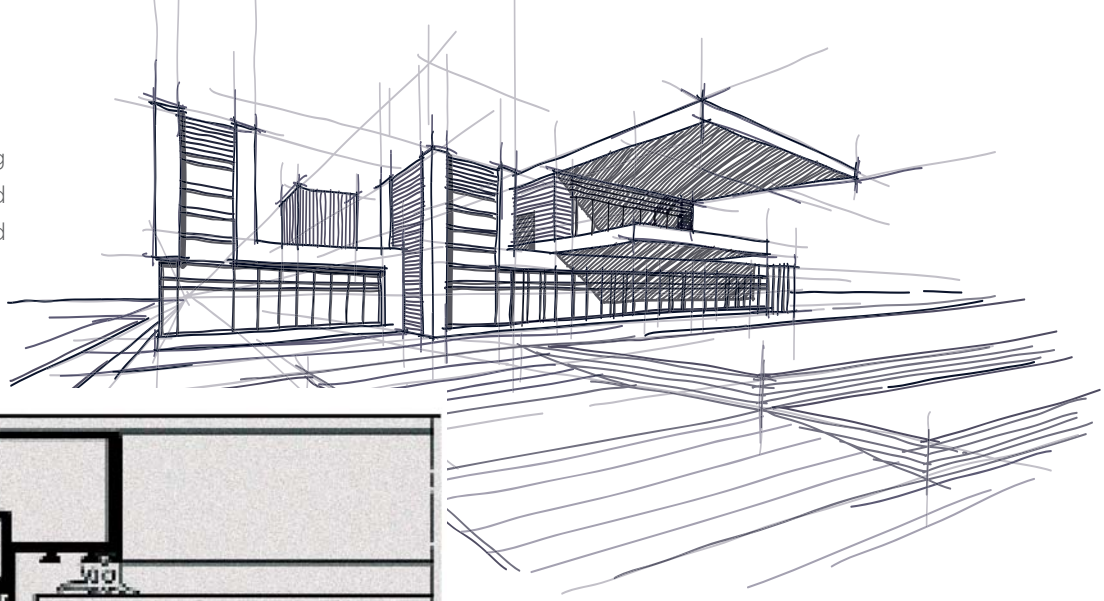
The REHVA guidebook no 12 called "Solar Shading – How to integrate solar shading in sustainable buildings" appeared in 2010, there are a lot of interesting discussions in it, reading is recommended, but the case studies are all on outside shading. I see this trend in Norway now, buildings are moving from the 30/17 glass to the outside shading, mainly with zip screen. This is a way to swing the pendulum all the way from solving the façade with glass only to maximizing daylight with low e glass and solving the solar shading with outside shaders only.

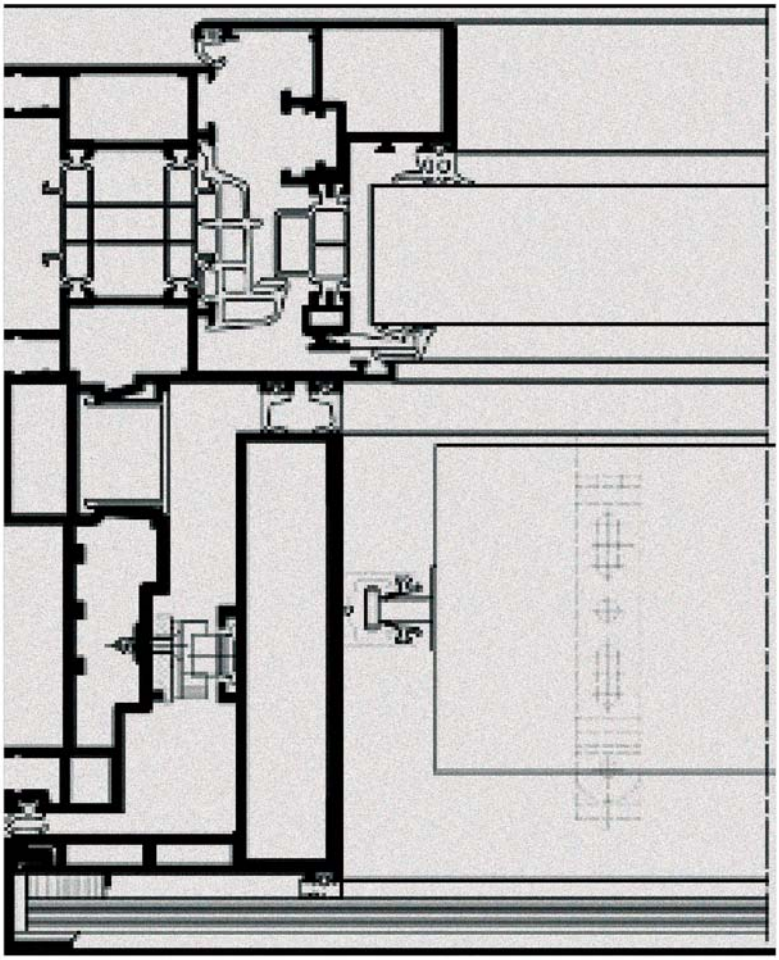
In Sweden we have used outside shadings over a number of years and drawbacks are starting to appear. The REHVA guidebook has a full chapter on maintenance of solar shading systems. They recite the EPBD recast 2008/0223: *„Regular maintenance and inspection of heating and air conditioning systems by qualified personnel contributes to maintaining their correct adjustment in accordance with the product specification and in that way ensures optimal performance from an environmental, safety and energy point of view"*. This applies equally well to solar shading systems but that is not written out.

In fact the maintenance is the main drawback for the outside shaders. They become dirty, are not cleaned and maintained. In many cases experience show serious malfunction even in high quality equipment after 10 years. On top of this the patent for the zip screen has expired, and now cheap suppliers are flooding the market with solutions of very doubtful quality. Anders Hall of Somfy had seen cutting of screen material even, and straightness is imperative.

Another drawback of external zip screen is noise, here is an example of the Quadrum Building in Vilnius. Lithuania: There are reports that on windy days, the zip screens create a lot of noise when closed shaders whip the glass.

The Swedish market is starting to look for new solutions, and the solution given was a hybrid window or box window.





From the top you see an IGU, then space for the screen and lowest the single glass protecting the screen.

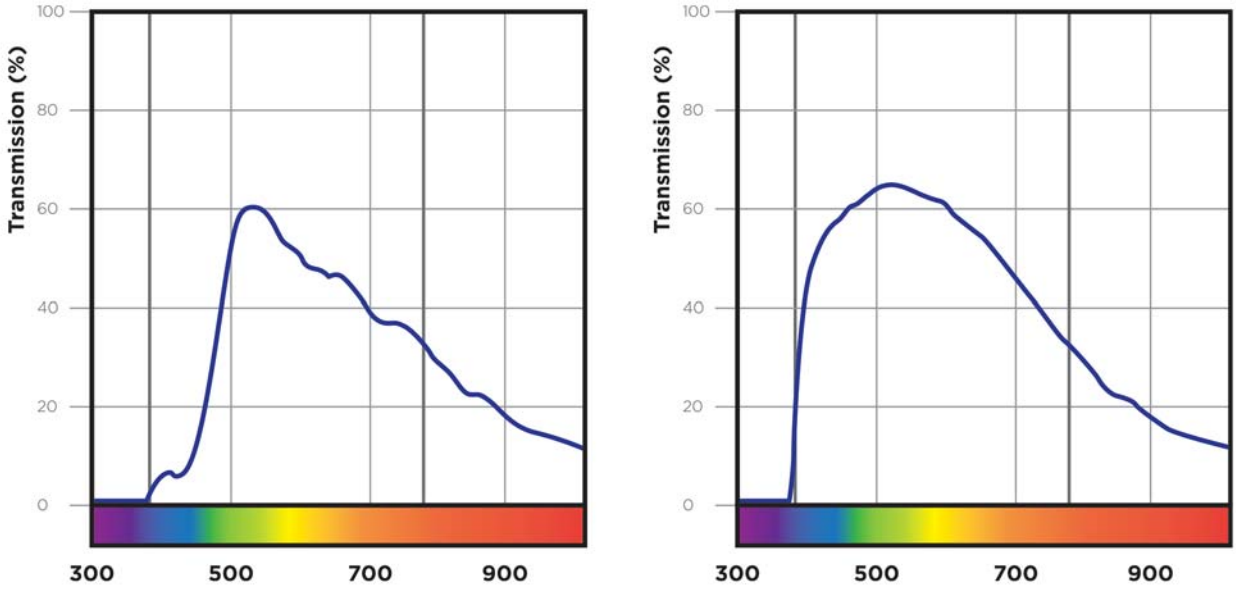
Now we have a solution protecting the screen, but also adding reflection, lowering light transmission and increasing cost. The main drawback is that in the hybrid solution either the single glass or (more often) the inner IGU must be made openable for maintenance.

Openable windows create a main cost driver and also provide a more clumsy look from the inside, since they are generally locked. A fixed IGU has a frame percentage of 5-10%, an openable window often has a frame percentage of up to 30%. The decrease in glass to frame ratio also decreases light transmission, further reducing the TL-advantage of low e glass.

The most used outside zip screen is the Soltis 86. The 86 comes from the amount of material, 86% of the surface is fabric, 14% openness factor (OF). The decrease in daylight is of course great, and one must also point out that 86% coverage is not enough to prevent glare. Inside glare control is needed even when screens are down. The color must be dark.

An interesting case of box windows is the ÅF-Huset in Gothenburg. This is a good example of box windows, they work really well and bring the g-sys value down to approximately 0,10 when screens are down. Two costly mistakes were made in the design, due to the architects wish for a white building with blue stripes, like the local football team IFK Göteborg.

The first was to use Vanceva Aquamarine in the outer skin. It does give a blueish impression, at least against a white background, but it really warps the daylight quality. Colored PVB should never be used for all see-through glasses in a room.



Spectral analysis of the 1+3 build up at ÅF-Huset with Vanceva Aquamarine (left) and had it been standard clear PVB (right)

The second mistake was to choose a very light color on the Soltis 86 fabric. When the screens came down the blue of the glass was emphasized to the outside, yes. But at the same time enormous glare was created on the inside, you could not look at the windows. Within 9 months of opening the building all screens had been switched to dark grey.

ÅF-huset Gothenburg

EXTERNAL SHADING COMBINED WITH SOLAR CONTROL GLASS

As mentioned before there are arguments for using solar control glass in combination with outside shadings as well. The first argument is that you normally get a g-sys value of 0,12 and if needed this can be vastly improved with the combination of outside shading and solar control glass, down towards 0,05.

The next advantage of the combination is that the outside screens need not be down so much. Users complain that a building with outside zip screens and low e glass will not give you any real contact with the outside during the summer. When you come to work in the morning the screens will go down to greet you and as you leave in the evening the screens will wave goodbye by going up again. The addition of solar control glass as stated before gives a soft advantage that is often difficult to sell to the project.

Lund + Slaatto Architect office in Oslo. The outside screen has OF only 2% and so gives glare control. The combination with SKN 174 menas it is only down when glare control is needed, and then only 2/3 of the way, letting in natural light at the bottom of the glass surface.

DOUBLE SKIN FAÇADE

Architects and other stake holders think we should love double skin facades in the glass industry, since there are so many tons of glass involved. But it is a common misunderstanding that the glass industry wants to sell as many tons of glass as possible. That we love double skin facades because of the many tons of glass in all those layers of glass. But in fact raw glass producers prefer to sell the know-how bottled up in the coatings. Double skin facades are often expensive facades with very little value added for the raw glass supplier.

We do find some ways to try and squeeze in some fancy coatings:

1. The architect wants a light and shiny building from the outside – ST Bright Silver outer skin.
2. The temperature in the cavity between the 2 skins gets too high – SKN laminated to PVB in outer skin.

But these are crumbles in relation to the opportunities if double skin can be switched to single: There is enough money in the budget to afford even Sageglass, a shift to Screenline also solves any g-sys problems in a single skin.
The conclusion to draw is that the single skin is always the most affordable and can replace double skin by adding functions to the TGU. The only case where the box window or double skin façade cannot be avoided is when the sound reduction demand is too high. If the demand for the whole façade is above 49 dB (43 dB CTR) we can be fairly sure that it is not feasible to solve it with a single skin façade.

INTERIOR ROLLER SHADE

The big driver of success for Xtreme 70/33 on the Swedish market is the strong increase in facades with interior roller shades. There is a definite cost advantage compared to external shading. TGU 70/33 plus inside shader is about 30% cheaper than a box window construction for the whole façade. With a very small difference in light transmission, because the fourth pane of the box window eats away about 8 percentage points of light. 1+3 or TGU with 70/33 glass both struggle to stay above 63% light transmission.

And there is a big advantage in accessibility for maintenance and replacement. And a much smaller need for maintenance with very little climate stress. There are three main reasons why the solution is growing right now:
Glass development: The Xtreme 70/33 has very high selectivity and low reflection. It is an effective solar control glass without the appearance of solar control glass.

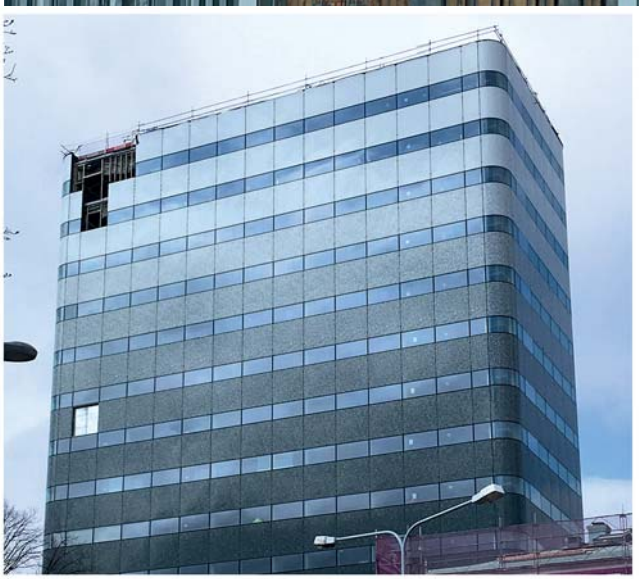
Development interior roller shade: The inside shaders look better than they used to, the reflectance is higher (close to 80% for the one I acquired for my home) and the price of motors for inside shaders is dropping.

Software development: In July 2017 SSF ESBO program for building simulation transferred its calculations to the fully spectral version. On January 31 this year IDA ICE also went into fully spectral mode. In a fully spectral calculation the energy transmission and reflectance is calculated for each wavelength, not as an average.

This method is described in EN 410 and is more accurate that earlier arbitration methods. Sommer Informatik GmbH has had this type calculation for some years in the Sommer program, but ESBo is a freeware and with over 600 fully spectral screen for inside shading to choose from, it is superior to Sommer.

To cut to the point: High reflective shaders and low reflective solar control glass give vast improvement in performance of the solution. 70/33-XN TGU plus Verosol Silver Screen would have landed at g-sys approximately 0,22 in old style calculation, now it gets down to 0,13 in the best case. For DGU it is even more effective, g-sys can get down to 0,12 or less. For TGU we have a 63/31 solution that drops to 63/13 with inside shading. In the DGU case 70/33 drops to 70/12 with inside shading. Magnificent values that include glare control and a lowering of operative temperature in the area near the window exposed to direct sunlight.

In short solar shading entered a new era with these calculations. With the combination of selectivity over 2 and low reflection the Xtreme 70/33 is outstanding in performance together with inside shading.



Regionens Hus in Gothenburg and Axis head office in Lund both use 70/33 plus interior roller shade. Other advantages are less cold bridges with inside shading (Regionens Hus) and increased design possibilities (Axis). Regionens Hus became the first building to be rewarded Miljöbyggnad Gold.

Picture shows SKN 154 DGU without interior roller shade (g-value 0,28) and with Verosol Silver Screen (g-sys 0,13). Please note that in TGU SKN 154 and Xtreme 70/33 have very similar g-sys values for TGU you can choose between 64/13 and 46/12. In DGU 70/33 even outperforms SKN 154. Behold the power of the fully spectral calculation.

DESIGNING FOR COMPLIANCE OR PERFORMANCE?

What demands should be written in specifications? It depends on the legislation or certification chosen. If the design is for compliance it means that the project need meet some demands only on paper. Maximum values in SSF ESBO tool can be used.

If the design is for performance, measurement when building is in use will be needed to prove the design. Here a margin on the systems values is advisable, to give room for some tolerances. The screen values and performance over time need critical analysis. But we can safely say that the relative differences remain. In the tables below the g-sys value for Xtreme 70/33 + inside shading is three percentage points lower than SKN 176 with inside shading. That difference will never be lessened.

PRODUCT	TL%	g-value	Outside shader	Inside shader
TGU ECLAZ	77%	0,60	0,13	
TGU XN	74%	0,55	0,11	
TGU SKN 176	64%	0,35	0,08	0,15
TGU Xtreme 70/33	64%	0,31		0,12
TGU Xtreme 60/28	55%	0,26		0,11
TGU Xtreme 50/22	42%	0,19		0,09

Value pairs LT/g for glass and system for common façade solutions - compliance.

To evaluate the different façade options it is a good idea to check the selectivity of the glass as well as the selectivity of the whole system; light transmission without shader divided by the g-value for the combination of glass and shader down.

PRODUCT	TL%	g-value	Outside shader	Inside shader	Selectivity glass	Selectivity system
TGU ECLAZ	77%	0,60	0,13		1,28	5,92
TGU XN	74%	0,55	0,11		1,34	6,72
TGU SKN 176	64%	0,35	0,08	0,15	1,83	8,00/4,26
TGU Xtreme 70/33	64%	0,31		0,12	2,06	5,33
TGU Xtreme 60/28	55%	0,26		0,11	2,11	5,00
TGU Xtreme 50/22	42%	0,19		0,09	2,21	4,66

System selectivity ranging from four to eight depending on solution, design for compliance.

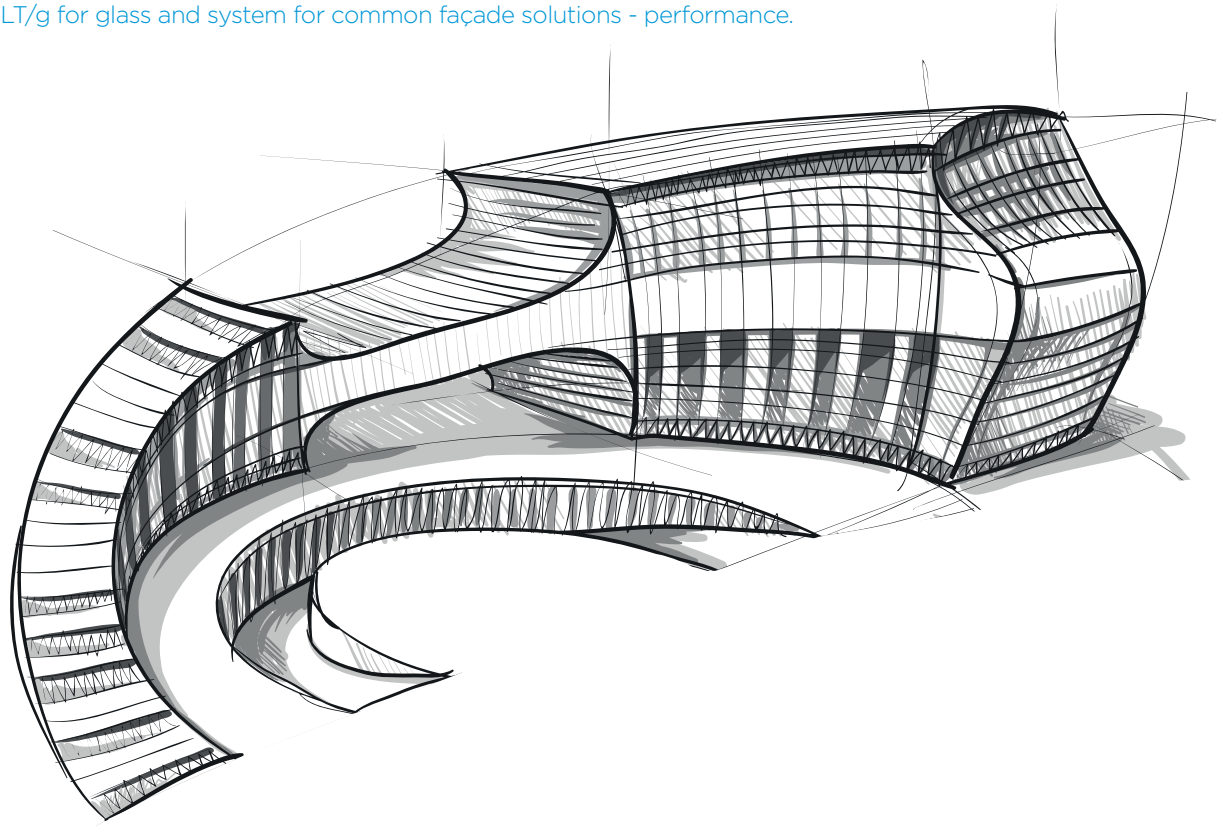
The g-system values required for documentation are different from those needed to make the building perform correctly. If design for performance is required, the specifier need to demand more than needed, setting tolerances to the perfection in the application of the solution. The system demands visible in the design for compliance tables above might be enough to reach the performance indicated in the table.

The basic assumption in setting tolerances is that the façades with outside shadings have less things that can go wrong and in that case the g-sys values are fairly stable. For the inside shadings tolerances are higher and differentiated; more expensive glass (Xtreme) indicates more ambitions solution and higher grade inside shaders, and smaller tolerance.

The light transmission values are pushed down 1-2 percentage points for preformance. 1mm of extra glass fives 0,25 percentage points less light, one PVB foil 0,38 mm does the same. Brighter low e glass and low iron glass can offset the extra glass and PVB.

PRODUCT	TL%	g-value	G-sys outside shading Soltis 86	G-sys metalized refl >70% OF 4%
TGU ECLAZ	75%	0,60	0,13	
TGU XN	70%	0,55	0,11	
TGU SKN 176	62%	0,35	0,07	0,20
TGU Xtreme 70/33	63%	0,31		0,15
TGU Xtreme 60/28	52%	0,26		0,13
TGU Xtreme 50/22	41%	0,19		0,10

Value pairs LT/g for glass and system for common façade solutions - performance.



VENETIAN BLINDS BETWEEN PANES

Saint-Gobain calls it Screenline or Climaplus/Climatop Screen. It creates a dynamic façade where the shader is well protected from the climate. With closed blinds the g-value drops very low, around 0,10. With the help of a solar control glass (only allowed with slat V95) a g-sys value down to 0,05 can be achieved.

When visiting a bigger project with integrated blinds it is striking to see how mild and comforting the light is inside such a building. The glare control of blinds is the best of all shading solutions. But for best glare control the blinds must be well synchronized in the tilt movement and also possible to control at the individual work station. This is not an obvious possibility, since a fully automatic control system is a much less costly solution. We will get back to the important topic of control systems in Dynamic facades later.

The solution is used a a lot in hospitals for hygienic reasons, and it would have many advantages in Norway. Most buildings in Norway stand very exposed close to the coast and in the winter temperatures shift a lot around zero degrees. Not ideal for external screens. But integrated blinds is a no-no in Norway for historic reasons: Some big projects failed.
The first thing to deal with is the hesitation of the customer about the risk: If the blind breaks down a whole new unit must be retrofitted at high cost and with long delivery time.

And the greatest risk for the function of the blind is in fact that cold temperatures can make panes bend inwards and lock the blind on its way down. This risk is much increased in triple glass solutions and must be carefully calculated. There could be an easy solution here in the new SWS pressure equalizing plug re-released Swisspacer Air just a short while back. With equalized pressure on building site the climate load calculation gets a lot easier, but only air filling is possible in such a cavity, leaving small u-value disadvantage.

Another risk is the facts that during the first six months after IGU production, slats can stick together from moisture remaining in the slat pack. For unitized facades there can be the need for advanced logistical operations to avoid this problem: Slats must be up during transport but then down during storage.

FAÇADE CONTROL SYSTEMS

The remaining products for discussion in this booklet are Microshade and Sageglass. They always give a view to the outside, so it is important to discuss control systems for shaders first because the disadvantages with control systems are one big advantage with these products. The view to the outside is a very basic need in mammals, and the blocking of this view imposes a serious drawback of many shading systems.

“30% of all users are dissatisfied with their shading system”. This was the blunt conclusion by a seller when trying to sort out problems with the Glasvasen project in Malmö. The background was the failure of the advanced “plug and play” control system purchased. The demand was such: Blinds must go down by signal of the Building Management System (BMS) but also be possible to control from each office in sections of five to six blinds after the drop. The reason for this added control option is that BREEAM Ecxellent has a demand for user influence over shading system.

The design was terrific: When the blinds go down the manual controls are locked for 4 minutes not to interfere with this maneuver. Then users can control – mainly tilt – the blinds in sections of four to six. With integrated brushless motors the slats tilt with exact synchronization. A joy for the author who fought with tilting blinds at Psykiatrins Hus Uppsala some years before. There the three blinds in each room tilted fully independent from each other after a few runs back and forward.

But what you do not ask you do not hear: Any attempts to push the manual controls during the automatic operation (four minutes) was stored in the system and shot into the blinds when the four minutes were up, bugging blinds to stop at some different strange position. This problem has been corrected in some more expensive control system version, but gives an idea of how tricky building management can be; a normal period for getting fairly good adjustment of most systems is a year. Last I heard Glasvasen is in fully manual mode for the blinds.

The first thing to know about control system is that they have to be automatic to make it possible to use the full ESBO calculated benefit in building simulation programs. Manual systems are corrected with a factor, generally 0,5. The automation need becomes obvious if we look at the east façade case:

In Stockholm and Oslo the sun hits a building from the north east at 4 am in the morning on an average day in June. Who is there to lower shaders at that time of the day? And heat entering the building in the morning stays all day, only at night standard ventilation can cool a building. Still this is the first mistake in many constructions, the desire to save the cost and the headache caused by building automation.

Headache because façade automation is not only about money, it is also about comfort. "My view to the outside is blocked when the sun is shining", a woman from Philips Lighting once told me. Users of a building are generally never educated in the what's and why's of the façade system in the building. And buildings where outside shadings are down look hideous to me.

Architect: Schmidt Hammer Lassen Architects and Lund+Slaatto Arkitekter in cooperation with local partner Arches

Façade automation systems are surprisingly primitive considering the cost, the big players involved (like Siemens) and the bright future in perspective – it is a market projected to explode in coming years. Most of all the systems are usually non-flexible – difficult to make changes in, and based on 2 signals, down or up.

If we take the example of Glasvasen; any attempt to replace the Pellini in-house control system will have problems with the the special shake-loose movement the blinds do to get all slats in order. The fact that control systems usually give only "down" or "up" signals an extra move like that is a problem. Also the tilt synchronization becomes very complicated as tilt is basically the beginning of an up or down move and requires very short and controlled pulses.

The tilt problem is common to all slat based shading systems. The shader sales people will talk about different angles of the slats for different parts of the year and even the day. In the end the building maintenance crew will normally just set a down and close when necessary and then up again at the end of the day. How to set the down point is also a bit tricky. The normal thing is to put a sun sensor, and in many cases also a wind sensor, on each façade, signaling to the building management system that shading is necessary, in the best case over a certain amounts of W/m2 hitting the building in combination with a certain max temperature on the inside. To learn more about these things it is recommendable to read the 76 pages short book "Solar Shading – How to integrate solar shadings in sustainable buildings" ISBN 978-2-930521-02-2 and to connect with a local Somfy representative.

Somfy supplies façade automation motors and hardware/software. They are the driving force behind the release of SSF ESBO and ESSO ESBO and they have recently developed the most flexible control system on the market, with three main drivers behind flexibility:

1. The motors are not controlled over cables, but wifi, all motors are part of a cloud and the when and why the motor is activated can be changed fairly easily.
2. All facades of many buildings can rely on one advanced weather station on a roof.
3. A 3D-model of the house and its surroundings clarify when a window is shaded by another building – a signal to raise the shader.

Still this fancy system cannot guarantee user comfort. If and how to design manual overrides is a very difficult decision to take. And an important one, because there are so many personal preferences. Looking at the MT Högaard main office below, I think there will be some increased worker efficiency by the possibility to influence the venetian blinds, comparing to ICON Växjö, where the building management system has full control over the IGU integrated venetian blinds.

MT Höjgaard head office in Denmark. Staff can adjust blinds themselves in groups of three.

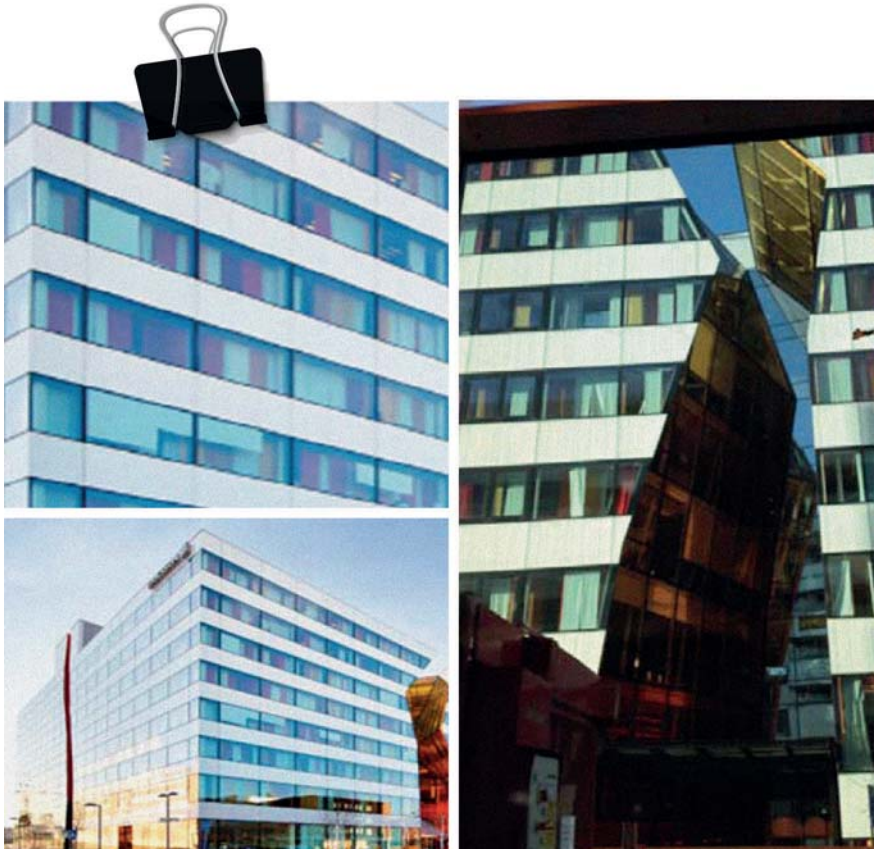
Try to find out how many different choices have been made on this east façade. And notice the façade sensor on the top floor in the fourth white field counting from the left.

Inside view from the same building. 3 different slat positions visible.

The Danish Glassolutions organization have come the furthest in seeing the importance of the control system for customer satisfaction. They have sold many thousands of IGUs like this where their electrical systems manager Peter Krogh supports the projects through the whole process and system warranties are given (or should we say charged for?).

CONCLUSION

Buildings are designed to meet legislation or in the best case certification. User comfort is seldom in focus here. What we need to focus on in our prescription for facades are the softer values. The notion that any shader can be used much less in combination with a solar control glass, more hours enjoying good daylight and perfect view to outside. And that Screenlines, Sageglass, Microshade (most of the time) and inside shading (the fastest growing product in Sweden) all provide glare protection. But we also need to be ready to inform about the risks involved.



Detail of Hekla building Stockholm. Very fancy glass building, but due to glare problems curtains will be closed most parts of the year, no matter what the weather is like.

MICROSHADE

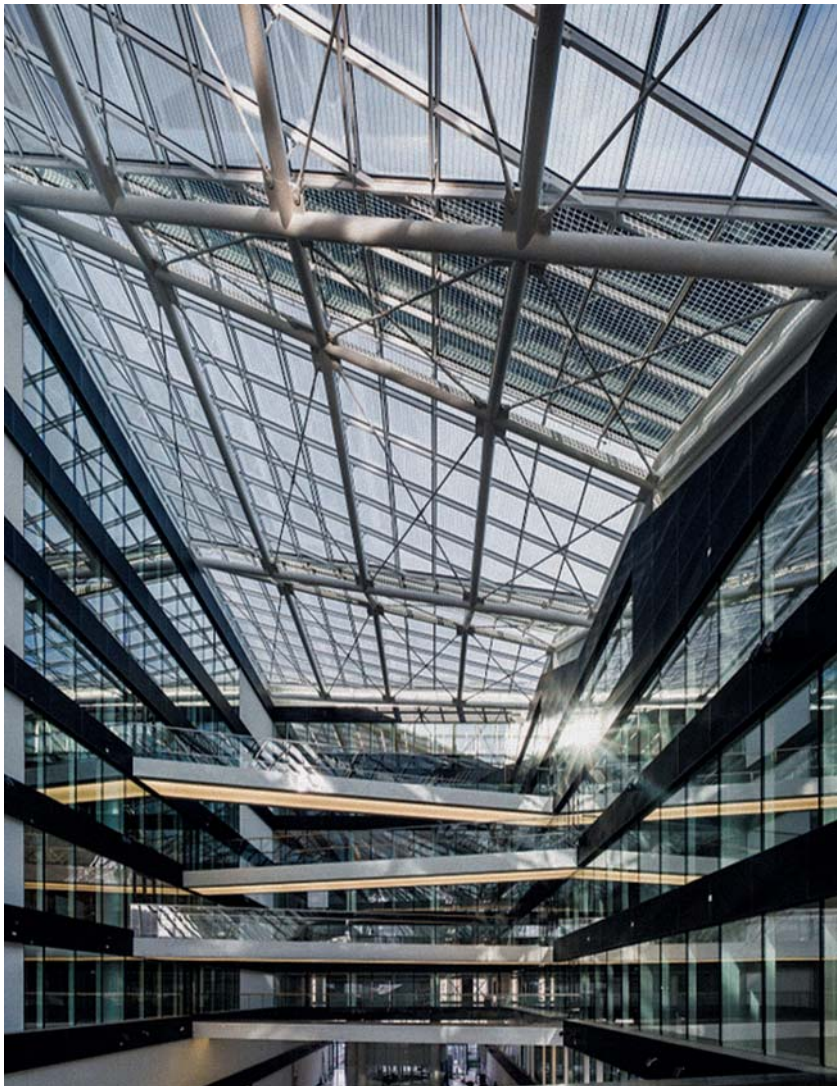
Moving on to Microshade it is maybe now more understandable why MS makes such a big deal out of the fact that that it is a dynamic solution without any moving parts or settings, when the solar angle increases the direct sunlight is automatically blocked. But here we still need to communicate building simulation benefits a lot, because the product looks really poor in accordance with EN 410. The standard Microshade type A in TGU with 2x XN has LT of 45% and g-value 0,34, not a very good selectivity. If we run a simulation for a south façade and a day in July the solar curve plays its part, the sun rises from the perpendicular EN410 perspective and the g-value "for cooling design" drops to 0,24 in the Gothenburg case. Change the address to Katowice with higher sun angle and it is 0,22, selectivity over 2 with glare control during large parts of the year.

Microshade have some problems. The look is not liked by everybody, and the price is HIGH. In SG-solutions the white off becomes very apparent and needs to be dealt with. Another thing to consider is the climate loads. Outer pane should be thick or unit pressure equalized. Because difference in bending caused by different air pressure on day of production made the external impression of the reflection of the glass seem very different when the sun was shining from an angle at the Sweco office façade in Örestad, CPH.

There are two main applications for Microshade:

Roofs: The sun in Europe is never in Zenit, so no glare problems and very stable values for MS. For a roof in Stockholm MS calculated LT/g values 34/10. With a very high Ra-factor, only low e glass affects the colors of the light. And dynamic solutions for roofs are very expensive because of the problem of gravity, making even Microshade competitive in price.

Rooms with peak loads at midday: In a cantine or lunch restaurant facing south the amount of people generating heat and demanding ventilation gives a short but high peak in solar control demand during lunch hours. This peak coincides with the best values for Microshade, the sun is nearly fully blocked at this hour. Unless the view to the outside or to the inside is vital, this is a match made in heaven. Microshade provides a lousy shop front.



Confederation of Dunish Industry

SAGEGLASS

Sageglass carry all the advantages of Microshade when it comes to product stability. No climate loads can have a negative impact on the function. In fact Microshade and Sageglass are the only shading options where you can estimate a life cycle cost for the façade without replacing parts at some point. And Sageglass is dynamic.

Electrochromic glass is the only solution that guarantees a view to the outside in all modes. And concerning the positive effects of this view and daylight researchers agree: Everything from savings in shorter care time in hospitals to higher efficiency among office slaves is true. Sage glass is the only electrochromic glass that fades the light down to 1%, hence the only electrochromic glass that can be used without further glare control.

Sageglass zoned (authentic picture)

There is a disadvantage of the blue color of light – people tend to look like zombies in such light. That is precisely why the possibility of dividing the glass into zones is so good. At a school in Bergen where the glass is installed, one of the zones at the bottom is only ten centimeters high. It is supposed to be completely clear most of the time and is enough to ensure that the children do not look like quiet customers to a funeral parlor.

Sageglass is easier than standard glass to handle in prescription because there are not so many things to consider:

Different solar control glasses: No need, Sageglass contains all different values, at least up to 55% light transmission (in triple glass)

Dimensioning: With a maximum of 1500x3000 mm and the outer glass laminated with Sentry foil, you hardly need to dimension any loads. The glass should handle all wind- and snowloads you throw at it.

Self-Cleaning / Anticondensation: Sage does not approve # 1 coatings, so this type of complexity does not exist. The reason is that Sage company is uncertain how these coatings can affect the extended ten-year warranty that the system often comes with.

Fire glass / bullet-resistant: These types of inner panes are not currently delivered, the maximum protection level is currently P8B according to EN 356.

Sound reduction: This is a very important subject, Sageglass needs to come up with about eight different Rw configurations from 35-50 dB, then we can quickly advise on the correct total thickness and spec. Rw over 50 dB may be good in theory, but as the frames usually set the limit of sound reduction in a single skin facade, it is seldom necessary with higher noise reduction than 50 dB. And if you go to double skin for better sound reduction, the Sage glass is no longer feasible.

The next challenge, instead, is to bring manufacturing to Europe to shorten lead times. The lead time and the serial length's effect on the price means that the product can now compete primarily in unitized facades.

SPANDRELS

In conclusion to the façade let us finish with a very short discussion on spandrels. I have written articles about look alike facades and patterened glass in facades that can be googled from GLAS magazine of Sweden. But a brand new theme is the use of high reflective spandrels to improve daylight calculations:

Many governments or other organizations realize the risk that close to zero buildings will become unattractive due to the low share of glazed surface, and so add daylight requirements, usually some type of daylight factor.

Here it should be mentioned that the daylight factor must be checked in detail. For Sweden the required daylight factor is 1% whereas in Norway it is 2%. This sounds like a huge difference, but in fact the Norwegians calculate average daylight in the room, and in Sweden it is about a single point half way into the room at desktop level one meter from a wall. With no benefit of the strong glare found next to the window boosting the Norwegian average calculation, the Swedish and Norwegian rules are in fact more or less the same.

Back to the topic: The daylight factor in densely built places (like cities) has a very strong correlation to any building shading the new construction. White is becoming a favorite in cities to bring more light all the way to the first floor. Introducing high reflective spandrels into the game (Mirastar or IGU with ST Bright Silver #2 and Diamant RAL 9003 #4) gives better reflectance of the façade and could tilt the daylight calculation in the right direction:

For an important project in Oslo we had discussions with consultant responsible for daylight. She complained about difficulties in getting enough daylight on ground floor. "What light transmission do you need?", I asked. "200%" she replied.

For a new care building at Malmö Hospital the architects have brighter and brighter materials higher up in the building. To make the building blend in with older buildings of bricks at the street level but the gradually become brighter and sort of vanish into the sky. This is a very old trick, and it releases the glass advisors fantasy: ST Bright Silver spandrels and/or to changes Xtreme 50/25 silver at the top, shimmering spandrels from patterened glass (although difficult to calculate the reflection for these) and double printed enamel spandrels slowly moving from dark to bright.

For spandrels moving from dark to white it is important to point out the the move should not be made from 0% white to 100% white in one smooth move. Everything in the design happens somewhere between 40 and 60% white. So for a more subtle building use smaller steps in coverage differences from floor to floor, starting with some 40% white.

In any case it is feasible to predict that the days of facades with 90% window surface are over. In Sweden I see glass shares from 30-50%, sometimes up to 65%. To reach daylight targets without loosing out on contemporary u-value demands for the entire façade down to 0,5, a fully glazed façade is very difficult. For Saint-Gobain this means a stronger focus on finding and specifying interesting spandrel solutions, Alcubond is to be considered a competitor. When looking at Regionens Hus it has advanced solar control glass Xtreme 70/33, but the most expensive glasses are cornerpiece spandrels; the bent four side stepped silicone sealed IGUs with outer pane enameled first with green pattern and then with full white print compatible with IGU sealant from Sika. Printed in Lithuania, bent in Austria and assembled in Latvia.

To save some money Diamant glass option was sadly taken out in favour of standard float. Looking at the yellowish RAL 9010 mock up glass at perpendicular view there was no worries about greenishness. Standing below the façade and looking up at a strong angle the greenishness becomes a little more apparent.

Kronprinsen building in Malmö (right) is a great 1960's example of making a building vanish into the sky. He mosaic wall cladding slowly gets brighter towards the top of the building. Regionens Hus in Gotheburg is more obvious in the shift. Kronprinsen is closer to 40/60 and Regionens Hus is more of a 0/100 example.

In order to maximize glass share in future facades we finally need to draw attention to the benefits of bigger glass panes. Bigger quadratic panes (not necessarily oversize) and fewer profiles allows for a much lower u-value than a fashionable façade of narrow glasses known as "stading French fries", given the same share of window surface. Regionens Hus only has 35% glass share and huge spandrels of over 4 m2 to minimize u-value.

SHOP FRONTS

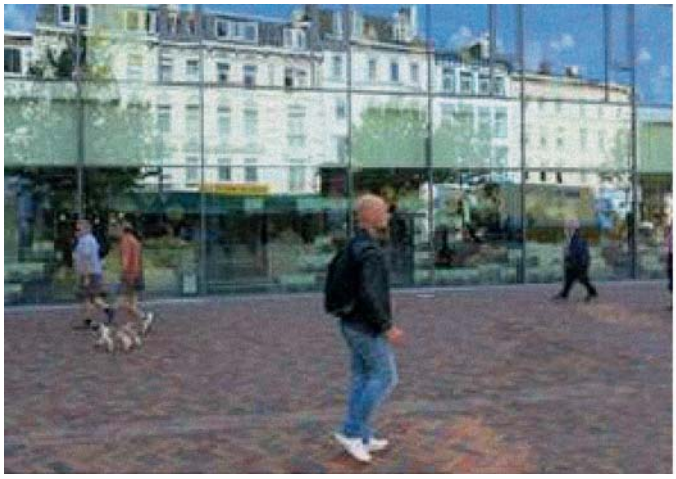
A special case of the modern façade is the shop front. I stated earlier that modern solar control glass gives an excellent view to the outside, also in a triple glass unit. But the triple glass unit has drawbacks when it comes to the view from the outside in – the shop front.

Shop front windows used to be much more expensive than regular glass, You see, the standard drawn glass we know from old windows is somewhat irregular in its structure, and this did not please shop owners, who wanted unobstructed views to the merchandise. Instead, glass for shop fronts was produced in the same way like glass for mirrors and vehicles: The glass was first cast online some 10 mm thick. Then polished down to 6-7 mm thickness with even structure and parallel surfaces. You can imagine the extra costs incurred. This tradition stopped when the float glass gained momentum in the 1960's. Shop fronts was made cheap by using 6 mm float glass cut to size. You can still see a lot of those old shop fronts walking through any city shopping street.

This type single glass with parallel surfaces is still seen as a standard by shop owners and they fight to keep it that way. On the other side near zero energy buildings need at least double glass and prefer triple glass. Shop owners instinctively feel that DGU/TGU obstruct the view to the inside and they are right: Glass is a glossy material, each glass surface adds 4 percentage points of mirror effect from a perpendicular view. A single glass shop front mirrors 8% of the light, and an uncoated double glass unit mirrors 15%, triple 20% of the light, obscuring the view to the inside.

So once again we must consider shop front glass as more exclusive than standard glass. In order to promote the view to the inside without failing to build in a sustainable way. The answer to this riddle is to use non-reflective coatings on glass. These coatings can be standard low e or solar control coatings, but also specialized and expensive non-reflective glass mainly used in museums. With this help we can move beyond the old shop front (8% mirror) to near zero reflective shopfronts. At Ikea in Altona, Hamburg, such an investment brought the store from not visible to the best display in town. 2x low iron glass with one low e coating is generally accepted as the clearest possible glass. With non reflective coatings the mirror image gets blueish, but taking reflection down from 12% to 3% is a drastic improvement in View to inside.

This low reflective type of glazing can help rent out the difficult ground floor locations to commercial activities.



Before and after change of glass.

Saint-Gobain Glass has set up a matrix of glass alternatives for different situations. They are based on the assumption that a shop front never moves over 8-9% reflection. And that in inner city stores we should move beyond this border to stand out. With shop fronts reflecting 3% or below, a company can stand out and make a bold statement of it's brand, even in locations where colors and logo are not allowed on the outer façade.

PRODUCT	TL%	g-value	u-value	LRE%
DGU VLII + ECLAZ/VL*	92%	0,73	1,1	2,0%
TGU VL/ECLAZ + VLII + ECLAZ/VL*	86%	0,60	0,6	2,5%
DGU VL/XTR 70/33 + VLII*	78%	0,35	1,0	3,3%
TGU VL/XTR 70/33 + VLII + ECLAZ/VL*	73%	0,34	0,5	3,7%
Stadip 44.2 laminated float	90%	0,80	5,6	8%
DGU ECLAZ + ECLAZ*	83%	0,63	1,1	8%
TGU 6XTR 70/33 + 6VLII + 44.2 ECLAZ*	68%	0,32	0,5	9,2%

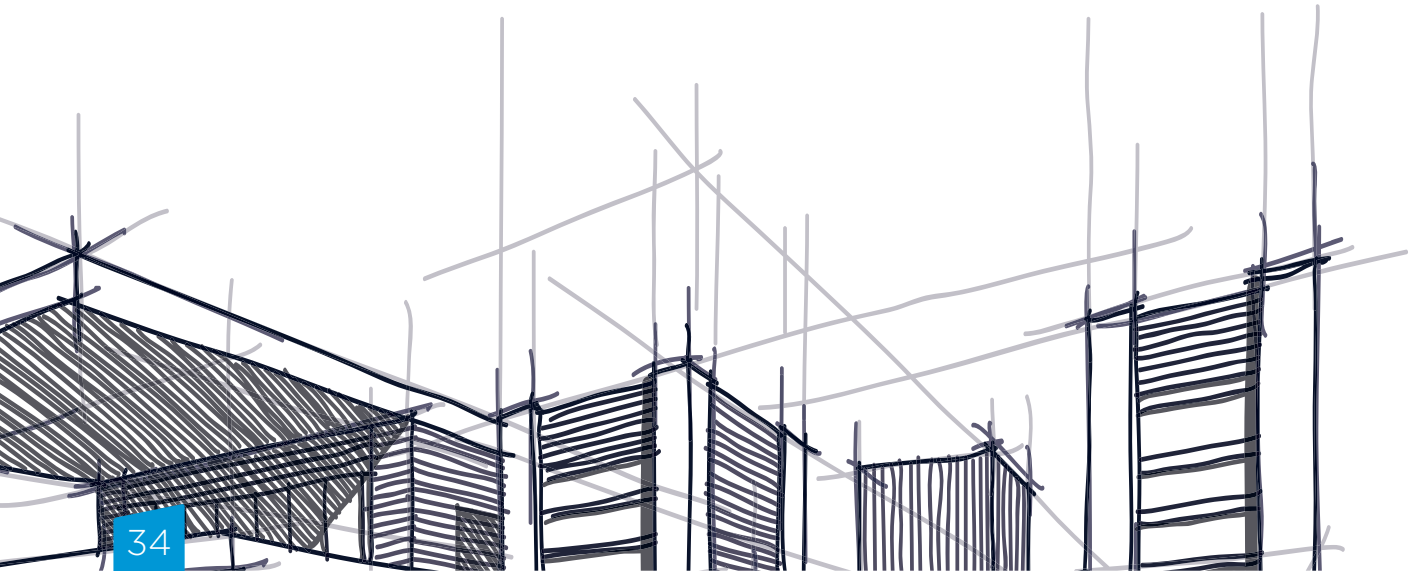
* Coating: VL Vision Lite antireflective, ECLAZ low e, XTR 70/33 solar control

When it comes to the view to the inside aspect of daylight becomes very important.

View to inside is improved vastly if light enters the room from 2 directions. Car dealers tend to put the newest release in a corner of the show room for best effect.

View to inside has problems when the shop front allows for no glazed corner and is facing north. Sun shining on the opposite façade will make it a bright mirror image blocking views to inside. This is exactly the Altona case. The level of acceptable reflection in a shop front varies from case to case, and must be evaluated individually.

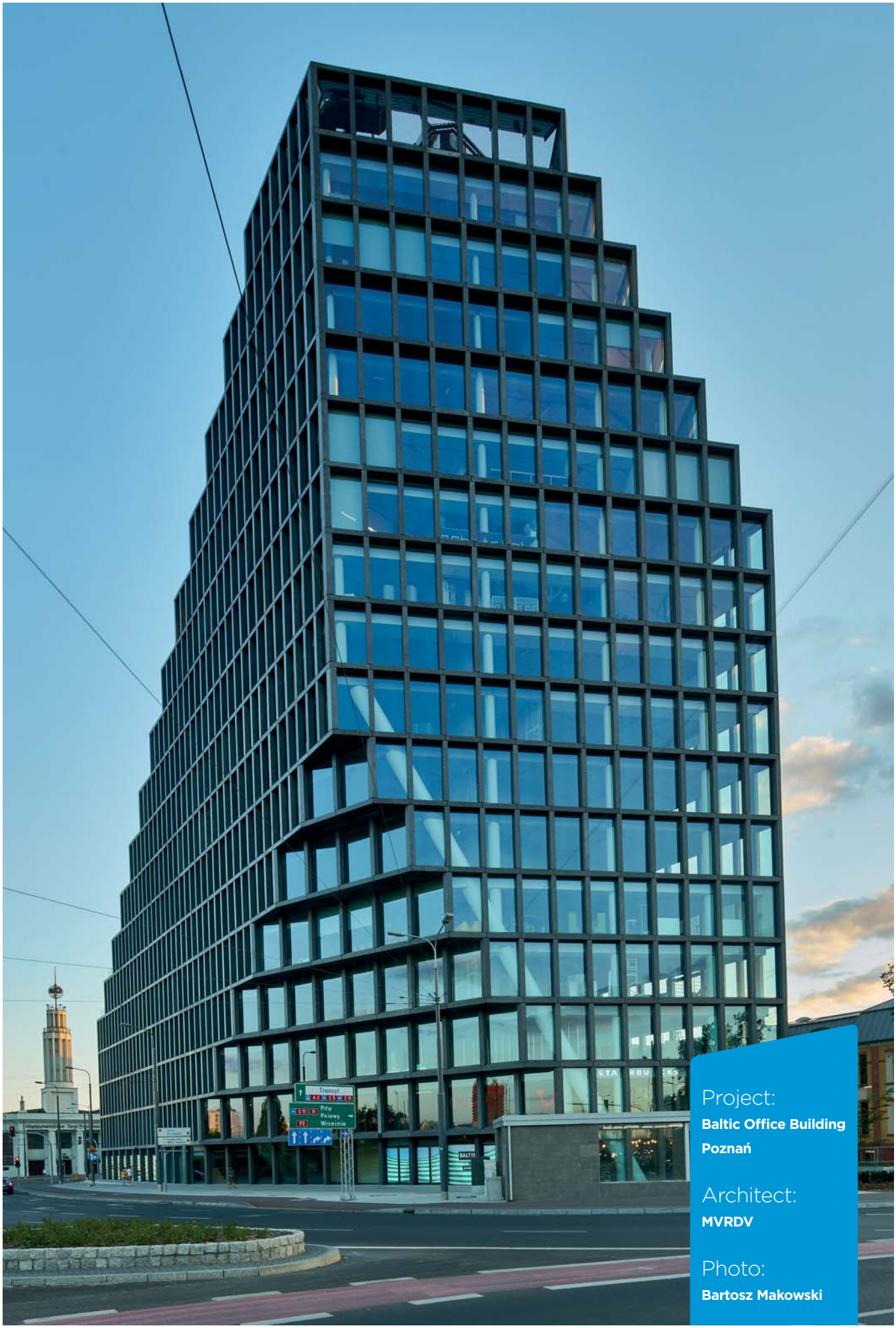
The general rule is that price goes up as reflection goes down. But it does not apply to DGU with coating on both inner and outer glass. Here low e or solar control coatings with low reflection as a side effect to chasing light transmission, can be applied to lower reflection at a marginal effect on cost.



Show room, Germany
Architect: JSWD Architekten GmbH & Co. KG

IMAGE OF GLASS

Connected to the shop front case is the question of the image of glass and evaluation of façade mock ups. It is important to understand that different light conditions and different inside daylight level has a great impact on the image of the glass. Here below a few examples with the SKN 176. The 70/37 type glass is dominating the Polish market, but looks different from project to project. Some pictures below tell the story. It is important to find the correct daylight level behind the glass in a mock up and to see it under cloudy conditions. Most glass looks poor when viewed in direct sunlight.



Project:
Baltic Office Building
Poznań

Architect:
MVRDV

Photo:
Bartosz Makowski

Domaniewska Office Hub Warsaw, pictures taken at dusk. Same glass and same occasion but the angle make the glasses look greyish black or blueish. When the light is on inside glass looks fully transparent. Next time you see a reference picture of a nice project, chances are that the pictuire is taken at dusk with lights on inside the building. These precious minutes of the day is the only time the building can approach the rendering in look.

This is an actual photo of the Malmö Arena Hotel, believe it or not. The lower façade was supposed to have the same 70/40 glass as the standard windows, 13% reflection. But only g-value was written in the spec, so author found cheaper solution to sell with 30% reflection. In this case it emphasized the exciting design of the façade, so no harm done. It was not a shop front. The picture puts great focus on the importance of indoor daylight level to the view to inside. On the left the façade turns he corner and is transparent. On the right the 30% reflection turns into a perfect mirror.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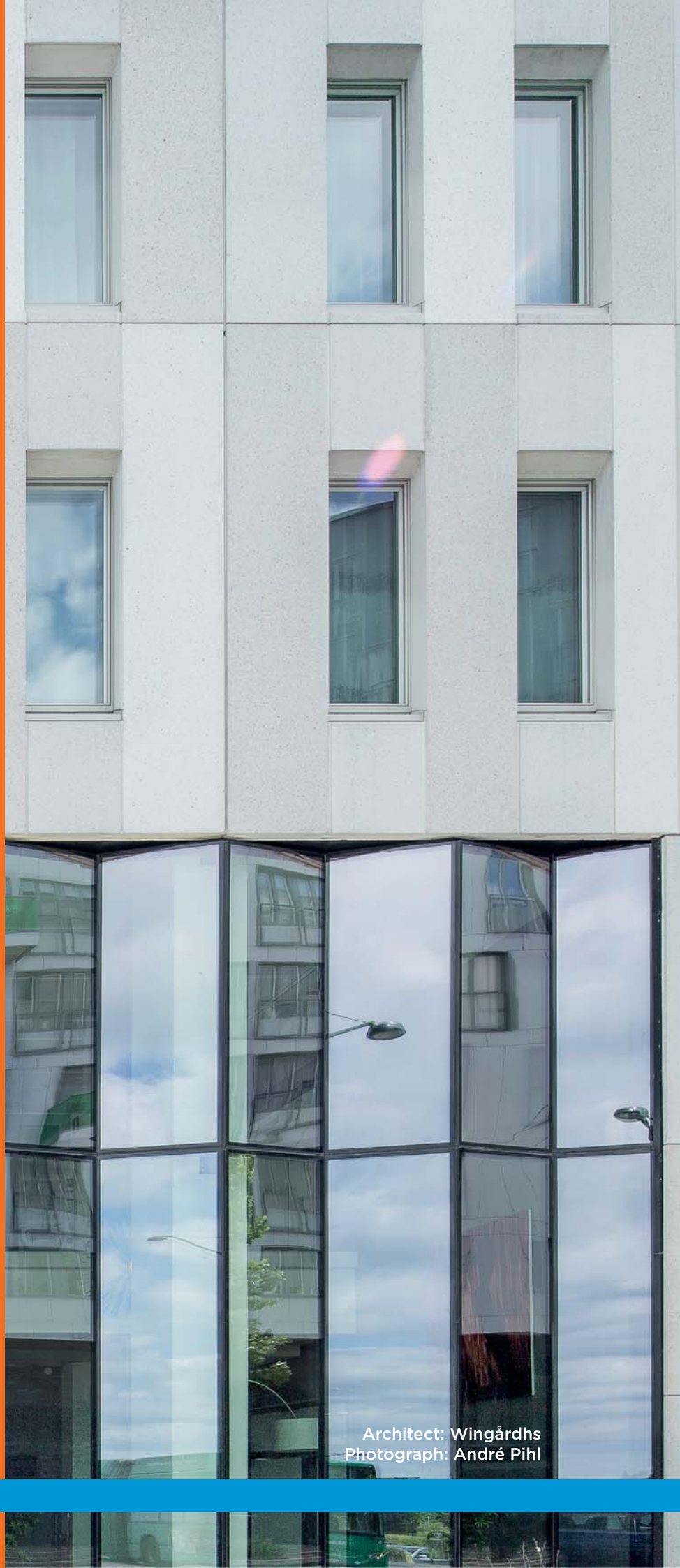

Architect: Wingårdhs
Photograph: André Pihl

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