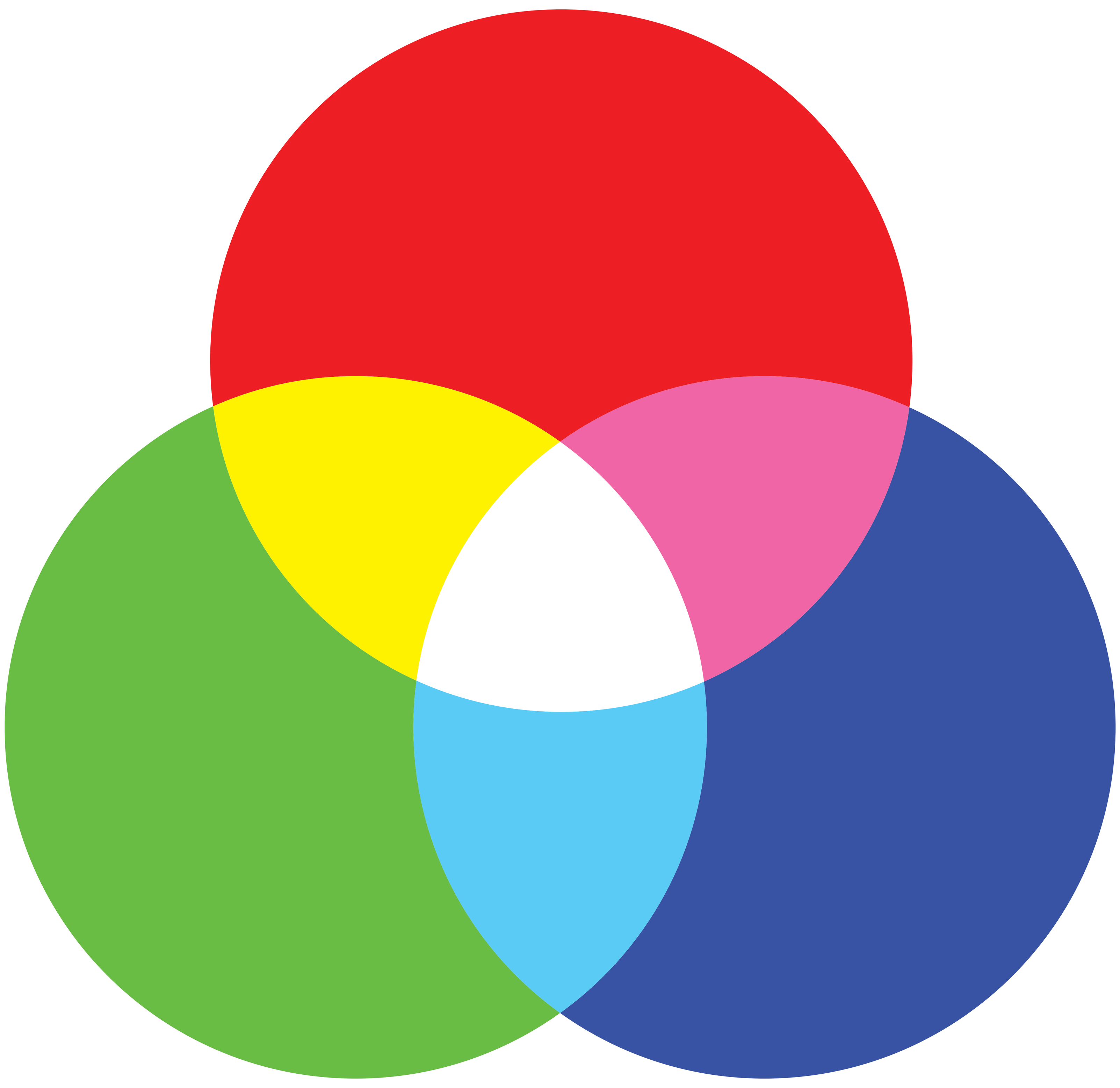
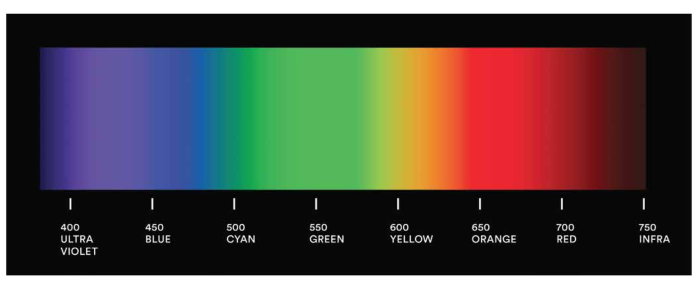


# Understanding How We See White Light

## Color temperature and color rendering both affect our perception of white light

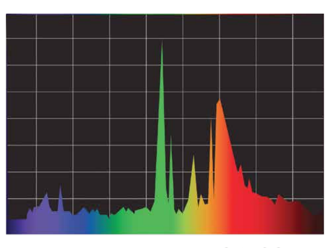
### The Facts

What we see as white light can be created through a mixture of the three primary colors of light (red, green, and blue, or RGB) or through a continuous spectrum of nearly equal amounts of energy at all color frequencies. While both types of light may appear white, a continuous spectrum renders colors falling between red, green, and blue more naturally.
The charts to the right are called Spectral Distribution Curves (SDC).

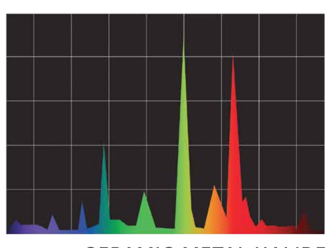



THE VISIBLE SPECTRUM

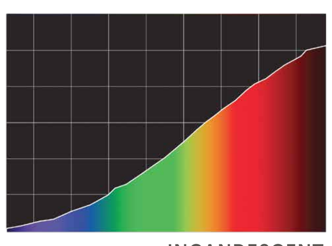
**The Visible Spectrum**
This chart shows all the wavelengths of light within the visual spectrum. Each wavelength represents a different color. The shortest wavelengths are violet, and the longest are red. Ultra-violet and infra-red lie just outside the visible spectrum at each end.



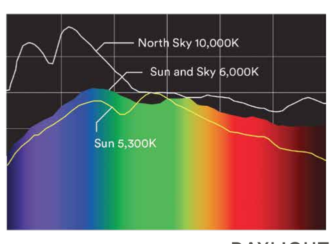
FLUORESCENT



CERAMIC METAL HALIDE



INCANDESCENT




DAYLIGHT

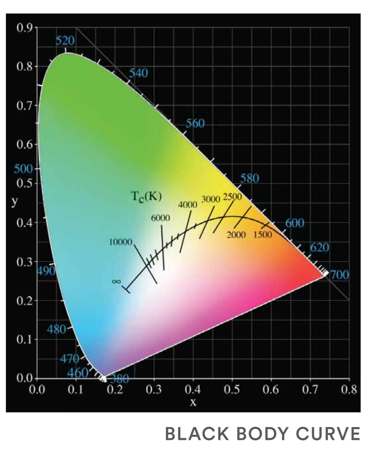
**Light Source Color Comparison**
Each light source has a unique color signature, defined by how much energy is emitted at each wavelength. Sources emitting the most energy in a particular color range will accentuate that color in an environment. For example, in a grocery store, red wavelengths will enhance the appearance of tomatoes, and green wavelengths will enhance lettuce.

## The Bottom Line

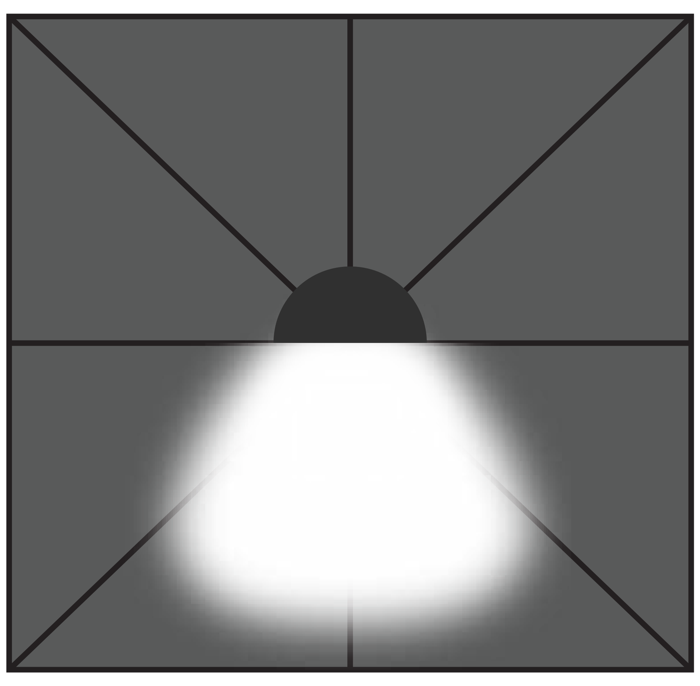
Newer energy efficient sources can provide lighting that looks just as good as traditional incandescent sources, with longer lives. A higher initial expense is quickly offset by energy savings and lamps (bulbs) that need to be replaced less frequently.

**Color Temperature vs. Color Rendering**
Color temperature refers to the perceived “warmth” or “coolness” of the color of a light source. Sources below 3000 Kelvin appear warm white or yellowish, while sources above 5000 appear cool or bluish-white. **Correlated Color Temperature**, or **CCT**, value is determined by the Kelvin value of a heated standard black body, and all commercial lamp catalogues provide the CCT values for their products. The black body curve within the chart to the right can be used to determine where various lamps fall on the CCT scale. Sources falling in different positions on the curve can still be considered the same color temperature, even though the eye will perceive them as noticeably different. The color temperature does not determine color rendering capabilities — light sources with the same color temperature may render surfaces quite differently, so both metrics must be considered together.

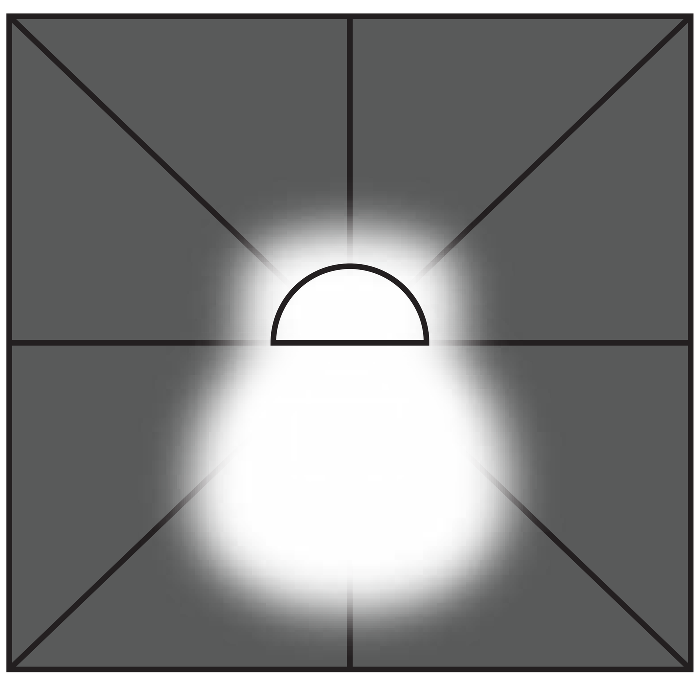
**The Color Rendering Index (CRI)** is a scale of values from 0 to 100, indicating how a light source makes a material appear in comparison to a reference source of the same color temperature. It is used to predict the effect of a light source on the color appearance of an object. Objects and people viewed under sources with a high CRI rating appear more natural.



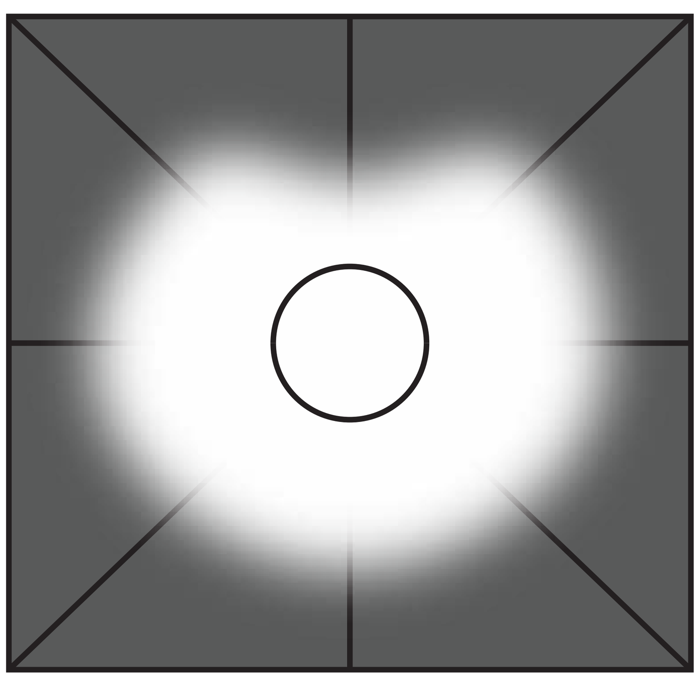

BLACK BODY CURVE



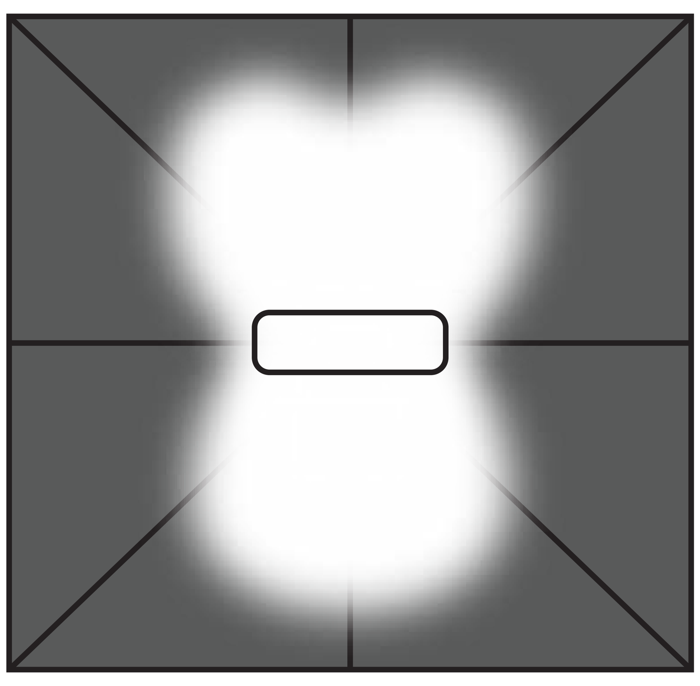
DIRECT



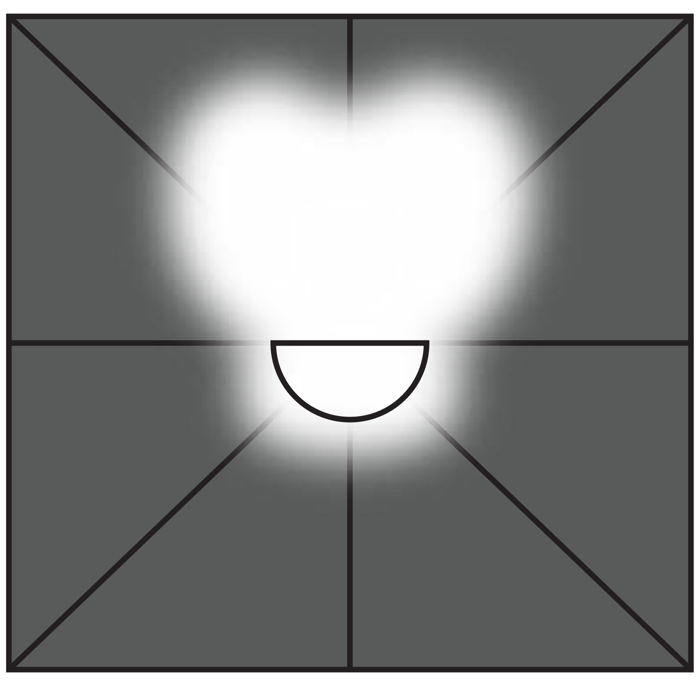
SEMI-DIRECT



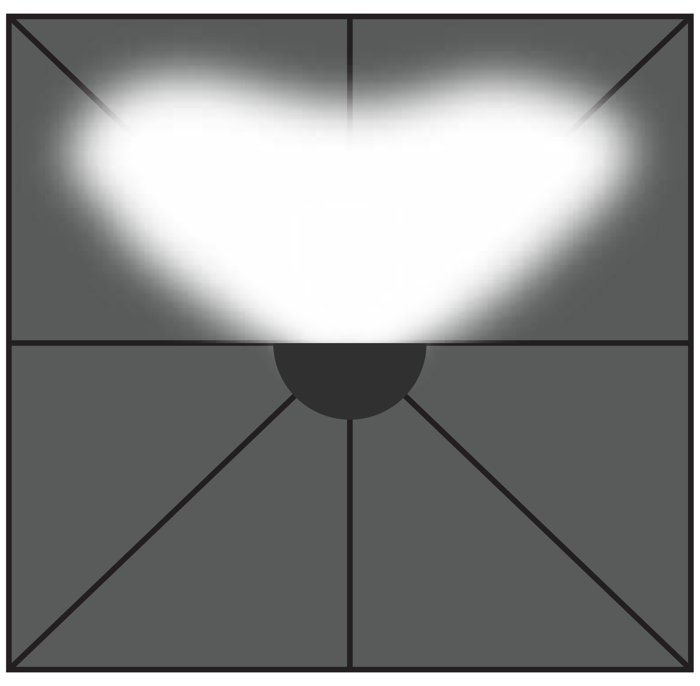
GENERAL DIFFUSE



DIRECT-INDIRECT



SEMI-INDIRECT

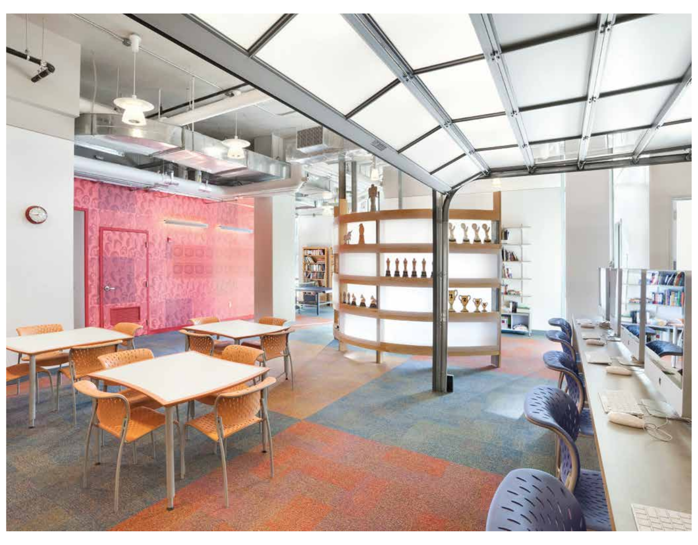


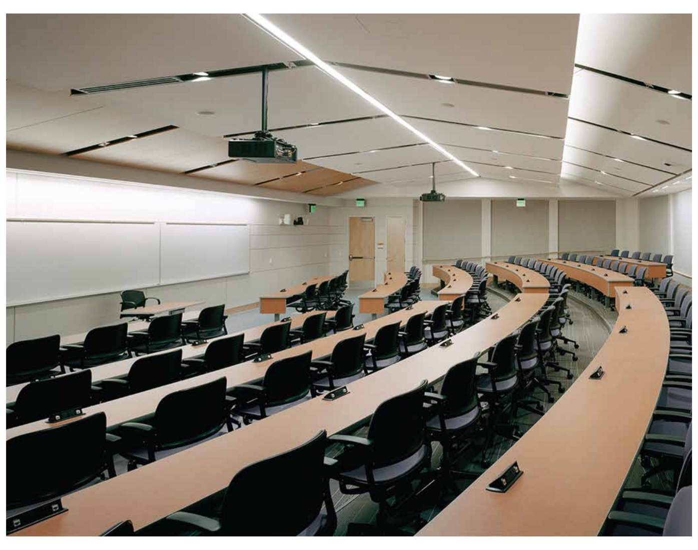
INDIRECT

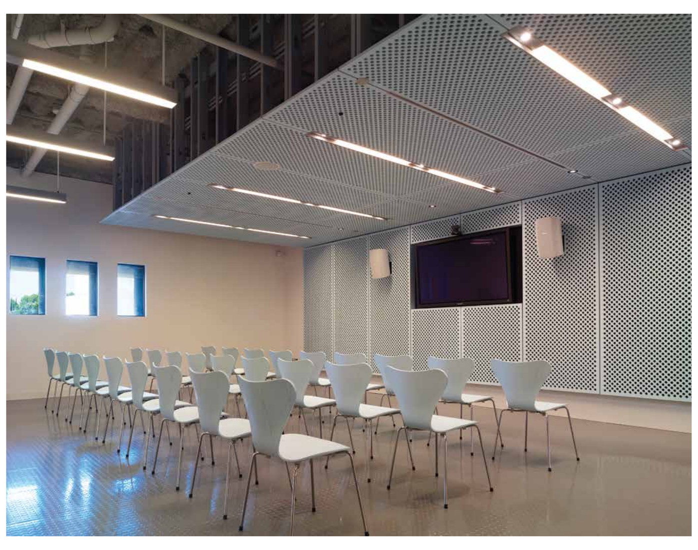
CREDIT: IESNA

# Luminaires: Choosing the Right Fixture for the Function

One size does not fit all







## The Facts

Selecting the right fixture for each job provides better quality, flexibility, visual interest, and energy savings.

There is no benefit to using one "building standard" luminaire for every function.

Best design practice reduces the number of different lamp types and sizes on a project for ease of maintenance.

## Why?

Each luminaire has a specific distribution tailored for a specific job. Some are meant to provide light to the walls or ceiling, while others are intended to add sparkle or ambient glow, or to function as focused task lighting.

Some luminaires integrate multiple sources for different functions.

Energy effective lighting creatively combines luminaires with varying distributions to provide a balanced and functional luminous environment.

## The Bottom Line

Luminaires are durable and should be selected as long term solutions. Some types of light sources (especially those with shorter lives) should be minimized project-wide to simplify stocking and replacement. Lighting control zones should be employed to take advantage of different luminaire types or functions.

CREDIT

Top left: 52nd Street Project, HLB Lighting Design.
Photo courtesy of BKSK Architects

Top right: Gateway Community College, HLB Lighting Design.
Photographer: John Woodruff & Peter Brown

Bottom left: Museum of Tolerance, HLB Lighting Design.
Photographer: Benny Chan @ Fotoworks

Bottom right: Tenley-Friendship Library, HLB Lighting Design.
Photographer: Mark Herboth Photography

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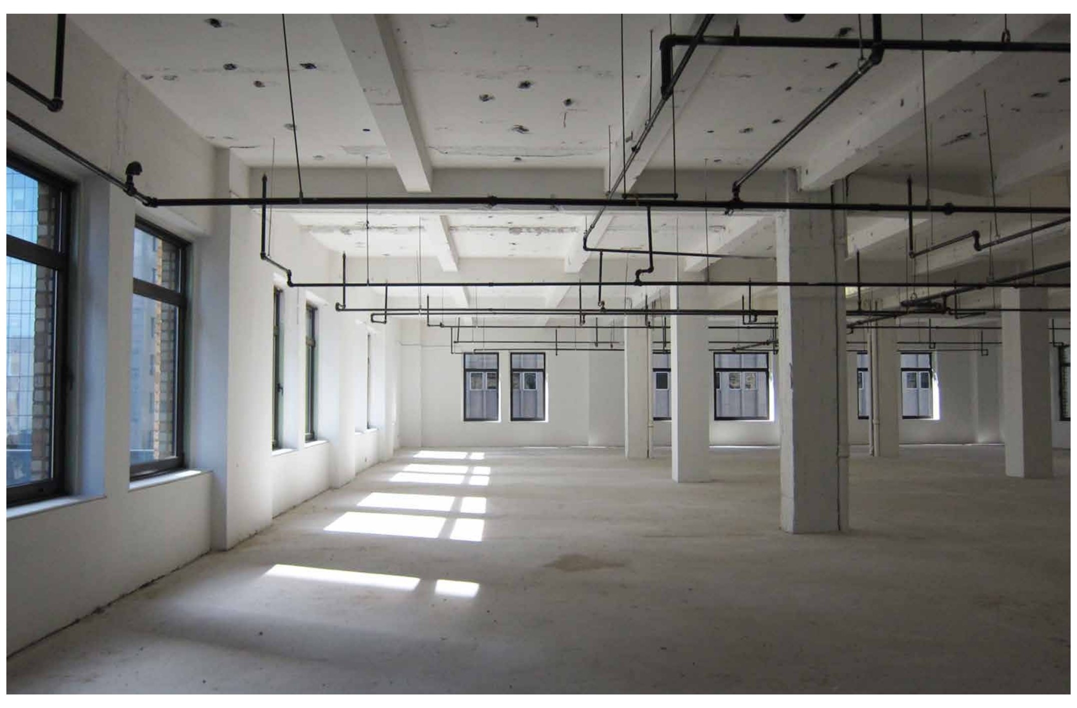
building
energy
exchange

The **building energy exchange** connects the New York real estate and design communities to energy and lighting efficiency solutions through exhibitions, education, technology demonstrations, and research. We identify opportunities, navigate barriers to adoption, broker relationships, and showcase best practices at our resource center in the Surrogate's Courthouse.

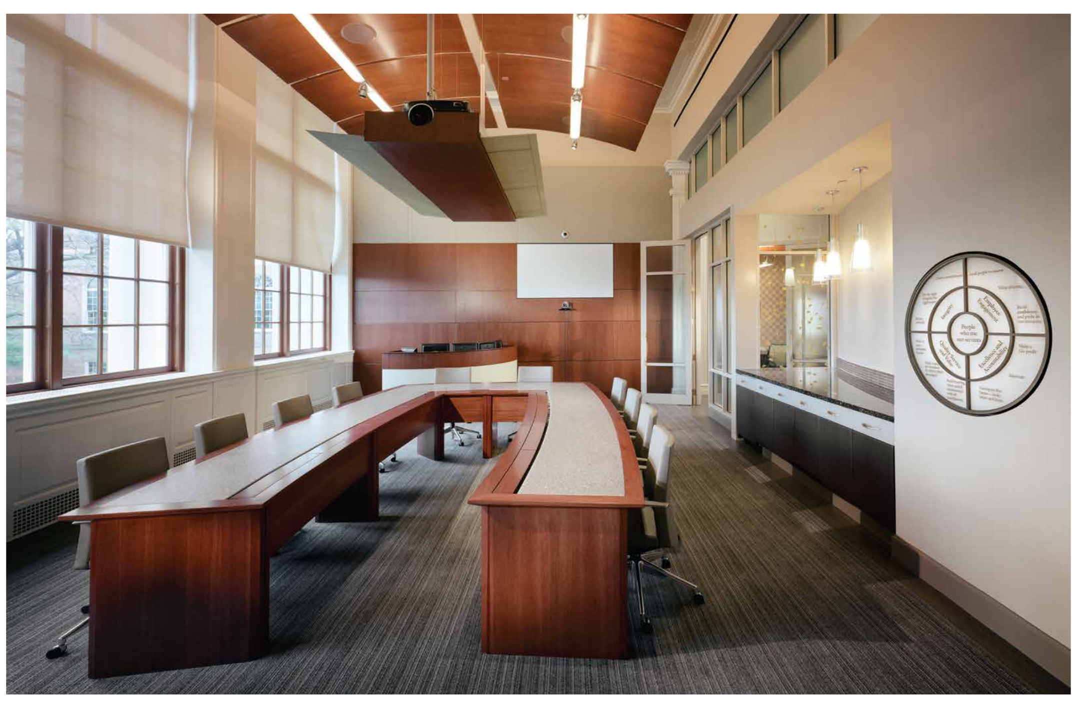
www.be-exchange.org

# Daylighting Saves Money and Energy

## Many existing New York City buildings have opportunities for daylight harvesting



SCENE A



SCENE B

SCENE C

SCENE D

**Daylight Harvesting** refers to the ability to "reap" energy savings by reducing electric light consumption at times when daylight provides ample illumination. This typically requires an automated control system comprised of a photosensor and controller that varies the electric light by either switching or dimming in response to daylight levels. Successful daylight harvesting depends upon:

1. sufficient daylight to achieve adequate energy savings;
2. physical conditions such as high window headers and light interior finishes that promote daylight distribution;
3. acceptable sun, glare and thermal control; and
4. lighting control performance that does not distract or annoy the occupants.

### The Facts

In New York City, buildings constructed before the 1950s are often more conducive to daylighting than newer structures.

Glare control is a higher priority because the nature of office tasks has changed.

Floor to ceiling windows are seldom the best choice for effective daylighting.

Glass closest to the ceiling is the most effective location to maximize daylight penetration.

The images above provide daylight harvesting examples:

**Scene A:** Window-wall ratio and placement will allow for effective daylight harvesting opportunities.
**Scene B:** Tall windows and narrow room provide excellent daylight design.
**Scene C:** Adjacent obstructions limit daylight availability, but views greatly enhance the occupant experience. (but is more visually enhancing to the occupant)
**Scene D:** Tall windows and shallow spaces offer excellent daylight design opportunities. However the bottom 30" of glass (is inefficient and will) are not effective and increase thermal heat gain.

### Why?

Prior to the 1950s, buildings were designed for daylighting with higher ceilings and shallow floor plates to allow workers access to windows. The introduction of cheap energy, fluorescent lighting, and mechanical ventilation reshaped commercial buildings. Executive offices moved to the perimeter, while most workers were pushed deep into the interior.

Office work used to be primarily a "heads-down" activity, but the use of computers now means that most people work facing forward, and are more sensitive to glare from windows and electric lights.

Floor to ceiling windows, even those utilizing high-performance glass, experience greater thermal gains and losses and require more hours of shading.

The tops of windows are often obstructed by dropped ceilings from upgraded HVAC equipment.

### Other Considerations

Automated blinds for sun control will limit solar heat and glare from windows while maximizing daylight harvesting. Keep in mind that lower floors are often obstructed by surrounding buildings, or subject to unusual reflections, and may not be able to utilize daylighting efficiently.

## The Bottom Line

Many existing New York City buildings are well positioned to utilize daylighting. Optimal window placement will take both daylight and views into consideration. Ductwork can be relocated to make best use of ceiling heights within 12' to 15' of the window wall.

CREDIT

Scene A, D: HLB Lighting Design

Scene B: Aetna, HLB Lighting Design. Photo courtesy of Perkins + Will

Scene C: Moet Hennesey, HLB Lighting Design. Photo by Adrian Wilson, Interior Photography Inc.

OPEN OFFICE LIGHTING CONTROL PLAN


## DEFINITIONS

**Daylight Harvesting**
The use of available daylight for illumination. This requires an automated control system, comprised of a photosensor and controller, that either switches on or dims electric lights in response to available levels of daylight.

**Set Point**
The light level that triggers an action like switching a zone on or off, or the maintained level for dimming.

**Dead-Band**
The difference between the high illuminance set point used to turn lights off and the low illuminance set point to turn lights on. This should be wide enough to prevent frequent switching, called “cycling”, which will severely distract the occupants and often shorten lamp life.

CREDIT

ALG-Online, New Buildings Institute, PNNL

# The Lighting Control Intent Narrative

**7 Steps to Developing a Successful Lighting Control Plan of Action**
The Lighting Control Intent Narrative is an essential communication tool at all phases of design, construction and operation. It addresses the functionality of the space's lighting at different times, describes how each event should be triggered, and defines the mandatory controls required by the energy code. Here’s how to create and implement a successful lighting control intent narrative:

**1. Define**
Start by writing, in simple, straightforward language, a description of how each space is intended to be controlled. This serves to reach a consensus on the plan of action between the design team, owner, and intended occupants.

**2. Delineate**
Supplement narrative with diagrams to indicate intended zones or groups of lights to be controlled together.

**3. Disseminate**
Share narrative with manufacturers as the basis of discussion and further refinement.

**4. Commit**
Include a final version of the narrative as an integral part of the contract documents.

**5. Certify**
During shop drawing review, manufacturers should state in writing that they are meeting the performance criteria established in the Control Intent Narrative.

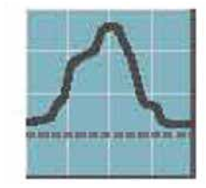
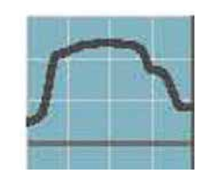
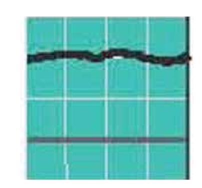
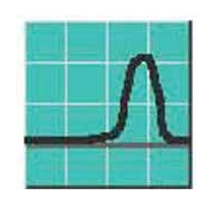
**6. Commission**
The Control Intent Narrative will assist the Commissioning Agent during final calibration. The final calibration settings should be recorded for future re-commissioning.

**7. Maintain**
The Control Intent Narrative should be kept on file by the owner so that the facilities manager, occupants, and recommissioning agent can refer to it and understand the intended operation of the lighting controls.

RECOMMENDED CONTROL
DEVICES BY SPACE USE

| Ask this about the application: | If YES, consider this strategy: |
|---|---|
| Is occupancy unpredictable? (e.g., unpredictably unoccupied for over 30% of the time: restrooms, stock rooms, warehouse aisles, hotel rooms) | Occupancy sensing timer switches |
| Is space use highly predictable and not a 24-hour, 7-day operation? | Scheduling |
| Is exterior lighting used for facades, signage, or parking areas? | Photosensors<br>Scheduling<br>Occupancy sensors |
| Is daylight available from windows or skylights? | Photosensors (automatic switching or dimming)<br>Manual dimming<br>Bi-level and multi-level switching<br>Time switches |
| Is there a need to vary light levels during the day or after hours? | Manual dimming<br>Bi-level and lumti-level switching<br>Adaptive compensation (nighttime light level reduction via scheduled dimming) |
| Does the space have many different uses (e.g., conference room, ballroom)? | Multiscene controls<br>Manual or automatic dimming<br>Bi-level and multi-level switching |
| Is there a lot of churn or turnover in the space (e.g., open office)? | Manual or automatic dimming<br>Bi-level and multi-level switching |

RECOMMENDED CONTROL DEVICES
BASED ON LIGHTING LOAD PROFILE

| Lighting Use Profile | | Selection | Devices |
|---|---|---|---|
|  | Typical work hours 9 to 5 with limited weekend use | Select controls that reduce peak demand | Occupancy sensors and photosensors for tenant space<br>Scheduling and photosensors for public areas |
|  | Extended hours | Select controls that reduce unpredictable use | Occupancy sensors<br>Manual dimming/bi-level and multi-level switching or scheduled dimming for adaptive compensation |
|  | 24-hour | Select controls that reduce lighting day and night | Photosensors<br>Manual dimming/bi-level and multi-switching or scheduled dimming for adaptive compensation |
|  | Event-oriented operation | Manual controls work best | Manual dimming<br>Bi-level and multi-level switching |

CREDIT
ALG-Online, New Buildings Institute

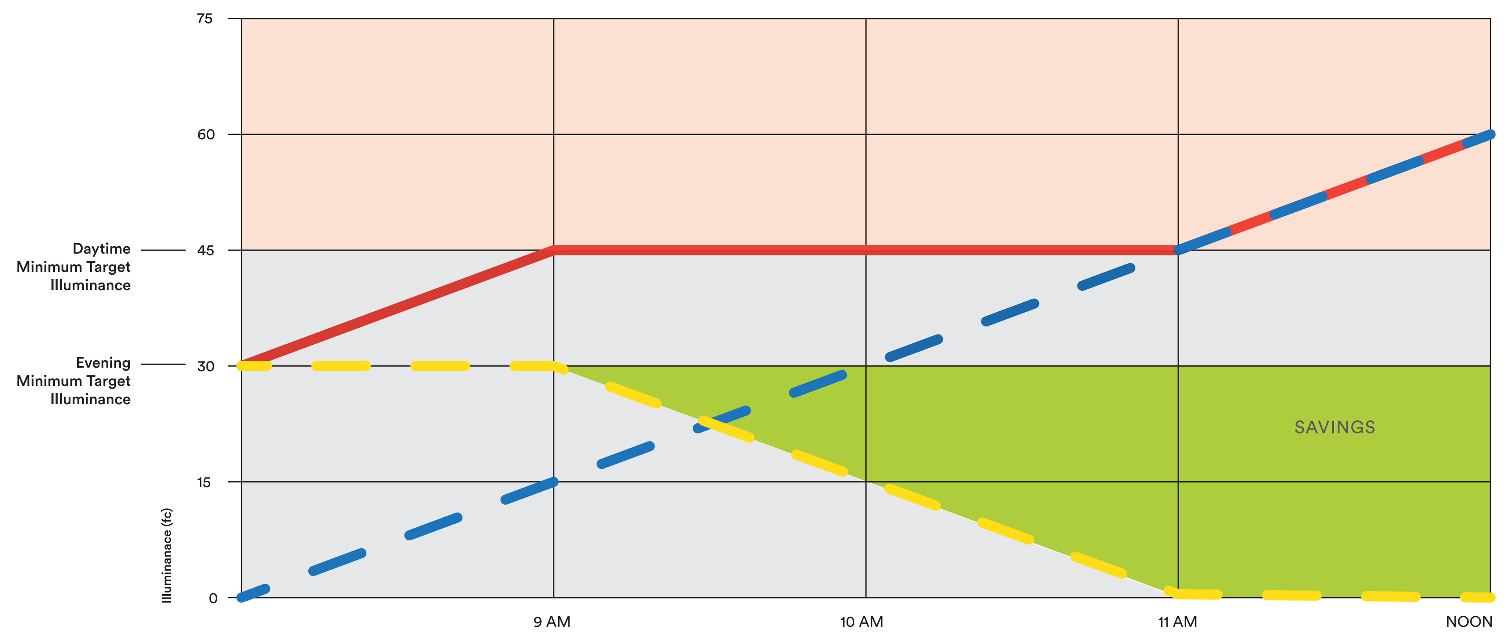
# The Bottom Line

Lighting Controls not only save energy, they provide flexibility and lighting quality by fine tuning the lighting for the space, time of day and function. Reducing operating time saves energy without reducing quality. Proper commissioning is essential for the success of any lighting control system.

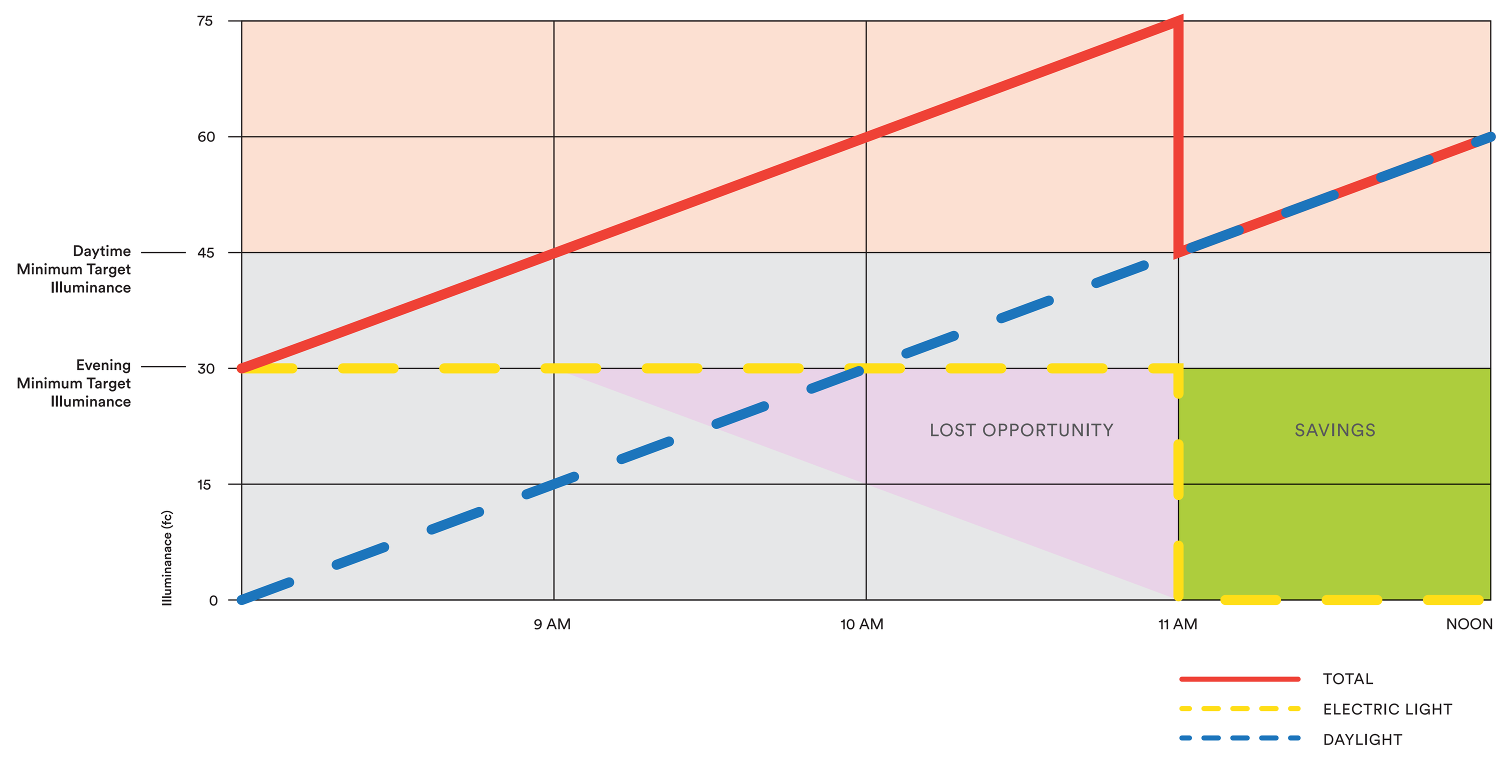
# Design Strategies for Lighting Controls

## Balancing energy savings and human needs

CONTINUOUS DIMMING




ONE STEP SWITCHING




## Daylight Harvesting

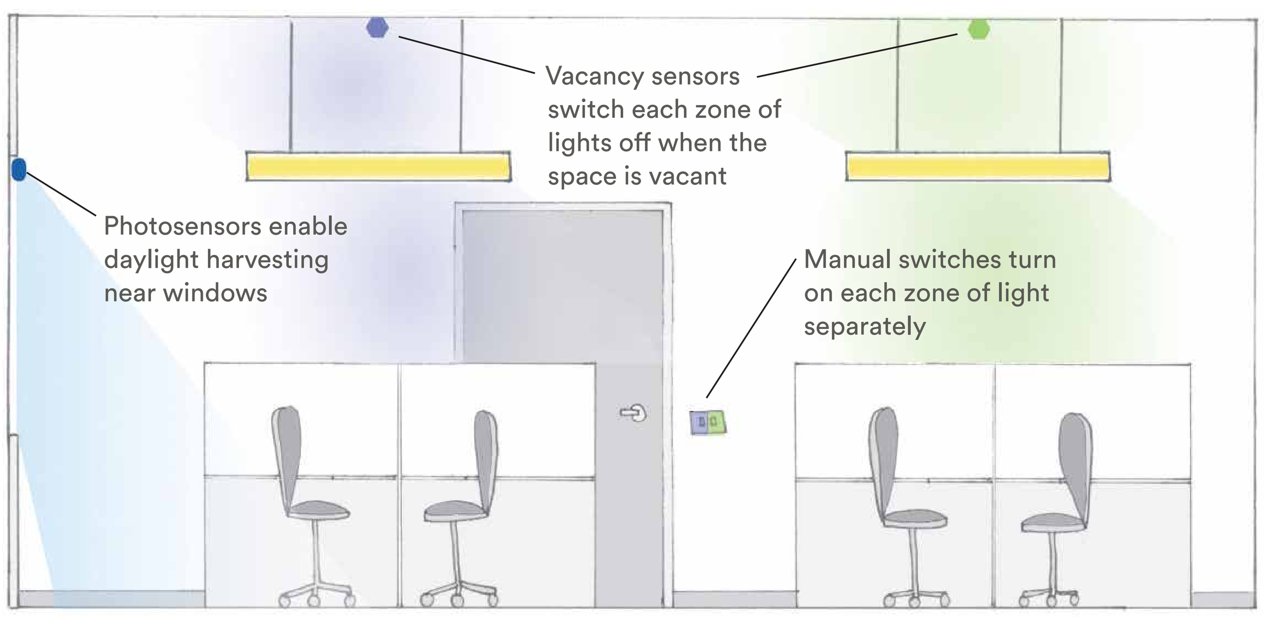
### Control Basics for Daylight Harvesting

Daylighting only saves energy if it reduces the use of electric lighting.

Direct sun penetration should be controlled to reduce thermal gains and glare.

Human control of interior blinds is often the weak link in the daylight harvesting system.

OPEN OFFICE LIGHTING CONTROLS




### To Switch or to Dim

Dimming is typically preferred for daylight harvesting, especially in workplace environments. It saves more energy because the set points are lower, the deadband ("Lost Opportunity" above) is smaller, and the refinements are more subtle. These features also make dimming more acceptable to occupants, so the controls are less likely to be disabled. The increased use of LED lighting will enable dimming for most applications, without the added cost of fluorescent dimming ballasts.

For some applications, switching may be a low-cost option for daylight harvesting. A greater number of zones means the incremental steps can be smaller, allowing this method to approach continuous dimming in terms of energy efficiency, cost savings, and user acceptance. However, the set points are typically much higher, to ensure that turning off one zone (dropping down one step) will be less noticeable to the occupants. Consequently, the savings are always less than those realized by a continuous dimming system. Appropriate applications for switching systems are lobbies, circulation, airports, gymnasiums, sports facilities, and primary schools.

### Open-Loop or Closed-Loop?

The type and placement of the photosensor is a determinant in the selection of Open-Loop or Closed-Loop strategies.

In an Open-Loop configuration, the photosensor is aimed toward a window or skylight and primarily senses daylight. It reduces electric lighting proportionally in response to daylight levels. This configuration is suitable for either daylight switching or dimming.

In a Closed-Loop configuration, the photosensor is located near electric luminaires, aimed at the floor or at a consistent horizontal surface. It is calibrated to a constant set point (about 50% higher than the nighttime design illuminance). As the daylight in the space increases, the electric light is dimmed to maintain a steady state. This method is only effective as part of a continuous dimming strategy.

Smart photosensors: Newer generations of photosensors with learning capabilities are able to distinguish between daylight and electric light and effectively control the electric light with less restrictions on the photosensor placement.

Be wary of combination occupancy and photosensors, since the optimal location for one function is seldom the optimal location for the other. However, they can be adjusted to serve a single function; use as many as necessary to meet the needs of the project.

CREDIT

Top: Horton Lees Brogden Lighting Design

Bottom: ALG-Online, New Buildings Institute, PNNL

Most offices leave the lights on even when ample daylight is available. Deployment of daylighting systems could save New York City owners and tenants $70 million in energy costs each year.

CREDIT

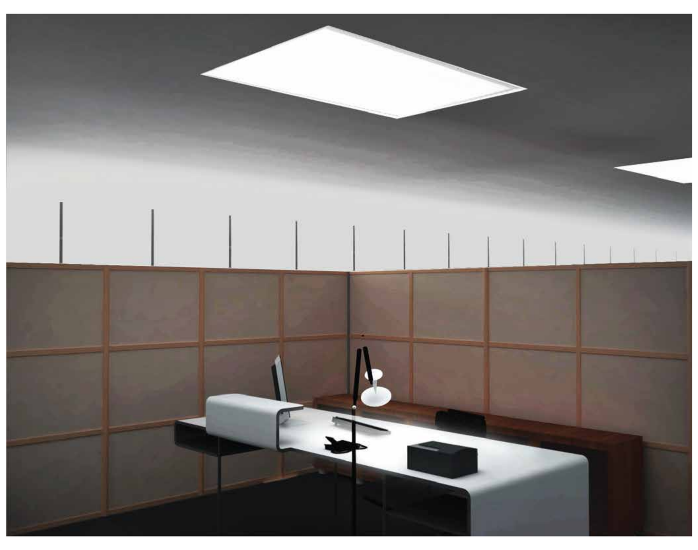
"Let There Be Daylight", Green Light New York

# Design Lighting for the Space First

## Creating effective task lighting is simpler in a properly lit environment

SCENE A

SCENE B



SCENE C

### The Facts

All of these scenes demonstrate poor quality lighting that wastes energy, with excessive levels of contrast and improperly lighted room surfaces. In Scene A, the ratio of task lighting to surroundings far exceeds best practice recommendations. In Scenes B & C, the spaces feel dark because of high contrast or dark surfaces absorbing light.

### Why?

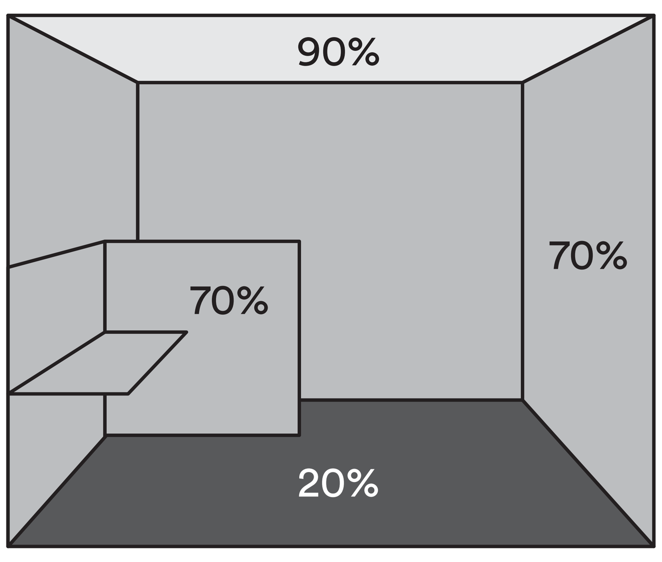
Dark finishes reduce inter-reflections and require more energy to achieve the same level of illumination as a room with lighter-colored surfaces.

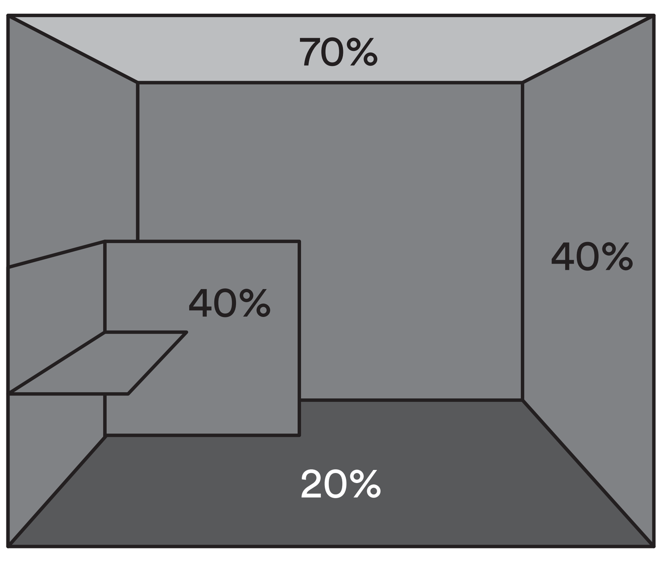
We judge brightness based on the room surfaces (wall, ceilings and partitions) within our total field of view. Dark or unlighted areas make a space appear gloomy, even when there is plenty of horizontal illuminance.

High contrast creates visual discomfort. It can affect work performance as the eye struggles to simultaneously adapt to separate brightness levels. Turning up the light on the task area adds contrast and glare, while increased light on the dark room surfaces is mostly absorbed and will result in excessive energy use.

## The Bottom Line

Create an overall luminous balance within the space, and remember that illuminance on the task area cannot fill in for poor overall lighting quality. More energy is required to compensate for glare or dark finishes that absorb light and require additional energy to achieve acceptable levels of brightness.

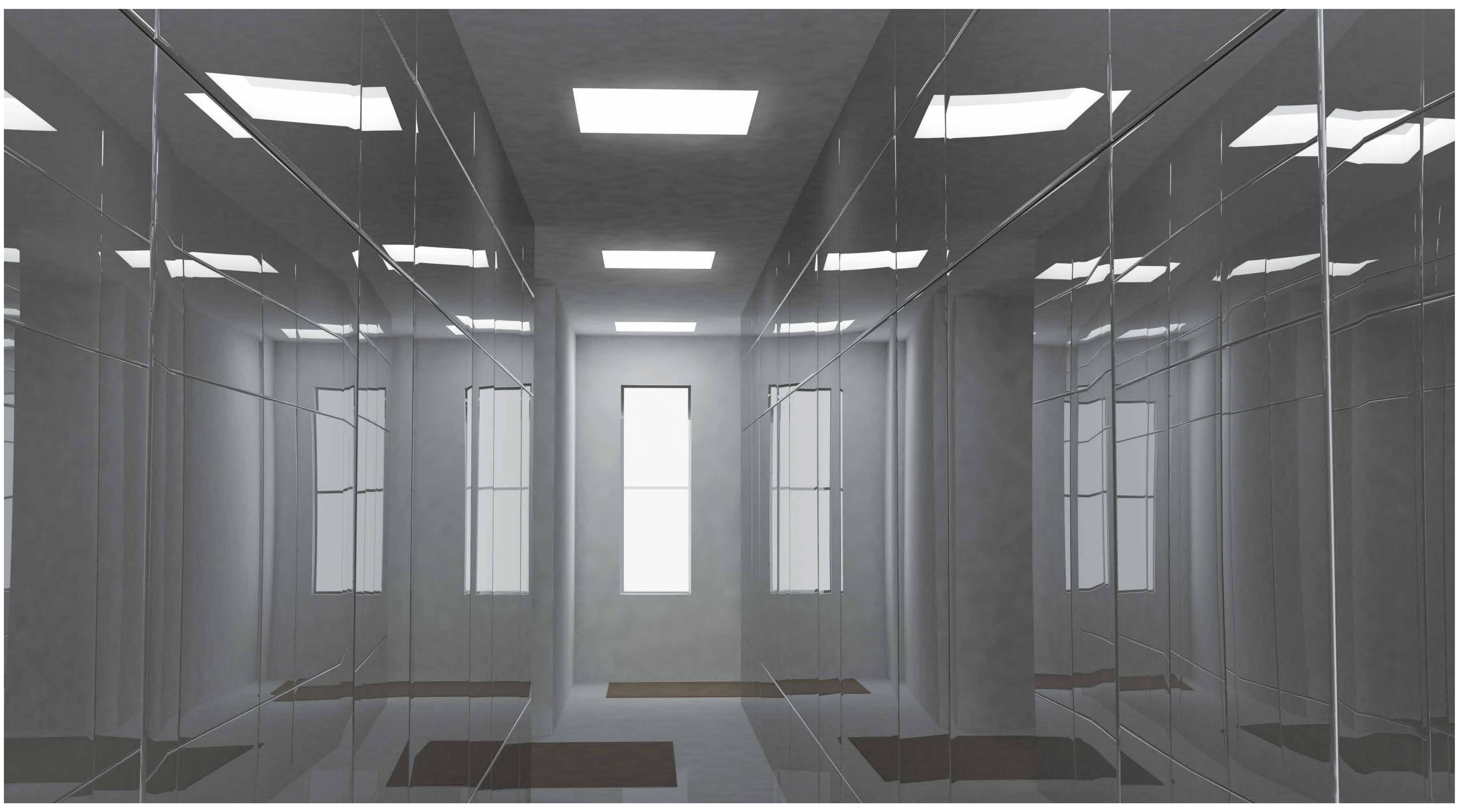


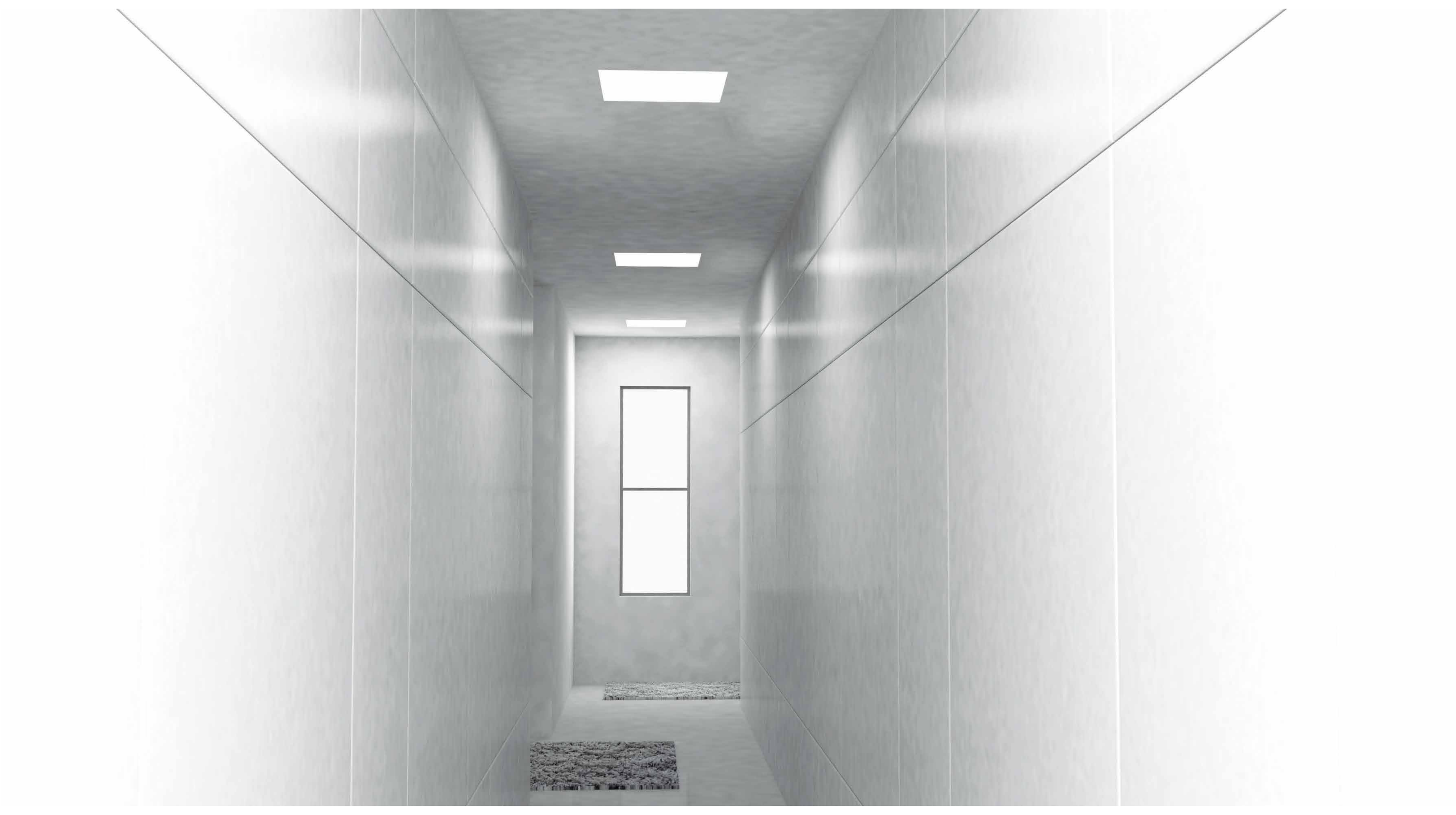

A small increase in room reflectances produces a big improvement in efficiency. The lighter room (top) provides 55% more light on the task area for the same amount of energy. It also uses 70% less energy to provide equivalent brightness, better brightness ratios, user comfort and daylight distribution.

CREDIT

Scene A, B, C: DesignLights Consortium



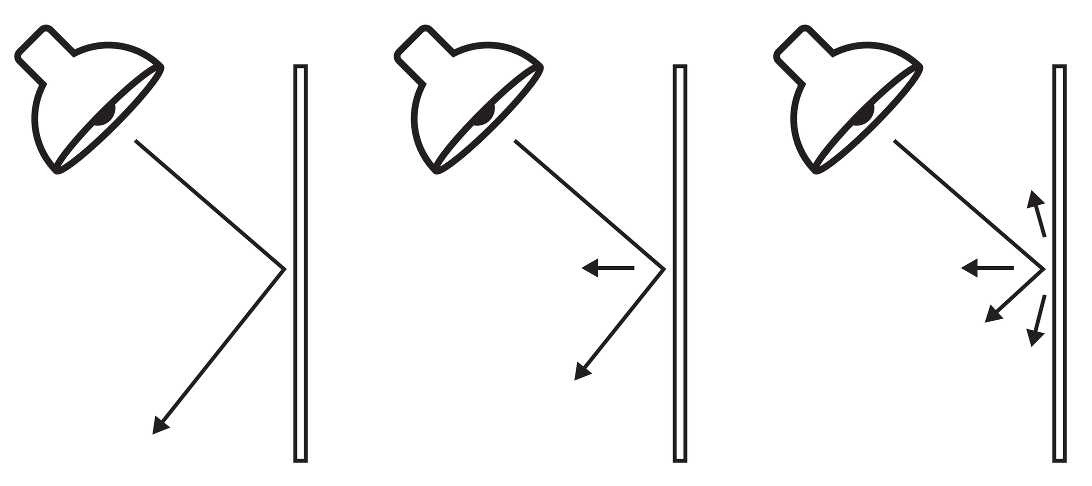
SCENE A



SCENE B

# Shiny Doesn't Mean Brighter

## Usually matte finishes appear the brightest




### The Facts

Shiny finishes use more energy and add visual confusion and glare to the environment as seen in Scene A.

Matte finishes are more energy-efficient and give the appearance of uniformly lighted surfaces as seen in Scene B.

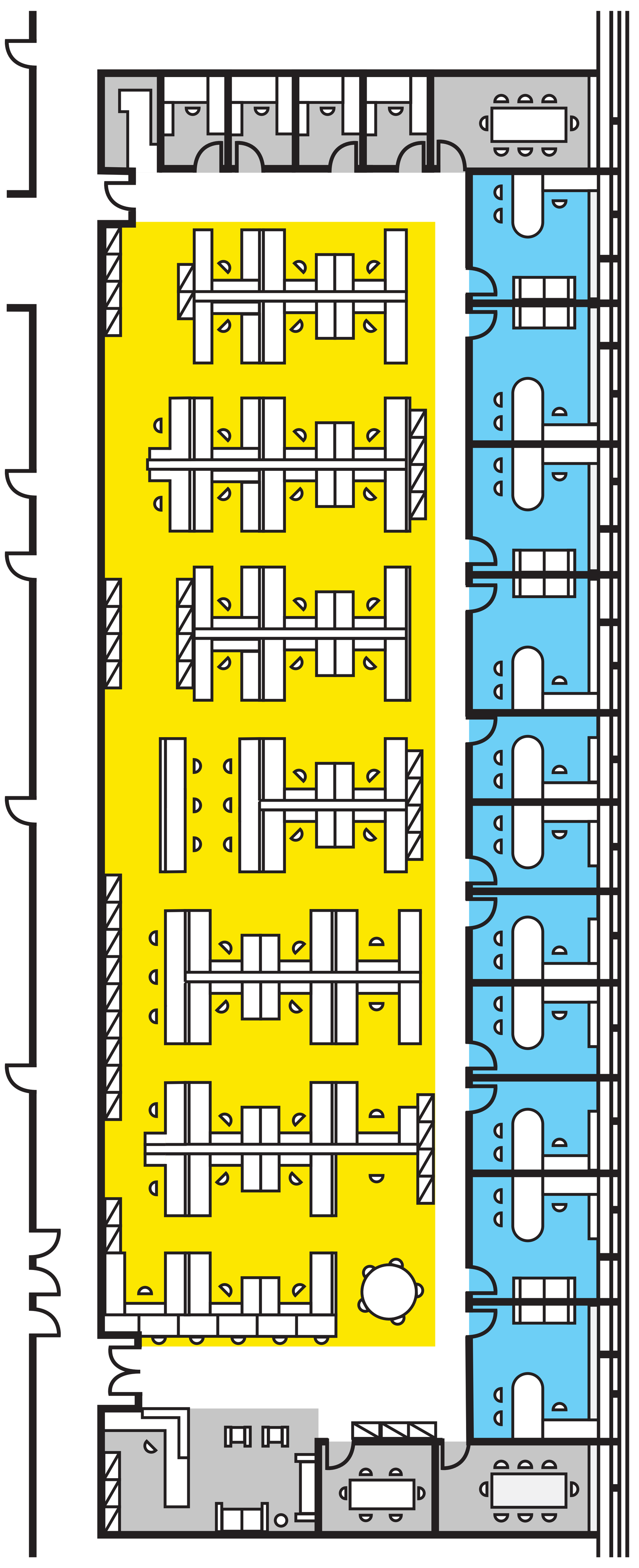
### Why?

"Specular" (shiny) surfaces reflect light in one direction. They create glare by causing clear images of the light source to be visible. More light is needed to compensate for high contrast and glare.

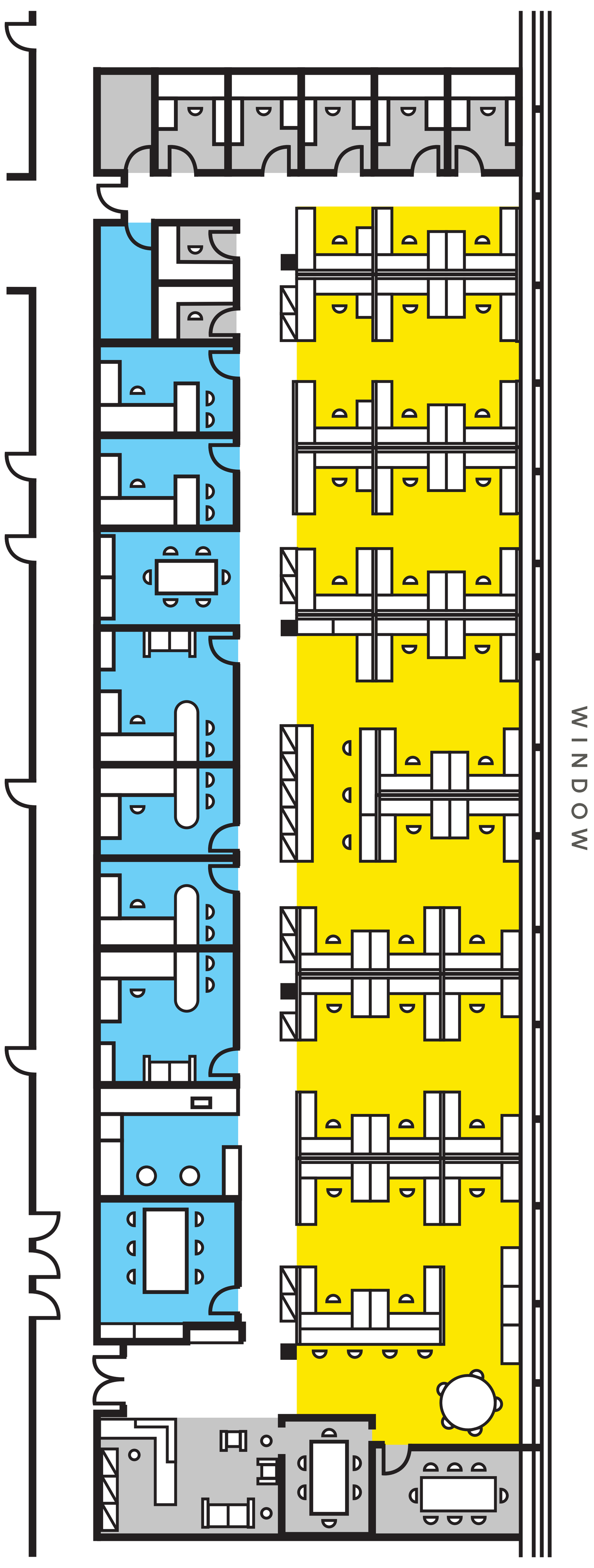
Matte surfaces reflect light in all directions. They prevent glare by obscuring the reflected image of the light source. A matte surface will appear adequately lighted with less light.

## The Bottom Line

Both finishes reflect the same amount of light, but matte surfaces look brighter and require less light and energy because they diffuse reflected light, while shiny surfaces create contrast and glare.




SCENE A




SCENE B

# Interior Design Can Save Energy

Initial decisions affect energy efficiency and enhance occupants' comfort

## The Facts

Scene B is more successful in every way: it costs less, saves more energy, and is more comfortable for the occupants.

## Why?

Open-plan offices with workstations located near windows enables "daylight harvesting". Daylight harvesting in private offices fitted with vacancy sensors, as shown in Scene A, is not cost effective.

Low partitions obstruct or absorb less light, making them more efficient for distributing both electric and natural lighting.

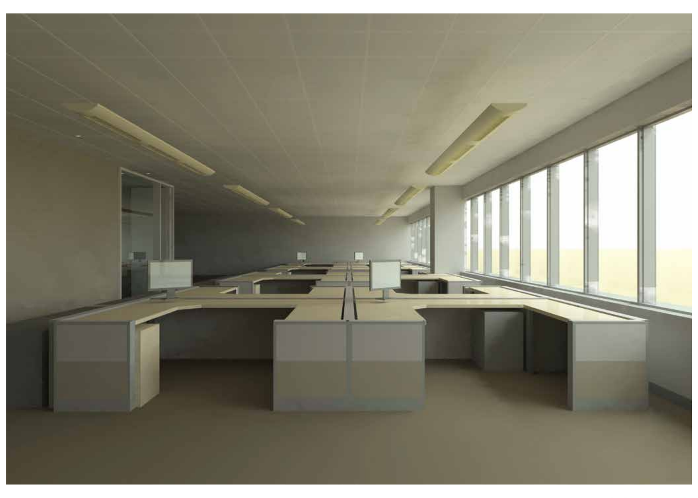
Open-plan offices are more energy efficient. Their decreased wall surfaces mean there is less vertical area to illuminate, and less light is obstructed or absorbed.

A higher number of occupants have access to windows and views.

Increased surface reflectances save energy, especially in small enclosed offices.

SCENE A

SCENE B



SCENE C

**Scene A:** 25% of the floor area is above 300 lux. Partitions 72" high.
**Scene B:** 45% of the floor area is above 300 lux. Parallel partitions 42" high; Perpendicular partitions 60" high.
**Scene C:** 75% of the floor area is above 300 lux. Ceiling height 10'-0". No partitions above 30" high.

The images of open-plan offices above are from the *Daylighting Pattern Guide*, a free web-based design resource for the schematic phase of design, for implementing proven daylighting design strategies in commercial buildings. Based on real-world built examples and advanced simulations, it includes patterns for offices, schools, libraries, laboratories, museums, and industrial facilities. The guide was developed by the Integrated Design Lab at the University of Washington in Seattle and the University of Idaho in Boise, in partnership with the New Buildings Institute.

## The Bottom Line

Interior design decisions have a tremendous influence on lighting efficiency, both in terms of cost and energy usage. Planning smart layouts and low cost passive design solutions rather than utilizing expensive technologies can have a positive impact on energy savings and occupant comfort.