

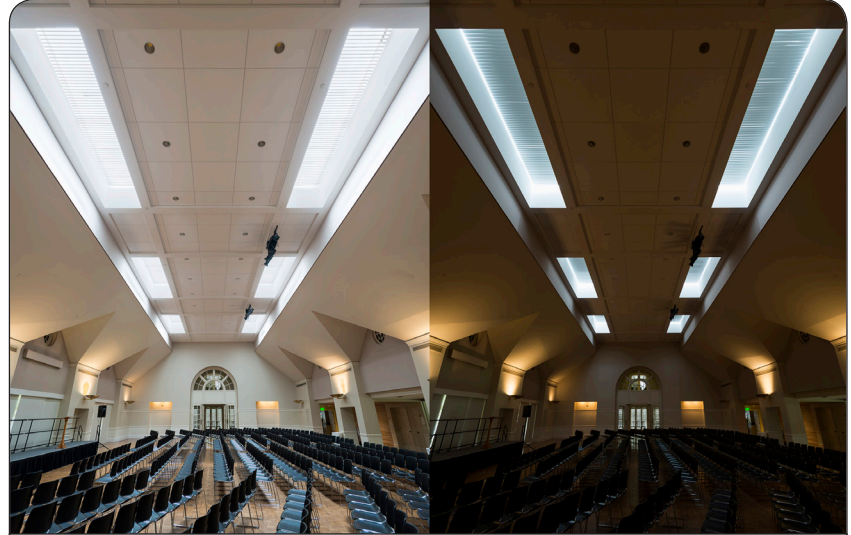
# Skylight Shading: Challenges and Solutions

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## ALTHOUGH SKYLIGHTS

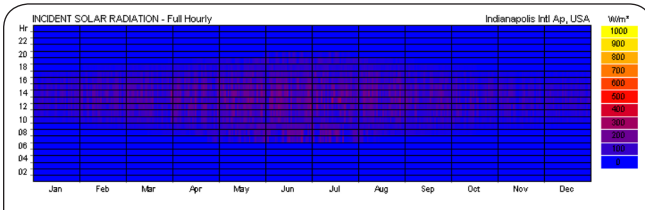
are very effective in allowing natural daylight into buildings, this light needs to be properly managed to ensure that spaces aren't flooded with too much natural daylight, and to mitigate the risk of glare. In addition, the amount of solar radiation that comes through horizontal and inclined glazing is much greater than is the case with vertical facades, and this can cause significant heat gain issues. As a result, it's important that the shading of skylights is addressed during the design process and that an effective approach is taken.

We have several graphs showing the level of incident

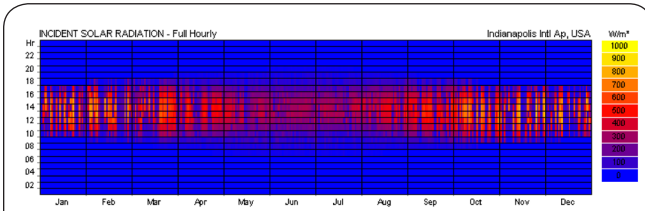


*FlexLouver™ Rack Arm System installed in the First Presbyterian Church, Houston, Texas. Photo by Barry Champagne, Houston, Texas.*

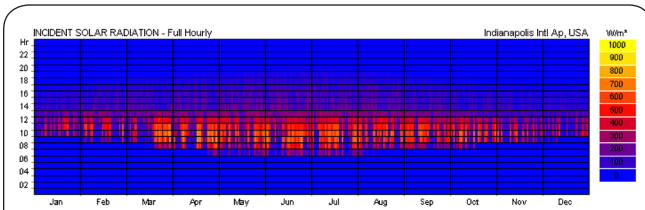
solar radiation by elevation for a building in Indianapolis, Indiana. Each graph shows the amount of radiation by time of day and by month.



*Figure 1—Incident radiation from the north.*



*Figure 2—Incident radiation from the south.*



*Figure 3—Incident radiation from the east.*

On the north elevation (Figure 1), there is only background radiation which remains at a broadly consistent level.

The south elevation (Figure 2) is interesting—because of the higher sun angles during the summer, the level of radiation on south-facing glazing is actually greater in the winter months than during the summer ones. The radiation levels on the east and west elevations (Figure 3 on page 1 and Figure 4 on page 2) are almost mirror images of each other. The highest levels of incident radiation occur during the summer—in the morning on the east elevation and during the afternoon on the west.

The amount of incident solar radiation, however, is significantly greater on roof glazing for almost all of the year and is noticeably more in the summer months when heat gain is an issue and needs to be

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dealt with by the HVAC system. To get a more specific understanding of solar gains entering the building, based on the same area of glazing for each situation, it's possible to look at the average daily levels as shown in Figures 6 and 7.

From both the tabulated data and the graph, the varying impact of sun on the glazing can be clearly seen. For the same area of glazing, during the summer months, the incident solar radiation through a horizontal skylight is between two and three times higher than through vertical glazing.

The light levels inside the building will also vary significantly depending on the orientation of the glazing, the time of the day and the day of the year. It's not as easy to undertake a comparison as is the case with direct solar gains—the images in Figure 8, however, are floor plans that show the light levels at noon on June 21 for a space with south facing glazing and one with a skylight. Both areas of glazing are the same. As can be clearly seen, using a skylight results

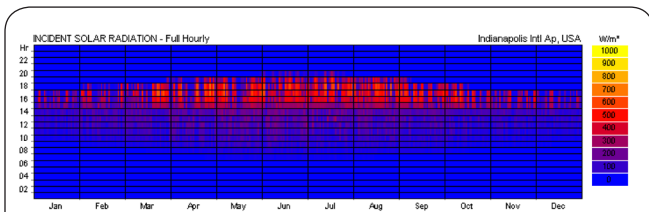


Figure 4—Incident radiation from the west (see page 1).

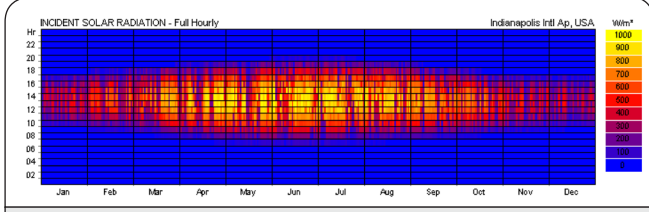


Figure 5—Incident radiation from the roof (see page 1).

in substantially higher light levels inside the space. In principle this is good, but there is a risk of glare if this natural light is not effectively managed.

From the brief analysis, it is evident that although skylights can be an excellent way of providing an abundant amount of natural daylight, particularly if they are above a central atrium, they can cause both

Month	North	South	East	West	Roof
January	684	9716	3707	2360	3926
February	966	11373	5025	3609	6796
March	1175	9804	7108	5108	10700
April	1515	7618	9455	6654	15122
May	2253	5296	9491	7442	16947
June	2822	4148	10181	7841	18440
July	2521	4824	10882	8649	20360
August	1727	7036	8832	7958	16484
September	1174	11017	8895	6796	14665
October	851	13420	7518	4746	10021
November	683	10281	4112	3073	4544
December	586	9246	3203	2118	3333
<b>Average solar gains</b>					
Winter	824	10640	5112	3502	6553
Summer	2002	6657	9623	7557	17003
Full year	1413	8648	7367	5530	11778

Figure 6—Average daily incident radiation by month.

glare and major heat gain issues. There is good news: If the solar gain through the glazing is controlled by a shading system, light levels can be moderated, as required, and excessive heat gain can be mitigated, so reducing the size of the required HVAC system. In addition, if the building has a heating requirement in the winter, certain shading systems can be retracted or alternatively set to a position to allow free solar gains in.

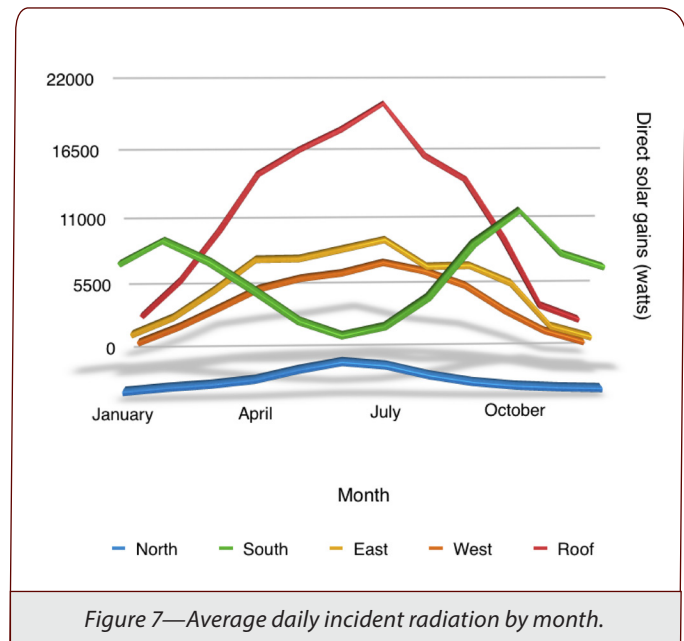


Figure 7—Average daily incident radiation by month.

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When considering the shading of a skylight, the standard approach is to use a fabric system. Possible options include fixed fabric panels, suspended elements such as kites, or retractable fabric tension systems. Fixed panels have the benefit of being relatively low cost and maintenance free. The downside is that they will remain permanently in place,

**“Although skylights can be an excellent way of providing an abundant amount of natural daylight ... they can cause both glare and major heat gain issues.”**

meaning that light levels will be reduced on cloudy days and at times when there is no sun. Rather than installing the panels directly underneath the glazing, however, they can be set some distance below to allow more light into the space.

Kites are also fixed elements but can be a decorative feature in addition to providing shade. Kites will always be a compromise, in as much as they will only provide partial shading and significant amounts of sun penetration will occur.

As a result, these systems can be ideal for public spaces but may not be appropriate in working environments where more responsive light control is required.

Fabric tension systems offer the benefit that they can be deployed when required and retracted when there is no sun on the glazing. Additionally, versions of these

systems can be installed either internally or externally. An exterior system will provide additional solar control compared with an interior one, dealing with a large part of the solar energy before it comes through the glazing and into the building.

A variety of fabric tension systems are available. What all of them have in common is a drive tube (normally housing a motor but manually operated systems can be used in some situations) onto which the fabric panel is installed, as well as a mechanism to provide tension to the deployed fabric. Springs are normally used to achieve the required tension but opposed synchronized motors are sometimes used as an alternative. Spring systems can have a separate spring tube, or a single tube that incorporates both the motor and the spring tension mechanism.

Not all shading fabrics can be used under tension—most polyester based ones are insufficiently stable and will stretch. As a result, fabrics that have a core glass fiber yarn are mostly used, although one pvc polyester fabric, Soltis, works extremely well due to the way that it is produced, which means that it is very stable under tension. The range of fabrics for exterior systems is not as great as is the case for interior ones. They do use the same materials and have similar weave structures, but the base yarns are thicker.

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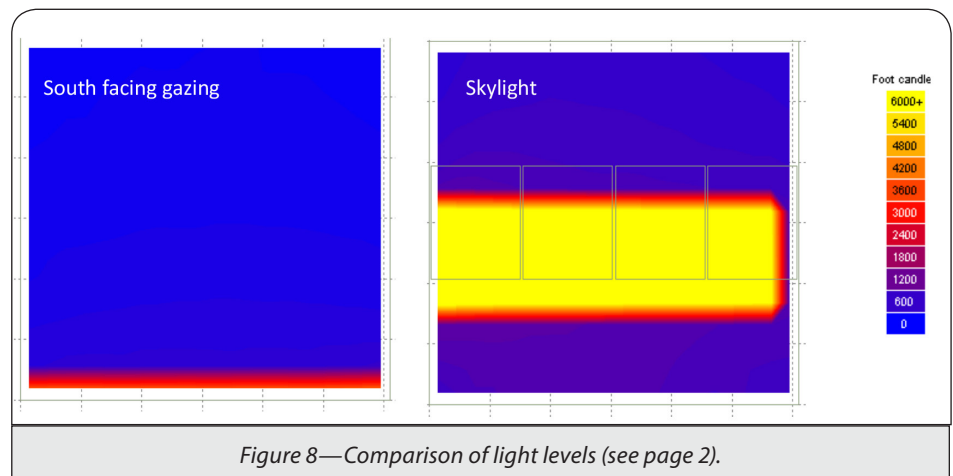


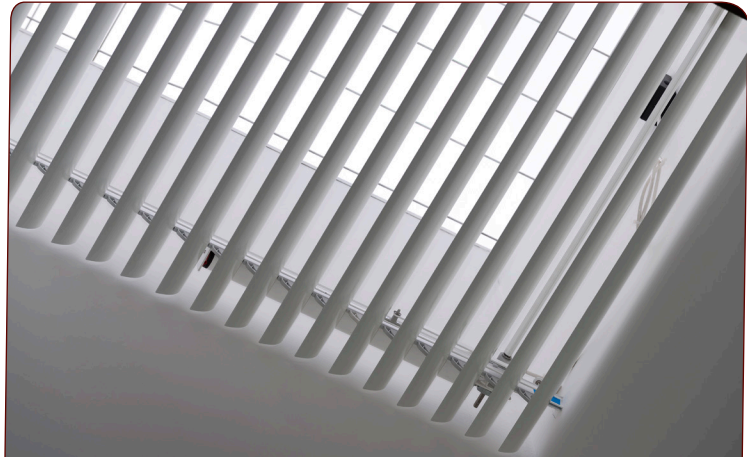
Figure 8—Comparison of light levels (see page 2).

As with a standard roller shade, a variety of fabrics can be used on skylight tension systems in terms of weave structure, openness factor, and color, giving different performance criteria with regard to visible light transmittance, solar performance, and view through. For a common weave structure and openness factor, lighter fabrics will provide a greater level of light transmittance and will have a better solar performance than darker colored ones. View through the fabric will not be as good, however. Twill weave fabrics that incorporate different color yarns in the warp and fill directions can have a lighter side and a darker side. If the lighter side is installed to face the glazing, a reasonably good balance between solar performance and view can be achieved.

An alternative to a standard tension system is a product called Topspin. This also uses a motorized drive system but is made up of a number of fabric panels which are attached to a series of spring roller tubes. Two fabric panels are attached to each spring tube which means that as the system is deployed, one is wound off the top of the tube while the other is wound off the bottom.

The spring roller tubes and the hem bar run in “side guides” which also carry the drive cords that deploy and retract the system. The design means that the system can achieve substantial draws and can cover any orientation of glazing—horizontal, vertical and inclined. If the tracks are curved, barrel vaults can be shaded. The construction of the system also means that it can withstand substantial wind loads when installed on the exterior.

Further variations to the idea of a retractable fabric system include horizontal roman shades and sail



*Rack Arm systems are a highly effective shading solution for skylights.*

shades. Sail shades are similar to a standard motorized roller shade but instead of a spring tension mechanism use counterweights to provide some tension and enable the fabric panels to be deployed. With a standard fabric tension shade, the aim is for the fabric panel to be as flat as possible. With sail shades, however, a much more sculptural effect can be achieved with the amount of curvature of each panel being dependent on the size of the counterweight. Given this curvature of the fabric panels, sail shades are generally only appropriate for higher atrium spaces. There will be relatively large gaps between adjacent panels and, as with kites, these systems are therefore generally used in public spaces rather than in environments where people will be working with computers. As an alternative to fabric, louvered systems can also be used. The most flexible option is the non-retractable louver or rack arm system. As the name implies, the louvers always remain above or below the glazing—they can be rotated, however, from the fully open position to fully closed. The design of the system means that it can be installed on any type of glazing—horizontal, vertical or inclined. It can also address almost any shape of glazing including rectangular, circular and trapezoidal openings.

The system is made up of a number of rack arms.

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*SkyLight FlexShade 2 installed at AVI Systems, Inc.  
Photography © Barry Rustin, Evanston, Illinois.*

These are aluminium extrusions which incorporate pivot arms and clips onto which the slats or louvers are connected. Each rack arm also incorporates a drive mechanism so that when a number of them are connected together with a drive shaft, rotation of the shaft results in the slats being rotated from open to closed or vice versa. The slats themselves are

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**“Properly designed skylight shading systems can make an important contribution to building performance.”**

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relatively small profiles ranging in size from 50mm (2") to 145mm (5 3/4") which means that the spacing between the rack arms is generally somewhere between 3' and 5' depending on the slat profile selected and whether the installation is an interior or an exterior one. Where possible, the rack arms are aligned with the skylight structure.

Some available slats can be perforated. There is also an extruded aluminum profile which interlocks with the adjacent slats to provide high levels of light exclusion. There will be some light ingress around the perimeter of the system, however, so it will not achieve complete blackout.

The rack arm system can be manually operated by means of a gearbox or crank handle or alternatively can be motorized. Motorized systems generally use a tubular motor which is mounted on one of the rack arm profiles and connected to a reduction gearbox which, in turn, is connected to the drive shaft. In standard configuration, slats take approximately 15 seconds to move between open and closed positions allowing fine light control to be achieved. Because of this, the system is often used in museums and galleries and other light critical installations. An automatic control system can also be specified to allow light levels to be maintained within a defined range.

In addition to extremely good light control, the system will also reduce the amount of heat gain. If the system is installed on the interior, solar control is dependent on solar energy being reflected back through the skylight. A greater reduction in heat gain will be achieved, however, if the system is installed on the exterior. The system has been tested in a wind tunnel at speeds up to 100mph, and installed in locations such as the Caribbean and Hong Kong. There are issues, however, with ice, due to the number of small rotating components that can freeze up; as a result, the system can only be used on the exterior in certain locations in North America. In the northern part of the U.S. and Canada, the system will be primarily installed on the interior.

As an alternative to the rack arm system, larger scale louvers can be used. These are generally produced from extruded aluminium but other materials such as wood or glass can be used. Moving to larger louvers means greater spans between supports can be achieved. The weight of the system, however, will be much greater than the case with a rack arm system. Whereas the rack arm system can weigh less than a pound per square foot and can be attached directly to the skylight, large scale louvers will generally be fixed to the main building structure and may need additional steel framing to support the applied load.

Large scale louvers can be fixed or operable. As with the rack arm system, the louvers will not retract but, depending on the design of the drive mechanism, can be rotated through 360°, should this be required. Because the system components are larger and more robust than is the case with the rack arm system, louver systems can also be designed to withstand all weather conditions - wind, snow and ice - and exterior systems can therefore be used on projects throughout North America.

Many different approaches can be taken to shading a skylight. Some of the options blend in with the building architecture whereas others can have a significant visual impact and become an important element of the buildings design. In all cases, however, properly designed skylight shading systems can make an important contribution to building performance, controlling both heat gain and natural daylight.