

Synergies Between Solar Shading and HVAC Technologies

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Buildings use a lot of energy

The energy crisis and the concern about climate change have put the subject of energy efficiency right at the top of the political priorities. Generally, three large energy-using sectors are considered: industry, transport and buildings. The built environment - residential as well as commercial - plays a major role in the various energy-saving scenarios, because it consumes just over 40% of all primary energy, for the construction, operation and maintenance of buildings. The European Commission has taken a number of initiatives, the best known of which is the so-called EPBD, the Energy Performance of Buildings Directive, issued late 2002. In a previous issue of this magazine (March 2008), a comprehensive survey has been given of the main subjects covered by this far-reaching directive.



Figure 1. Dome over the Reichstag Building in Berlin, by Sir Norman Foster.

Saving energy in buildings is usually and spontaneously identified with at least these three measures: insulate more, use high-performance double glazing and use energy-efficient installations for HVAC. The insulation industry in particular has been very active in showing the benefits of better and more intensive use of its products and has published serious and convincing studies on its effect on energy use and on the reduction of greenhouse gas emissions. Insulation of walls and roofs, among other things, helps keep the cold out. But the problem is often to keep the heat out in summer conditions, especially in buildings with lots of glass, as the architects now love to build them. Glass admits natural light and shows openness. Sometimes there is a message behind the use of fully glazed buildings: transparency and democracy, as in Norman Foster's dome over the Reichstag building in Berlin. But even the best type of glass is basically static. Solar control glass will keep a good part of the sun's energy out in summer time, but unprotected, it will still allow a sizeable part into the building. As we become more demanding for our comfort conditions, air conditioning moves from luxury to standard equipment in offices and, depending on the climate, also in residences. This creates a considerable extra need for electric power and often causes peak demand problems that our electricity grids are not equipped for. On the other hand, solar control glass will also prevent the sun's energy entering the buildings when it is welcome, in winter time. That's where mobile solar shading comes in. To make glass dynamic and to make buildings more comfortable at a lower energy cost.

The Greenhouse Effect in a Building

When a glazed surface is exposed to the sun, a sort of 'greenhouse effect' takes place: the sun's energy has a short wavelength and travels easily through the glass. Once inside the building, this energy is absorbed by walls and floors, by furniture and all sorts of objects, and transformed into a higher wavelength, infrared radiation. It becomes heat and these heat waves do not travel as easily through the glass. Therefore, heat will accumulate and a greenhouse effect happens. That's why inside a car, parked in the glaring sun, the temperature will rapidly rise beyond the outside temperature.

The capacity of a glass quality to manage energy is measured by its U-value and g-value. What is usually seen as the main characteristic is the U-value, or thermal transmittance, the capacity to insulate from conduction. But U-value is not about radiation, it's about what happens when there is a temperature differential between outside and inside. For the sun's radiation, however, the g-value is representative, a dimensionless figure that indicates how much of the solar radiation will travel through the glass towards the inside of the building. The databases of the frequently used high performance glazing show U-values like 1.1 W/m²K or 1,3 W/m²K, while 'ordinary' double clear glass is still abundantly available at 2.9 W/m²K. On the face of it, there has been a sizeable progress from the typical 5.7 W/m²K for clear single glazing - still current some 30 years ago. But at the same time, the g-value has only gone down from values like 0.83 to 0.73, or maybe 0.61 for the most popular types of glass. Yes, there are values in the low twenties for the most advanced solar control glazing, but these will cause a need for extra heat in the winter, as the glass will also stop up to 80% (and let in, say, only a bit more than 20%) of the solar energy, when this energy would be welcome and contribute to the heating of the building.

Mobile solar shading adds a dynamic capacity to the glass

Solar shading (blinds, awnings, shutters etc.) comes in a variety of types, shapes and colors. Roughly speaking, there is the break-down between external and internal shading systems. In another logic, we can distinguish between fixed and mobile systems. Fixed, like canopies or louvers; mobile, like retractable awnings or motorized roller blinds, to name but a few. In this context, we will only discuss mobile systems. That leaves us with mobile external and mobile internal systems. These

Three important parameters for glass and solar shading devices:

U-value: in W/m²K is the *heat transfer coefficient*, or *thermal transmittance*: a measure of how well the glass or shade insulates

g-value: the *solar heat gain factor*: the measure of how much solar energy is let in. Expressed as a fraction or %

Tv: the *visual light transmittance*: the measure of how much visual light is let in. Expressed as a fraction or %

constitute the vast majority of all applications. In double skin façades the shading is usually placed between the two panes, which somewhat combines the advantages of internal and external systems.

Common sense dictates that external systems will be more efficient for controlling the admittance of solar energy. The shading device (usually a fabric or a slatted venetian blind) will stop the vast majority of the sun's energy, depending upon its coefficients of transmittance (how much is let through?) and reflectance (how much is reflected?), both of which are measured in a spectrophotometer according to EN410. The g-value then is calculated according to EN13363-1 (the simplified method) or EN13363-2 (the detailed method). These standards take into consideration the effect of both the glass and the

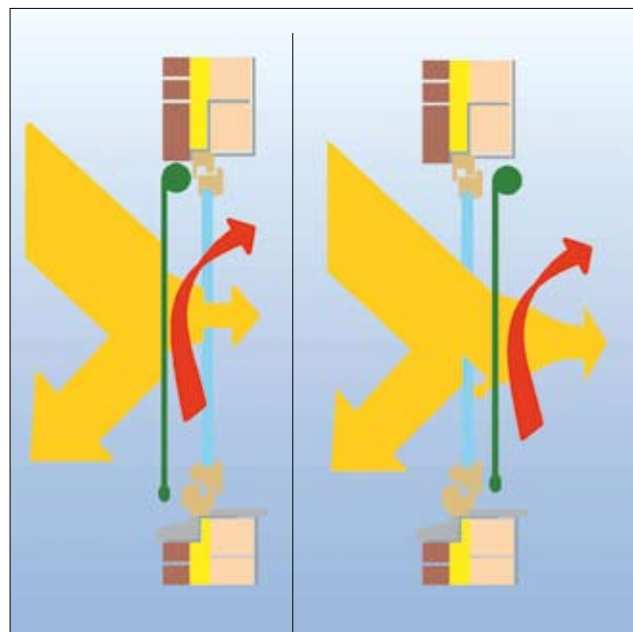
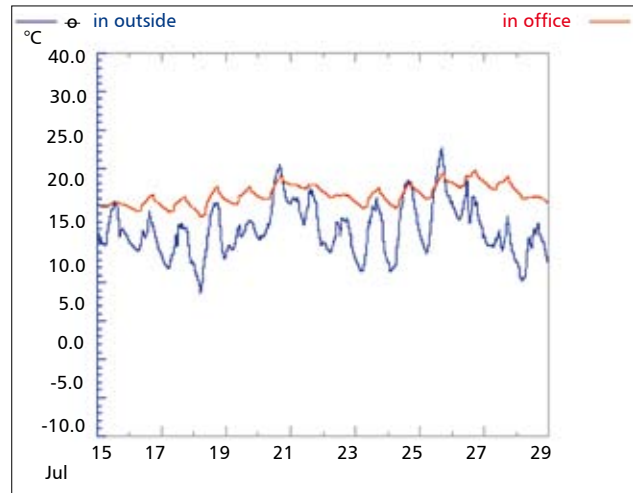
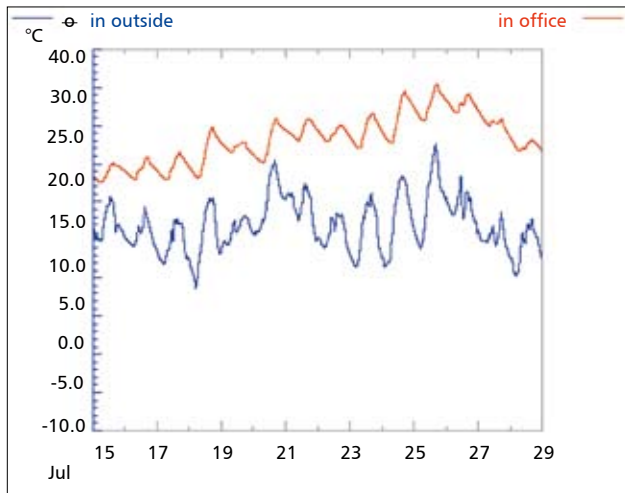


Figure 2. Typical representation of an external solar shading system

Figure 3. Typical representation of an internal solar shading device



solar shading device.(1) For a well-designed external solar shading system, the g-value is usually between 0.1 and 0.2, which means that 80 to 90% percent of the sun’s energy will be stopped by the combination glazing-plus-blind. For internal blinds, the g-value covers a greater range and could be anywhere from 0.3 to 0.7, depending on type and color. In both cases – external or internal – the solar shading device should be mobile, ideally motorized and automated, so that the full benefits are reaped even if the building is not occupied.

Influence of Solar Shading on HVAC: Rightsizing Cooling Equipment

For the sake of argument, let’s consider external shading and assume a g-value of 0.15. That means that 85% of the sun’s energy will be stopped by the blind or awning and only 15% will penetrate the building and be converted into heat. If the system is automated, a solar sensor will bring the blind down as soon as the sun is present, even if the building’s occupants are absent. A thermostat will keep the blind in the ‘up’-position as long as the

desired indoor temperature is not reached, bringing in some welcome, free and renewable solar energy as a contribution to the heating needs. Both these effects do influence the need for artificial cooling, heating and will therefore change the energy consumption of the building. To quantify this influence, the specifics must be known: the geographic location of the building façade, the applicable climate database, the orientation, the glass quality and quantity, the rate of ventilation, the internal heat gains, etc. Building simulation software programs are available to calculate the resulting indoor and outdoor temperatures, the energy needs for heating and cooling for the assumed indoor comfort conditions and the difference between the scenarios ‘with’ and ‘without’ solar shading. Often the energy demand for cooling will drop by 30% or more, while in some moderate climates, active cooling might not be necessary at all. The graphs above show the indoor (red) and outdoor (blue) temperatures without (left) and with (right) external solar shading, in an unspecified example for a building in Brussels in July.



Figure 4. One of the more popular external shading systems: a drop-arm awning

Solar Shading and Natural Night Ventilation

Summer heat accumulates in the structure of the building. The greater the mass, the greater the thermal inertia. Combining automated external solar shading with natural night ventilation will avoid excessive heat build-up during the day while evacuating some of the heat during night time, which reduces the need for artificial cooling during the following day. A study by the University of Delft in the Netherlands shows that the application of advanced solar shading systems combined with motorized windows for natural night ventilation can reduce the carbon emissions of a building by as much as 28%.(2) Some

buildings are designed to intentionally create a natural draught at night, by construction methods that stimulate a stack effect which enhances the passive cooling, such as a wide central staircase or a natural draught chimney. The nightly flush carries away the heat that has settled in the building during the day and brings down the temperature by several degrees. The EU-sponsored Keep Cool research project features several case studies where this has been applied, such as the Best Practice Project on the Swiss Federal Statistical Office, a recently built computer center with an overall energy use of 56 kWh/m²a, including the power needed for the computers.(3) That is a very low figure, compared with most of the existing building stock. Annual energy consumption figures are usually above 100 kWh/m² for recently constructed buildings and very often above 200 kWh/m² for older ones. Low energy buildings are associated with numbers in the area of 70 kWh/m²a, while the passive house label is applicable at 15 kWh/m²a.

ESCORP Study by ES-SO, the European Solar-Shading Organization



In 2004, the solar shading industry decided to establish an umbrella

association in Brussels, representative for the European industry, with the objective of bringing the solar shading associations of the various countries together. Today, ES-SO counts members from 14 countries, representing thousands of companies, mostly small and medium-sized enterprises, and hundreds of thousands of jobs. ES-SO's major objective is to demonstrate the benefits of solar shading and to inform the European and national authorities so that the energy efficiency effects of solar shading are recognized and taken into consideration in the building regulations. To support this message, figures must be produced: how much energy can be saved by the proper use of solar shading and how does this affect the comfort level? ES-SO has commissioned a scientific study, called ESCORP-EU25.(4) Based on a reputable, ISO/FDIS 13791-validated building physics simulation program, this study concludes that up to almost 10% of the total energy used in buildings could be saved if only one window out of two had some form of shading. Plausible assumptions have been made for parameters such as building envelopes, building orientation, user profiles and climates, and a representative mix of internal and external

Name of mfr & type	Type of shade	g-value*
Sattler 355-221	acrylic fabric	0,16
Sattler 355-261	acrylic fabric	0,19
Copaco S600-0251	glass fibre screen fabric	0,11
Copaco S600-0259	glass fibre screen fabric	0,12
Helioscreen Sergé 108101	glass fibre screen fabric	0,10
Helioscreen Sergé 112103	glass fibre screen fabric	0,09
Hunter Douglas Outside Blinds VB80 silver	exterior venetian	0,11
Hunter Douglas Outside Blinds VB80 silk perforated	exterior venetian	0,10

**The indicated g-values are related to the properties of the glass used for their calculation. As these vary from manufacturer to manufacturer, please use these data with care. All examples given here are with high performance glazing but of various specific characteristics.*

solar shading, and of residential and commercial buildings, has been taken into account. The study concludes that intelligently controlled solar shading will save heating energy in winter conditions, by letting in welcome free solar energy during the heating season, while a substantial reduction is demonstrated in the energy needed for cooling purposes in the summer season. Related to the total surface of the built environment in the 25 countries of the EU (in 2006), the total potential energy savings have been calculated and converted into carbon dioxide emissions avoided. The study concludes that over 100 million tons of carbon dioxide could be saved per year and a total of 9.5% of all energy used in the building stock. With the fairly conservative basic assumptions of this study, this number is impressive. Assuming the use of more external solar shading – with a much higher efficiency in reducing the risk over overheating in summer – the results could even be higher.

Keep Cool II and Other Intelligent Energy Projects

The Intelligent Energy Executive Agency of the European Commission (recently renamed EACI, for Executive Agency for Competitiveness and Innovation) encourages research into energy savings in buildings and into increased use of renewable energy. One of the approved projects is Keep Cool II: Transforming the market from 'cooling' to 'sustainable summer comfort'. Stated otherwise: looking for ways of passive cooling in buildings, minimizing the use of active energy use. Solar shading obviously is a natural method of

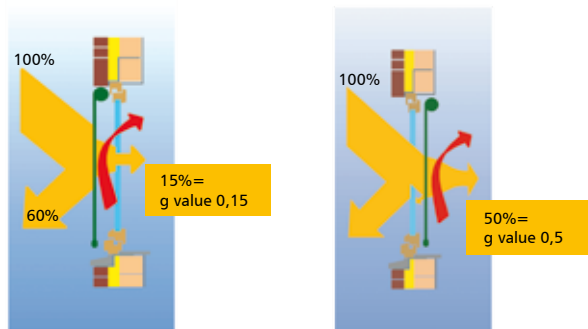


Figure 5. Exterior vs interior solar shading: typical values

passive cooling – keeping the heat out – and ES-SO is actively involved in the work packages about the cross-country comparative analysis of the best practices as well as in the dissemination methods on an international scale, such as papers at international conferences etc. Practically speaking, ES-SO will provide an overview of the best solar shading practices in the European countries. These vary with climate conditions, construction methods and cultural preferences.

For instance, some countries have a strong roller shutter tradition, others demonstrate a clear preference for external venetian blinds, still others for external roller blinds. ES-SO is also involved, in a supporting role, in three other projects: RESHAPE (about renovation of social housing), BUILDINGS PLATFORM (about the transfer of information to help member states implement the EPBD and about evaluation of early experiences; REHVA is also an associated partner) and ASIEPI (about assessment and improvement of EPBD impact; REHVA is also actively involved). ‘Summer comfort’ is a subject in several of these projects and that’s where ES-SO can make a contribution.

REHVA and ES-SO: a Common Task Force

It is obvious, in a holistic approach, that we cannot ignore the influence of HVAC and solar shading on the comfort level in the building and on each other. That is why REHVA and ES-SO have decided to set up a Task Force with the objective of working toward a REHVA-ES-SO Guide Book on Solar Shading, to fit into the available series of REHVA Guide Books. The Guide Book should give the designers in the building trade (architects and building services engineers) state-of-the-art information on the new possibilities in solar shading, and its integration with other building services, in particular HVAC, and how this affects the energy use of buildings. The Guide Book

should be finalized within 18 months and hold potential to be the subject of a major presentation during the 2010 CLIMA Seminar. We can expect among the topics of the future Guide Book subjects like solar radiation (basic data on short wave and long wave radiation), the effect of windows on the indoor environment, the effect of solar radiation on the energy use of buildings, properties of solar shading technology, integration of solar shading into BMS, lighting and HVAC, and many more subjects. For educational purposes, a slide show will be prepared to help teachers in architects’ and engineers’ schools.

Conclusion

In the present context of energy scarcity and deep concern for our climate and environment, it is no longer an option to build ‘the old way’. Constructing lightweight buildings with little or no thermal mass, then calling in the engineers to provide the comfort with a number of often oversized mechanical installation, is not a responsible way for today’s environment.

Buildings last for decades, sometimes centuries, and the way they are built today will determine their behavior for many many years. Therefore energy efficiency and sustainable building practices are a must in the construction methods of the 21st century. Solar shading, internal or external, depending on the application, should be part of every energy-efficient building, newly built or renovated. To help create thermal comfort conditions, by avoiding overheating in summer conditions, and to enhance visual comfort, by filtering down the excessive light of the sun to acceptable levels, compatible with work safety rules and pleasant contrast conditions. This also helps ‘rightsizing’ the heating and cooling equipment.

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