Appropriately incorporating natural light into an office space can improve employees' moods, reduce the building's peak demand of electricity, and contribute toward earning LEED credits.

LUTRON PRESENTS

Daylight in the Office Space

Light is a dynamic element of the built environment. Amidst concrete, glass, and cubicle walls, light provides a critical link between the earth, the building, and the individual. In an office building, light is necessary for the employee, an operational expense for the building, and supplied by the environment. Electricity is expensive and, of all building systems, lighting is typically the largest consumer of electricity. Natural light is free, but its availability fluctuates every day in both time and quantity.

How a building is lit impacts a variety of factors, from overall building performance and space functionality, to the interior and exterior aesthetic, and the way in which the building interacts with the neighborhood and environment. While the design of the interior lights is often specified by project engineers or lighting designers, the design of the building envelope and the window-to-wall ratio rests upon the shoulders of the architect. As more windows are added into a project, more natural light is invited into the space.

CONTINUING EDUCATION

Use the learning objectives below to focus your study as you read **Daylight in the Office Space** to earn one AIA/CES Learning Unit, including one hour of health safety welfare credit, answer the questions on page 187, then follow the reporting instructions on page 256 or go to the Continuing Education section on *archrecord.construction.com* and follow the reporting instructions.

LEARNING OBJECTIVES

After reading this article, you should be able to:

- *Identify potential benefits and dangers of incorporating natural light into an office space.*
- *Understand strengths and weaknesses of different natural light control systems.*
- *Specify appropriate fabric characteristics to meet project requirements.*

Incorporating natural light into an office space creates an opportunity to improve the environmental performance of the project, while promoting individual well-being and enabling capital building investments to provide better economic returns. In order to realize these potential benefits, the natural light must be effectively controlled. Today, there is a variety of technologies that provide natural light control. Architects can use these technologies as tools to tailor their designs to best fit the people and business goals of the spaces they create.

Natural Light in an Office Space and the Individual

The most basic goals in office space design are to create a place where work can be accomplished and communication can occur. Today, light is instrumental in creating that productive environment, because 90 percent of the communication in the workplace occurs visually. From reading and writing email messages to seeing a co-worker's body language and facial expressions, people use their eyes to interpret the world around them, and their eyes require light.

The same light that is the medium for visual communication also impacts the mood, health, and behavior of the employees it touches. Both natural and electric light can illuminate a space, but they do not impact people equally. Studies have corroborated a long-held belief that there is a strong correlation between positive mood and daylight exposure. Recent studies also imply that incorporating outdoor views into the office will positively effect employee motivation, satisfaction, productivity, and comfort, which can manifest in improved employee retention and workforce output.

Natural Light in an Office Space and Building Performance (Financial Efficiency)

In the United States, the peak demand of electricity occurs during standard business hours. The price of electricity used during peak demand times is higher than the price of electricity used when the overall demand wanes. Effectively using the daylight available during those business hours not only reduces the total electricity demanded by lighting and HVAC systems, but also reduces peak demand, minimizing the use of the most expensive electricity. Saving one kilowatt-hour (kWh) of energy during daylight hours saves a building more money than saving that same kWh at midnight.

Natural Light in an Office Space and Sustainable Design

The Leadership in Energy and Environmental Design (LEED™) rating system recognizes that incorporating natural light and views into a building can promote occupant well-being, while reducing the amount of electricity used by the lighting and HVAC systems.

LEED is a rating system sanctioned by the U.S. Green Building Council (USGBC) that provides a national standard for what constitutes a "green" building. LEED principles promote buildings that are environmentally responsible, profitable, and healthy places to work.

The rating system is composed of six categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Material Resources (MR), Indoor Environmental Quality (EQ), and Innovation and Design Process (ID). There are a total of 69 LEED credits available between these six categories. Twenty-six credits are required to attain the most basic level of LEED certification. Incorporating natural and electric lighting control into a project can contribute toward earning up to 22 LEED credits.

The Indoor Environmental Quality category offers up to two credits for providing building occupants with a connection to the outdoors by incorporating daylight and views into regularly occupied areas of the building. As specified in the Version 2.1 of the *LEED Reference Package for New Construction & Major Renovations,* to earn credit 8.1, "75 percent of all spaces occupied for critical visual tasks must achieve a minimum Daylight Factor of 2 percent, excluding all direct sunlight penetration." Credit 8.2 mandates that "occupants in 90 percent of regularly occupied spaces must have a direct line of sight to vision glazing."

The Energy and Atmosphere category offers up to 10 points for reducing the electricity consumption and costs attributed to various building systems (ASHRAE/IESNA Standard 90.1-1999 is used as the baseline). The interior lighting and HVAC systems are two of the systems considered by this credit. Using natural light to reduce a building's peak energy demand upon these two systems effectively reduces both the overall electricity use and cost.

For more information on LEED, visit www.usgbc.org.

Adding daylight into an office space can boost building and employee performance. However, effectively incorporating natural light into an office space requires greater consideration than simply increasing glazing area. Natural light needs to be managed and controlled. The fenestration is no longer just metal and glass. Instead, it is glass, metal, and a dynamic shading component.

Natural Light and Heat

Natural light is a tremendous source of light and heat. As more natural light is designed into a space, project architects and design teams are challenged to ensure that the light and heat are appropriately controlled. Without control of natural light, those highly coveted views to the outdoors can cause disruption and discomfort, while sending the building's HVAC demand soaring. The glare, solar heat gain, and exposure to UV radiation caused by uncontrolled daylight can negatively impact occupant comfort, building performance, and interior fabrics and furnishings.

Glare and Brightness

The word brightness is used to describe the intensity of a light source. People perceive the brightness of an object in contrast with its surroundings. Car headlights on a clear sunny day are barely noticeable. The same car headlights on a dark stretch of highway can be so brilliant that they are uncomfortable to look at. Glare occurs when a light source or the reflection of a light source is significantly brighter (generally more than three times brighter) than the ambient light surrounding it, causing visual discomfort.

Visual discomfort is the result of the human eye's inability to adapt appropriately to the contrast in light intensities in its field of vision. Adaptation is a chemical process that takes place on the surface of the retina, regulating the eye's sensitivity to light. In bright environments, this sensitivity decreases, because more visual stimulus is available. In darker settings, sensitivities increase. The change in sensitivity is uniform across the eye, leaving few options to compensate for hot spots and areas of irregularity. If the sensitivity increases to read the brightest object, the surrounding areas are too lowly lit to be seen clearly. If the eye's sensitivity to light increases in order to interpret the surroundings, the intensity of the brighter object becomes glaring.

Accommodation is the physiological response that compensates for shortcomings in adaptation. Accommodation is the muscular process that limits the amount of light entering the eye by constricting the pupil and squinting. People can also accommodate their visual environments by lowering their heads and furrowing their brows. This is often an unconscious, automatic response, like blinking when the eyes are dry.

In an office space, both natural and electric light combine to create the light environment. Glass windows can deliver daylight into the workspace that ranges in quantity from a few hundred lux (lumens per square meter), on an overcast day, to over 10,000 lux on a clear sunny day. In contrast, the average light level recommended for an office space is between 300-500 lux, which is often what the electric light in the building is designed to provide. If the disparity between the intensities of the task lighting, the ambient light and the direct or reflected daylight in the employee's visual field is too great for the eye to accommodate through adaptation, glare occurs.

On a dark highway, the exposure to glare is brief and infrequent, lasting as long as it takes for the two cars to pass one another. In an office space, an employee could be subjected to glare for several hours nearly every day. Physically unable to adapt to glare conditions, employees and building occupants spend their days accommodating the visual environment with involuntary contractions of the pupil, squinting, modifying the position of their head, and furrowing their brows.

Repetitive use of these accommodation tactics can lead to stress injuries and muscle fatigue that manifest in the forms of eye strain, headaches, and computer vision syndrome. These problems are uncomfortable, fatiguing, and attribute to decreased productivity in the workplace.

Harsh sunlight can create uncomfortable working conditions. Specify roller shades to keep glare to a minimum and reduce eye fatigue for workers.

Direct rays of sunlight are prone to causing glare, because their intensity has not yet been filtered or modified. One way of minimizing the threat of glare from natural light is to specify a device in the window that will either block, deflect, or diffuse direct sunlight. This reduces the intensity of the natural light entering the office space and the likelihood that glare-causing hot spots will occur.

Solar Heat Gain

One of the largest building expenses caused by uncontrolled daylight is due to solar heat gain. The sun's radiant energy appears in the Earth's atmosphere as visible light, UV radiation, or heat, depending upon its wavelength. Solar heat gain refers to the amount of solar heat energy that passes through the windows and walls, warming the building's interior. The amount of solar heat energy that is transmitted into a space can be measured in British thermal units (Btu).

The Btu is the universal heat energy unit required to raise the temperature of one pound of water 1 degree Fahrenheit.

As window-to-wall ratios increase to allow more natural light into the structure, more and more of the building's envelope becomes glass, instead of brick, concrete and steel. The thermal transmittance of glass is much higher than that of other structural materials, making a building with a lot of glass more susceptible to solar heat gain.

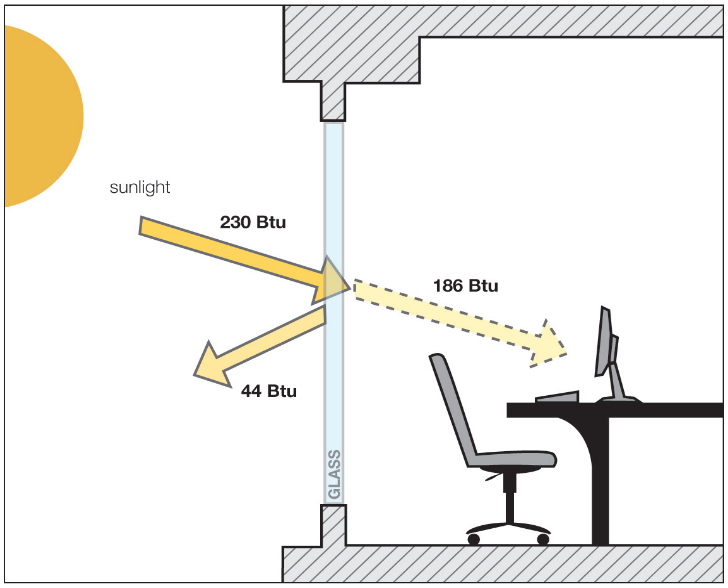
The amount of solar energy present at any given time is dependent upon the latitude and orientation of the space and the weather conditions of the day.

(See Figure 1) This representation illustrates the thermal interaction between sunlight and a glass window in an office space located approximately in New York City. In this example, the 1/4" clear plate of glass reflects only 20 percent of the available Btu. 80 percent of the sun's heat energy radiates into the interior.

As more of the sun's light and heat energy is allowed into a space, the interior is warmed and a greater demand is placed upon the HVAC system to keep building occupants comfortable.

Specifying a device to be an additional barrier between the window glass and the building's interior space creates an opportunity for some of the solar energy to be reflected back outside or absorbed by the apparatus, before seeping into the occupied spaces. Both color and composition of this barrier device are important considerations when determining which technology to select.

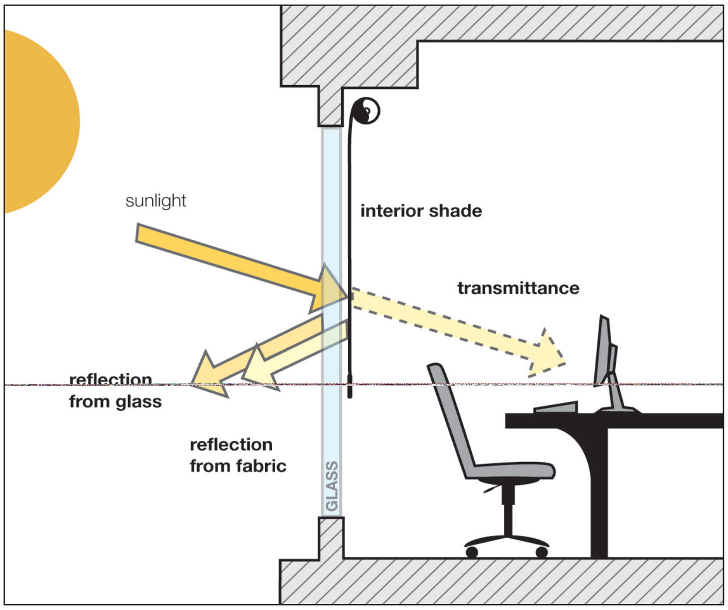
Even with the potential threats of glare and solar heat gain, the potential benefits of including daylight in the workplace to both employees and building performance are considered significant enough to continue exposing office spaces to the outdoors. This demand for daylight in the workplace has driven the development of numerous technologies designed to manage the impact that natural light can have on a space. It has also been a catalyst for the popularity of the daylighting movement.



(Figure 1) A building located in New York, with a 1/4" clear plate of glass, transmits roughly 80 percent of the present solar radiation into the building.

The Art of Daylighting

Daylighting is defined as the proper utilization of daylight to reduce energy consumption in the interior of buildings, while reducing sun glare and protecting the visual ergonomics of the space. Daylighting employs a regulated balance of electric and natural light in conjunction with the other building systems, finishes, fabrics, and furnishings that combine to make up the building's interior. To maximize the benefits of daylighting, daylight should be controlled.



Specifying an additional barrier between the window glass and the occupied interior will reduce the amount of solar radiation allowed into the space. The actual amount of solar radiation reflected, absorbed, or transmitted will vary by color and composition of the barrier.

A variety of technologies have been developed to control daylight, including, but not limited to, horizontal louvers, vertical blinds, draperies, and roller shades. These control devices range in price, flexibility, and ability to effectively manage light, minimize glare, preserve outdoor views, allow for privacy, reduce UV radiation, combat solar heat gains, and enhance "curb appeal" and property value by offering the opportunity for a more consistent façade appearance.

Horizontal Louvers (Mini-Blinds)

Horizontal louvers equip office windows with a "lift and tilt" system capable of partially or completely deflecting glare-causing light and repelling solar heat. Horizontal louvers can be positioned to direct available daylight more deeply into the space. When tilted closed, this barrier to light and heat also provides excellent privacy to building occupants, allowing zero view to outsiders looking in. Unfortunately, with manual louvers tilted to block solar heat, UV rays, and direct light, the view to the outside is almost completely compromised. Lifting or opening the louvers in order to see outside renders the apparatus nearly useless in terms of daylight management, exposing the interior to unfiltered solar energy.

Roller Shades

Roller shades reduce solar heat gain, UV penetration, and glare, while preserving the view to the outdoors. This valuable multitasking ability occurs when translucent shade fabric is used, acting as a finely woven light filter. The weave is so fine that the eyes move past it to the view beyond, while the fabric threads diffuse, absorb, or reflect the unwanted solar energy.

Roller shades, referred to as roller blinds outside the U.S., reduce solar heat gain, UV penetration, and glare, while preserving the view to the outdoors.

One thing to consider is that view can be two-sided. During the day, shades can provide building occupants with outdoor views. At night, if the interior of the building is sufficiently illuminated, it will be visible from the outdoors.

Curb Appeal is a Matter of Control

Curb appeal is not a strength of manual control. The ability to provide a consistent look from the outdoors is based on a system's ability to establish and maintain a uniform position for each component. Both blinds and shades can be manually controlled to accommodate differences in employee preference, time of day, and task. Placing the power of position in employees' hands is rarely conducive to achieving a consistent product height throughout an office space. When controlled manually, each blind or shade throughout a building can be positioned uniquely—up, down, or tilted, depending upon the preference, skill, and patience of the last operator.

Both horizontal louvers and roller shades can be automated or centrally controlled. The position and tilt of horizontal louvers can be controlled via automation. Automation guarantees that each shade is always positioned appropriately for maximum effectiveness and offers the opportunity for consistent curb appeal by programming shades to uniform, pre-determined heights throughout the building.

Types of Controllable Roller Shades

Today there are several types of automated roller shading systems available. Varying in sophistication and aesthetic appeal, an important differentiating factor between systems is whether it is automated with a motor or an electronic drive. Popular shading automation options include: AC-tubular motor systems, battery-powered motor systems, and low-voltage electronic drives.

AC-powered tubular motor systems have been used traditionally for exterior shade and awning systems. Especially popular in Europe, these powerful motors can support heavy fabric loads and are durable enough to withstand outdoor elements, such as wind and rain.

Although AC-tubular motors are a good solution for automating exterior shade and awning systems, certain characteristics (of AC shades) make this solution less desirable for interior systems for a variety of reasons. First, motors can be noisy and distracting when operated. Outside, this sound is drowned out by ambient noise. Inside an office space, it could be prohibitively distracting. Second, due to inherent variations in AC motor technology, these AC tubular motor systems cannot be relied on to track evenly over time.

Battery-powered systems are also available, providing wireless power and control. While great for retrofit projects, the lift capabilities and system size are limited by battery-power. With a battery life rated for between two to three years, replacement could be problematic in shades mounted in hard-to-access areas. Battery-powered shading motors operate with some audible noise (similar to a battery operated drill), and controlled movement and precision pre-sets with the battery-operated system are difficult.

Low-voltage electronic drive systems address many of the aesthetic and functionality concerns raised by the two previous technologies. Quieter than regular line voltage or battery-powered systems, electronic drives are capable of operating at 44 dBA at three feet, a sound comparable to a whisper. This near-silent movement can add an impressive element to a room's atmosphere, or occur almost invisibly without distracting room occupants. Intelligent electronic drive systems can be programmed to track multiple shades together, providing precise, coordinated movement across a wall or throughout a building. These systems can also be programmed with pre-sets. These pre-sets allow each shade in the system to be operated independently, to meet individual preferences, and then re-aligned with the rest of the shades in the group with one button press. ■

Roller shades automated with low-voltage electronic drives provide near-silent and precise movement of one shade or a coordinated group of multiple shades.

CLICK FOR ADDITIONAL REQUIRED READING
The article continues online at:
archrecord.construction.com/resources/conteduc/archives/0511lutron-1.asp

To receive AIA/CES credit, you are required to read this additional text. For a faxed copy of the material, contact Jeanette Fitzgerald at Lutron, (610) 282-6661 or fax (610) 282-6437. The following quiz questions include information from this material.

AIA/ARCHITECTURAL RECORD
CONTINUING EDUCATION Series

LEARNING OBJECTIVES

- *Identify potential benefits and dangers of incorporating natural light into an office space.*
- *Understand strengths and weaknesses of different natural light control systems.*
- *Specify appropriate fabric characteristics to meet project requirements.*

INSTRUCTIONS

Refer to the learning objectives above. Complete the questions below. Go to the self-report form on page 256. Follow the reporting instructions, answer the test questions and submit the form. Or use the Continuing Education self-report form on *Architectural Record's* web site—*archrecord.construction.com*—to receive one AIA/CES health/safety/welfare Learning Unit.

QUESTIONS

1. Which building system is typically the largest consumer of electricity?
- **a.** HVAC
- **b.** Security
- **c.** Lighting
- **d.** Computer Network

2. Appropriately incorporating daylight and views into an office space does NOT contribute toward which of these:
- **a.** improved employee mood and satisfaction
- **b.** earning LEED credits
- **c.** reduced peak demand of electricity
- **d.** improved water quality

3. Uncontrolled natural light can negatively impact:
- **a.** Occupant comfort
- **b.** Fabrics and furnishings
- **c.** Building performance
- **d.** All of the above

4. Which of the following controllable roller shading systems provides near-silent operation?
- **a.** AC-tubular motor
- **b.** Low voltage electronic drive
- **c.** Battery-powered motor

5. Which of the following is NOT a benefit of natural light controls?
- **a.** reducing UV radiation into the interior
- **b.** increasing the demand on a building's lighting and HVAC systems
- **c.** minimizing glare-causing light in a spacels.
- **d.** preserve a view to the outdoors

6. Which statement correctly describes the functionality of horizontal louvers and roller shades?
- **a.** Neither horizontal louvers nor shades can be controlled manually
- **b.** Horizontal louvers are more adept at protecting interior furnishings against UV radiation
- **c.** Roller shades can provide a view to the outdoors, while combating solar heat gain and reducing glare. Horizontal louvers can either provide a view to the outdoors, or combat solar heat gain and glare
- **d.** There is no difference between horizontal louvers and solar shades

7. Solar absorptance describes:
- **a.** The percentage of glare-causing light that passes through the fabric
- **b.** The percentage of solar radiation reflected by the fabric
- **c.** The percentage of solar radiation absorbed by the fabric
- **d.** The percentage of solar radiation transmitted into the interior

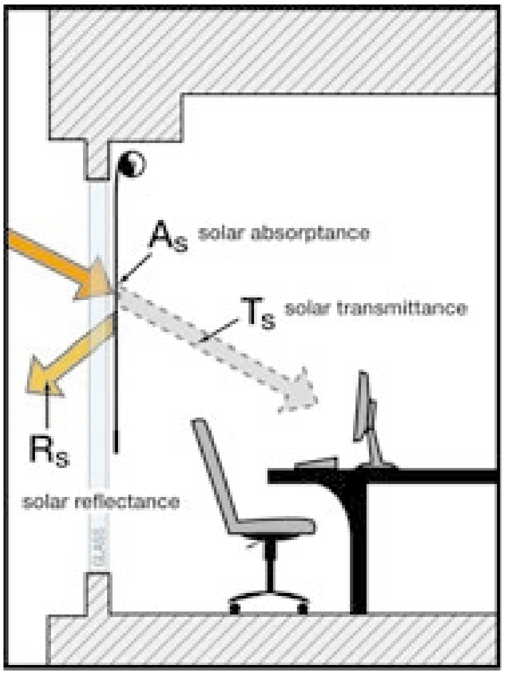
8. The dual-sided fabric that most effectively combats solar heat gain, reduces glare, and preserves the view outdoors will…
- **a.** have a dark color fabric facing the interior and a light color fabric facing the exterior
- **b.** have a light color fabric facing the interior and a dark color fabric facing the exterior
- **c.** have a same color
- **d.** color doesn't matter

9. Which of the following statements is true about openness factor of a fabric?
- **a.** As the openness factor increases, more natural light is filtered
- **b.** As the openness factor increases, the view is limited to shapes and shadows
- **c.** A 10 percent openness factor allows zero light into the space
- **d.** Different openness factors of the same fabric may be specified on different facades of the same building to effectively manage different exposures to direct sunlight, without compromising curb appeal

10. Which statement correctly completes the following sentence? PVC-free and halogen-free fabrics…
- **a.** smell plastic
- **b.** support sustainable design by promoting healthy indoor office environments and can contribute toward earning LEED credits
- **c.** emit highly toxic smoke when burned
- **d.** increase the number of potential toxins that can be released into the environment

The Fabric Matters

Regardless of whether or not a solar shade is controlled manually or electronically, specifying the right shade fabric is critical to managing the daylight in a space successfully. The shading system's capacity for reducing glare, preserving outdoor views, providing privacy, protecting interior furnishings from UV damage, and minimizing solar gains is determined by the unique characteristics of the shade fabric selected. The openness factor of the fabric, the color of the fabric, and the composition of the fabric each shapes how the shade will interact with and manage the sun's light and heat energy, also known as solar radiation.



Solar performance metrics measure how a shade fabric manages daylight by how effectively it reflects, absorbs, or transmits solar radiation.

As solar radiation passes through the glass window, the fabric determines the amount of solar radiation that is transmitted into the interior building, absorbed by the shade, or reflected back outside.

Solar Performance Metrics

The solar performance metrics that define the functionality of the fabric are: solar transmittance, solar absorptance, solar reflectance, and visual transmittance. Solar transmittance (Ts) is the percentage of solar radiation that passes through the fabric. Solar absorptance (As) is the percentage of solar radiation absorbed by the fabric. Solar reflectance (Rs) is the percentage of solar radiation reflected back out by the fabric. Each of these performance metrics is inextricably linked together in the following relationship:

Ts+As+Rs=100 percent present solar radiation.

Visual transmittance (Tv) is the percentage of glare-causing visible light that passes through the fabric. Lower values indicate greater glare reduction. For example, a Tv of 14 percent indicates a glare reduction of 86 percent.

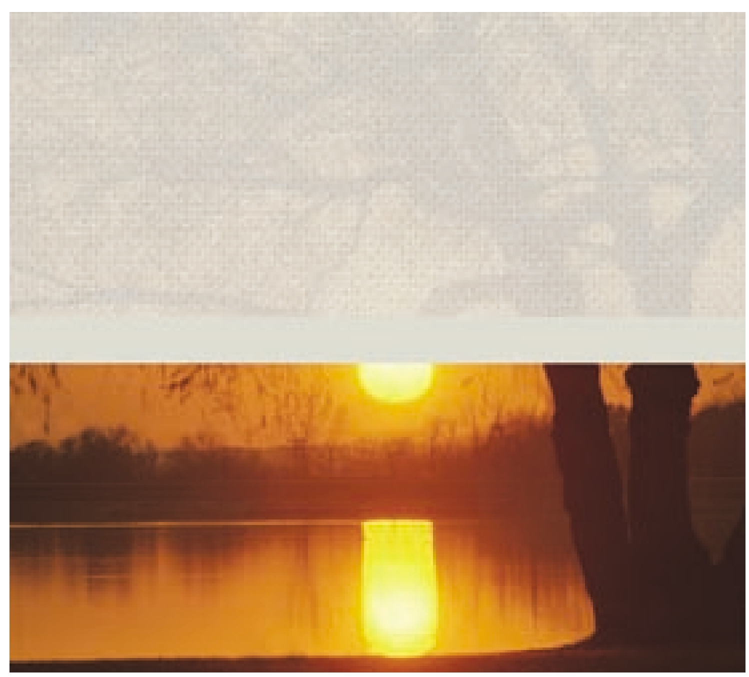
Solar performance metrics measure how fabrics with different openness factors, in different colors, and different compositions respond to solar radiation, providing a foundation for fabric comparison and a guideline for fabric specification.

Openness Factor

A roller shade fabric is woven together with fine threads or yarns. The openness factor of a fabric describes the ratio of open space to fabric material in a weave, which is essentially how much shade is not there. For example, a shade with 10 percent openness means that 10 percent of the physical shade is open space. The broader the open space between the threads, the greater the openness factor. The shade fabric's ability to reflect or absorb solar energy is determined, in part, by the amount of fabric present to either reflect or trap the sun's rays.

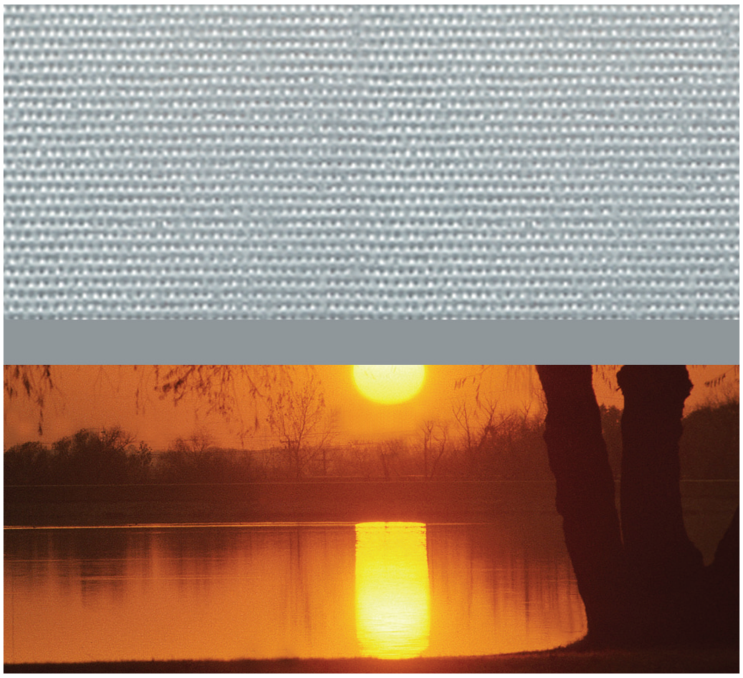
A fabric with a five percent openness factor features an open weave, filtering sunlight, while preserving the view.

Fabrics are available in a variety of openness factors, including (1 percent, 3 percent, 5 percent, 8 percent, 10 percent, and 18 percent openness), privacy and blackout. Privacy fabrics refer to fabrics that have an openness factor of less than 1 percent, but greater than 0 percent. Blackout fabrics offer 0 percent openness, transmitting no light into the interior. The wide range of available openness factors caters to different project priorities and natural light control expectations. Each is uniquely suited to meet the different requirements of a project.



Privacy fabrics permit some light to pass through the shade, but are not open weaves, so the view is limited to shapes and shadows.

Specifying a fabric with a higher openness factor will provide a clearer view. However, as the openness factor increases, more unfiltered light and heat energy pass through the shade into the building, increasing the risk of glare and solar heat gain, and reducing the



Blackout fabrics prevent all light from passing through the material. These fabrics are often combined with special side channels, top treatments, and other system components to ensure a complete light seal.

amount of protection against UV radiation that the shade is able to provide.

In many projects, different openness factors may be required on one building to provide optimal daylighting performance. The orientation and latitude of a building, in relationship to the sun and the rotation of the Earth, dictate that building's exposure to direct sunlight. To effectively diffuse the direct sunlight in these highly exposed areas, the shade fabric must be denser. Sides of the building with less direct exposure may permit a broader openness factor, allowing more light into the space, without the threat of glare.

In the northern hemisphere, southern- and eastern-facing building facades receive more intense solar exposure throughout the day. On these facades, it may be prudent to specify a three percent openness factor to appropriately filter direct sunlight and protect against glare, while a 10 percent openness factor could be ideal on the north-facing window wall, to permit more of the less available light into the space.

Today, many shade fabrics are available in several openness factors. Different openness factors of the same fabric may be specified on different facades of the same building to effectively manage different exposures to direct sunlight, without compromising curb appeal.

Shade selection is not a zero-sum game. Designers can protect against solar heat gain and UV radiation, while providing an outdoor view, instead of having to choose one or the other. A 10 percent openness factor provides great visibility, but allows more light and heat penetration into a space, which can cause glare and solar heat gain. A three percent openness factor filters more sunlight and, subsequently, provides more glare control and UV protection, but limits the view to shapes and shadows. An openness factor of one percent and lower allows the glow of exterior light into a space, but provides very little visibility.

As the openness factor increases, so does the solar transmittance (Ts) value. Both color and composition of the shade fabric influence how much of the remaining solar radiation is reflected or absorbed, as well as, the visual transmittance of the fabric.

Color

While shades are available in virtually any color, from charcoal or blue, to pink or sand, the behavior of the fabric in the presence of sunlight is determined by whether the fabric is considered light or dark.

Light-colored fabrics absorb little light energy and are highly reflective. This high solar reflectance (Rs), coupled with low solar absorptance (As), makes light-colored fabrics well equipped to combat solar heat gain. Since very little heat is absorbed, there is little risk that a light-color shade will become its own separate heat radiator.

While much of a fabric's solar transmittance (Ts) is determined by openness factor, color does affect the visual transmittance (Tv) or glare-reducing capabilities of the shade. Light colors have a higher visual transmittance value, which means they are less adept at reducing glare. When solar energy hits a light-colored shade, some energy is reflected, some is transmitted into the space, some is absorbed into the fabric, and some light is trapped inside the weave, not absorbed. This trapped light bounces around in the shade itself, making light-colored shades bright to look at and difficult to look through. For these reasons, light-colored shades are not the most effective at reducing glare or preserving an outdoor view.

Dark-colored fabrics are highly absorbent. These higher solar absorptance (As) values combine with lower solar reflectance (Rs) values to create a fabric body that will absorb significant amounts of solar radiation, essentially becoming its own heat radiator. When a screen is placed inside a window, the heat absorbed by the fabric is added to the heat transmitted. This characteristic makes dark fabric a less appealing project choice if the most important goal in the space is controlling solar heat gain.

Dark fabrics have lower visual transmittance (Tv) values, indicating that they are highly capable of reducing the glare-causing light in an application and providing a clear view to the outdoors. As solar energy touches a shade, it is either reflected, absorbed, transmitted, or trapped within the weave. The absorbent nature of the dark fabric allows much less light to bounce around before being absorbed, causing little visual distraction.

applying solar performance metrics

If needs are to:	Consider fabric with:	In openness factors of:	Also important:
• control glare • enhance visual comfort	low visual transmittance **(T_V < 10%)**	≤ 5%	dark fabric colors facing room
• maintain view outside	low visual transmittance **(T_V < 10%)**	≥ 5%	dark fabric colors facing room
• protect interiors from fading	low solar transmittance **(T_S < 10%)**	≤ 1%	select controllable system to maximize protection
• optimize energy efficiency	high solar reflectance **(R_S > 50%)**	≤ 5%	light fabric colors facing window
• optimize energy efficiency and control glare	high solar reflectance and low visual transmittance	≤ 5%	dual-sided fabrics with dark color facing room and white facing window

When selecting a fabric, this information may be used as a rough guideline. Each application presents unique requirements.

Dual-sided fabrics that effectively combat solar heat gain, while reducing glare and maintaining a view to the outdoors, are available. These fabrics provide a "best of both worlds" solution with a light color facing the exterior of the building to reflect heat energy, and a dark color facing the interior to effectively absorb or diffuse glare-causing light and provide outdoor views.

Fabric Composition

Many of the fabric options available today are composed of either fiberglass, polyester, acrylic, natural fibers, or a combination. Fabric manufacturers regard their fabric weave compositions as proprietary elements of their products. Strengths and weaknesses of fabric compositions will vary depending upon the application and the fabric manufacturer specified.

To specify an appropriate fabric on a project, the goals of the system must first be determined. If the objective of the system is to cut glare but maintain views, a weave fabric must be specified. Weaves come in several styles and material compositions; the two most popular are fiberglass and polyester.

Fiberglass and polyester weaves filter sunlight while preserving visibility to the outside. Fiberglass is a thin, delicate weave, while polyester is coarser in appearance. Both fiberglass and polyester come in blended weaves, are often coated with polyvinyl chloride (PVC), and offer a variety of openness factors.

Acrylic

Acrylic fabrics are popular selections for exterior shades or as blackout materials for interior shades. Today's acrylics are typically solution-dyed, which means that they have been dyed throughout the fabric, not just on the surface area. This solution-dying technique allows for the gradual fading of the color to occur evenly over the years.

Interior blackout shades are also available in blends of acrylic and fiberglass.

Natural Fibers

Natural fibers, such as cotton blends, weed grasses, and corn-based fabrics, are also available shade materials. Often selected for their unique aesthetic appeal, natural fibers provide an interesting design element to any décor. Not synthetic or artificially reinforced, natural fibers do not contain toxic materials that may be released into the air. Unfortunately, these untreated organic ingredients are less able to withstand the daily battering of UV, light, and heat radiation, showing wear and tear much more quickly. In some cases, natural fibers can be treated in order to improve their light-management characteristics, but the best results for natural light control are often found in synthetic materials.

PVC-Coated

Shade fabrics are exposed to harsh UV radiation daily. Many fabrics are coated with polyvinyl chloride (PVC) to improve durability and protect the fabric from UV damage. The PVC also enhances the fabric's flexibility, helping the material move smoothly into open and closed positions, while retaining its shape and pliability.

PVC-Free and Halogen-Free Fabric

Fabrics are available that are specifically PVC-free and halogen-free. Without PVC coating, the shade will not have a plastic odor, but may not be as durable. The absence of halogen compounds dramatically reduces the fabric's emission of toxic smoke when exposed to flames. Removing these organic compounds from the building interior reduces the toxins or volatile organic compounds (VOC) released into the office air. PVC-free and halogen-free fabrics support sustainable design by promoting healthy indoor office environments, and can contribute toward earning LEED credits.

Conclusion

Designing controlled daylight in a space creates opportunities for healthier, more productive, more satisfied employees, as well as enhanced building performance potential. The benefits of controlled daylight are substantial, but so are the long-term implications.

Natural light is a tremendous source of light and heat. Harness and manage it effectively.