WAUSAU

WINDOW AND WALL SYSTEMS

DAYLIGHTING
and Integrated Façade Design

(An Apogee IFD Presentation)

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PROGRAM SPECIFICS

Length: One hour
Credits: 1 learning unit (LU)/HSW/SD
Cost: Free - There is no cost to bring this program to your firm or chapter meeting, or to take the online course
Description: Fundamentals of daylight availability, the impacts of window and room geometry, glass properties, and the lighting efficacy of daylight versus electric light are presented.
Applications of sun shades and light shelves are reviewed, with benefits and concerns to be addressed during design.
Objective: Provide design professionals with valuable information on integrated façade design and natural daylight harvest, in support of sustainability goals.
Point of Contact: For more information or to schedule a presentation, contact Wausau at info@wausauwindow.com or call toll-free at 877.678.2983

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WAUSAU

WINDOW AND WALL SYSTEMS

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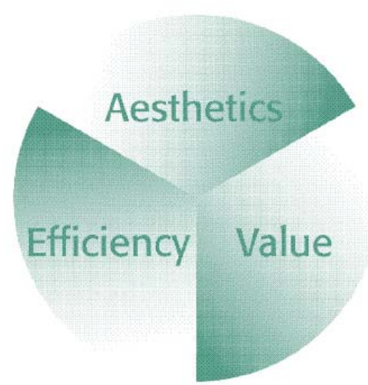
Integrated Façade Design (IFD) recommendations and training draw on the technical expertise of all Apogee architectural business units, to bring balanced and competitive energy solutions to the design community.



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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

CONTINUING EDUCATION AIA

DAYLIGHTING
and Integrated Façade Design

Learning Objectives

1. Identify the key variables, components, and benefits of Integrated Façade Design
2. Analyze glazing by "Daylight Types"
3. Discover how Integrated Façade Design can create successful daylighting with greater than 30% Window-to-Wall Ratio (WWR)
4. Describe appropriate window size and configuration for use with sun shades and light shelves

Section One

Introduction to Daylighting Strategies

Daylighting

"**Daylighting** is the controlled admission of natural light into a space through windows to **reduce or eliminate electric lighting.** "*

"By providing a direct link to the dynamic and perpetually evolving patterns of outdoor illumination, daylighting helps create a visually stimulating and productive environment for building occupants, while reducing as much as one-third of total building energy costs." *

* Gregg D. Ander, FAIA, Southern California Edison

Daylight as a Resource

Union Square, San Francisco, CA

Successful daylighting is informed by site, climate, and solar access.

Starting from the outside, and working our way inside, all that's necessary is common sense…

"Neighboring buildings control sky view.

Local climate determines the annual daylight resource.

Façades that face north or south will harvest more daylight with less chance of glare."*

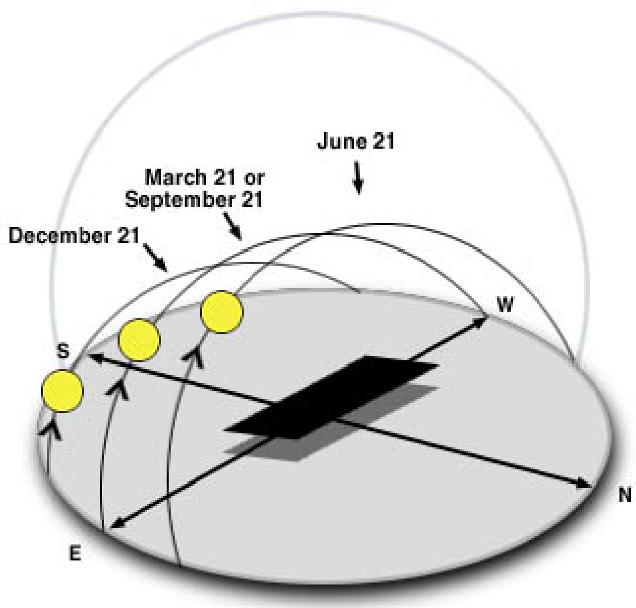
Successful daylighting is achieved by integrating climate, site, and orientation into the design of the building envelope.

* Tips for Daylighting, LBNL, 1997

The Sun's Path

Sunlight availability is set by site,
neighboring buildings,
and façade orientation.

The sun's path is low in the winter
and high in the summer.



All orientations see direct sun
some times of the year, even the north.

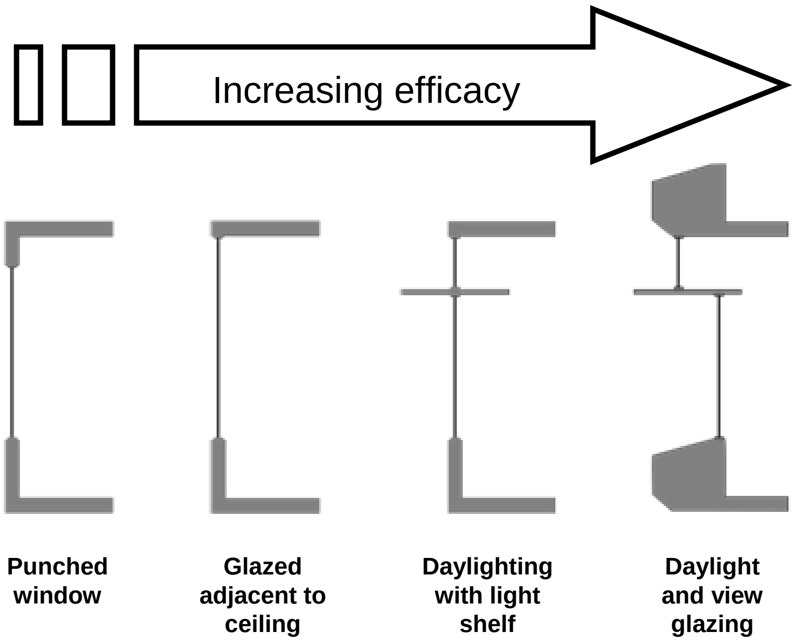
Daylight availability changes across the day, and throughout the year.

To realize the full benefits of daylighting,

- windows should face north or south,
- east- and west-facing windows should be avoided or minimized, and
- interior surfaces must help distribute the daylight into the space

Façade Design
and Daylighting Efficacy

Punched windows can produce high contrast and glare.



The **head height** of glazing determines how far daylight will penetrate.

Exterior sun shades and interior **light shelves** provide shading near the window, and reflect daylight inwards.

A daylight-optimized system uses high-transmission glass above a light shelf, moderate transmission below the light shelf, and sloped openings to admit more daylight. Interior operable shades provide control of direct sun and glare.

In office buildings, where side-lighting is the predominant light source, daylighting design shapes the window openings to push daylight further into the building. Additional devices like light shelves form the backbone of a successful daylighting system.

The size of the window and the shape of the window sill, jamb, and head, will enhance or detract from the window's daylight-gathering ability. Windows with deep frames, canted to the interior, will increase daylight penetration and decrease the contrast between the glazed area and the adjacent wall. Glazing that abuts interior walls allows more daylight into the space, and softens transitions.

Design of

Interior Spaces

Interior surfaces receive and distribute daylight.

Light colored ceilings, walls, and floors increase daylight penetration and reduce harsh contrasts.

While this presentation is focused on vertical glazing, **atria, skylights and light wells** offer excellent natural daylighting potential for some building designs.

The use of high-reflectance, diffuse surfaces on ceilings, walls, and window framing can encourage internal reflection that will reduce contrast and glare.

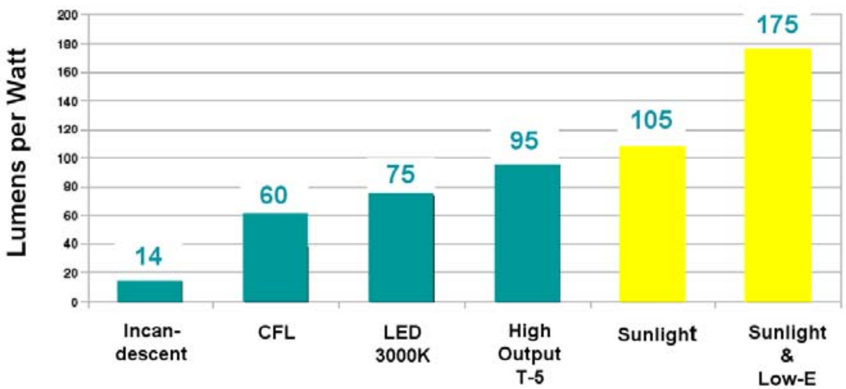
The **ceiling** is the most important light-reflecting surface, and should be at least 80% reflecting. Gabled ceilings that slope downward toward the center of the building can dramatically increase daylight penetration.

In small rooms, the back wall is the next-most important surface, and should have a matte finish with a reflectance of 50% to 70%. Floor reflectance should also be kept above 30%.

When possible, orient room occupants at right angles to the windows used for natural daylighting.

Daylight versus Electric Lighting

Light Created per Watt of Energy



Sunlight through high-performance glazing produces 175 lumens of visible light for each Watt of heat gain that must be cooled by mechanical means.

* Electric lighting efficacies; EERE, 2007; daylighting efficacies, Kaneda, IDeAs, 2008

All light sources use energy to produce light; a candle, an incandescent bulb, a fluorescent lamp, and the sun. However, some are more effective at producing light than others.

The measure of this efficacy is **lumens/Watt** (lm/W).

An incandescent lamp provides 14 lm/W.

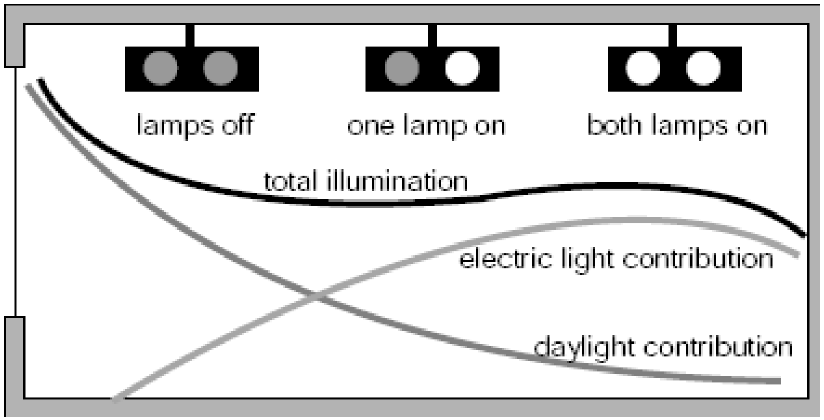
A high output fluorescent lamp produces 95 lm/W.

Sunlight with high performance glazing produces 175 lm/W of heat, and **is the most energy-efficient** light source.

Note: The DoE R&D goal for LED lighting is 160 lm/W by 2025. Higher efficacies are possible for "blue" light LEDs, however, these are not suitable for general lighting.

Automatic Electric
Lighting Controls

Automatic electric lighting controls blend daylight and electric light.



Net-zero energy buildings require daylighting **as well as** automatic electric lighting controls.

In this schematic representation of lighting, in a room with stepped lighting controls, the curves show relative light levels from both daylight and electric light.

As the daylight level falls off with distance from the window, electric lighting makes up the difference so that **total illumination** is evenly maintained at design levels throughout the room.

*Source: Tips for Daylighting, LBNL, 1997

Energy Efficiency
and Large Expanses of Clear Glass

One example:

A small Chicago office building

South elevation perimeter zone

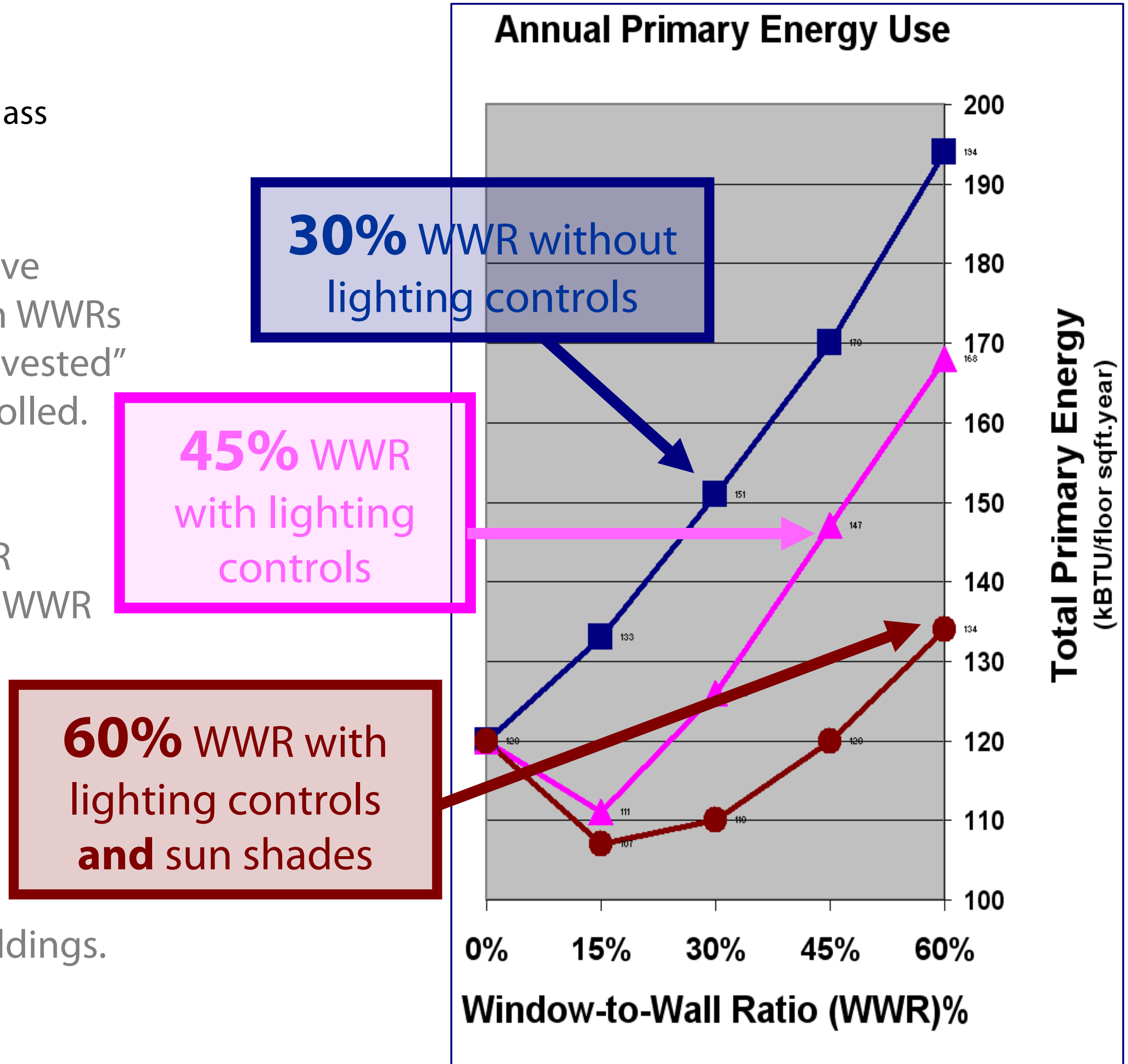
Spectrally-selective low-E clear glass

No interior shades

It is entirely possible to achieve **better** energy efficiency with WWRs above 30%, if daylight is “harvested” and artificial lighting is controlled.

Combining sun shades and lighting controls, a 60% WWR was more efficient than 30% WWR without these features.

People love large expanses of relatively clear glass, and this study proves that smart integrated design can result in efficient highly-glazed buildings.



Source: Pub LBNL-54966, Building Technologies Group, Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory

LEED®
and Daylighting

Indoor Environmental Quality (EQ) Credit 8.1
Daylight & Views - 1 point possible

Daylight 75% of spaces – Determined through one of three methods; calculation, simulation or measurement

Whitehall Ferry Terminal NYC

Indoor Environmental Quality (EQ) Credit 8.2
Daylight & Views - 1 added point possible

Achieve direct line of sight to the outdoor environment via vision glazing between 2'-6" and 7'-6" above finish floor, for building occupants in 90% of all regularly occupied areas.

Ultra-clear glass is not required to achieve these LEED points.

In fact, an Effective Aperture (EA) target of 0.30 is recommended, leading to darker glass in larger window openings, and clearer glass in smaller window openings.

EA is equal to WWR multiplied by Visible Light Transmittance (VT).

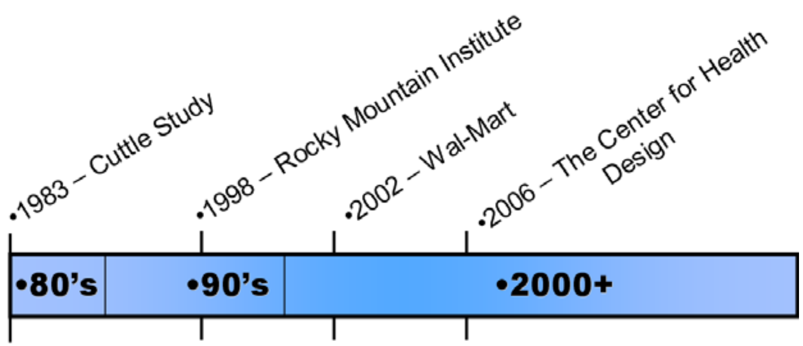
Note that building **energy efficiency,** made possible through integrated façade design, has a much more significant impact than daylight and views on LEED scores.

Based on LEED 2009
For the most current information contact the USGBC

Daylighting Studies

Cuttle Study (Office Buildings)
Excessive artificial lighting was associated with short-term stress and long-term psychological distress. 80% stated a daylit environment is “more comfortable.”

Source: “People and Windows in Work Places”



Rocky Mountain Institute (Bank Buildings)
“…increased daylight results in fewer days lost to absenteeism as well as fewer on-the-job errors.”

Source: “Greening the Building and the Bottom Line”

Christopher Cuttle found the larger the windows, the more desirable they are perceived to be, in an office environment.

Natural daylighting also provided a more comfortable environment, according to 80% of the study participants.

Another study, referenced by the Rocky Mountain Institute, looked at a new building and an existing building, occupied by the same bank.

The new building employed daylighting as one of its design features. All desks were located within 23 feet of a window, and interior louvers were used in the top 1/3 of the windows to bounce light onto office ceilings.

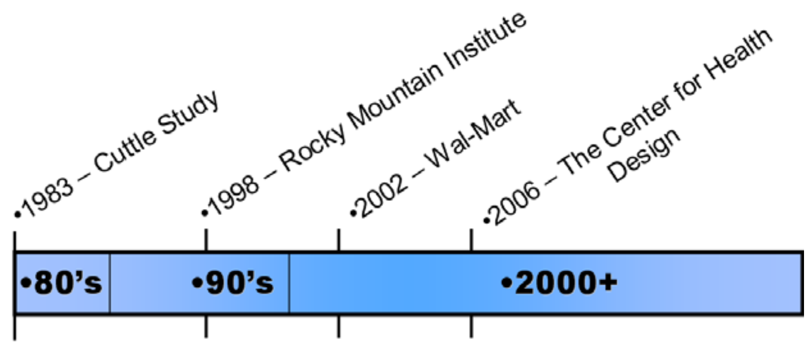
Absenteeism in the new building dropped and remains 15% lower than in the old building.

Daylighting Studies
(Continued)

Wal-Mart "Ecomart" Study (Retail)
Lawrence, Kansas

One half of the roof featured skylights. Sales per square foot "significantly" higher in daylit areas. Overall sales higher than other stores

Source: Energy Efficiency Opportunities: Big Box Retail and Supermarkets



Center for Health Design (Hospitals)
Daylight decreases hospital stay length, reduces depression, and improves sleep.

Source: The Impact of Light on Outcomes in Healthcare Settings

The Wal-Mart in Lawrence, Kansas was developed to experiment with environmentally-responsible design strategies.

The design team included daylighting as one of the strategies. In doing so, they found sales increased for the daylit areas.

As a result, many Wal-Mart locations now have skylights throughout the entire store.

The Center for Health Care noted decreased hospital stays for bipolar-depressed inpatients in east-facing versus west-facing rooms.

Reduction was an average of 3.67 days less in the hospital studied.

Another study found non-depressed patients in sunny rooms stayed in the hospital about one day less than those in other rooms.

Daylighting Strategy

An Integrated Approach

"…building decisions should be made within the context of the **whole building** as a single functioning system rather than as an assembly of distinct parts."

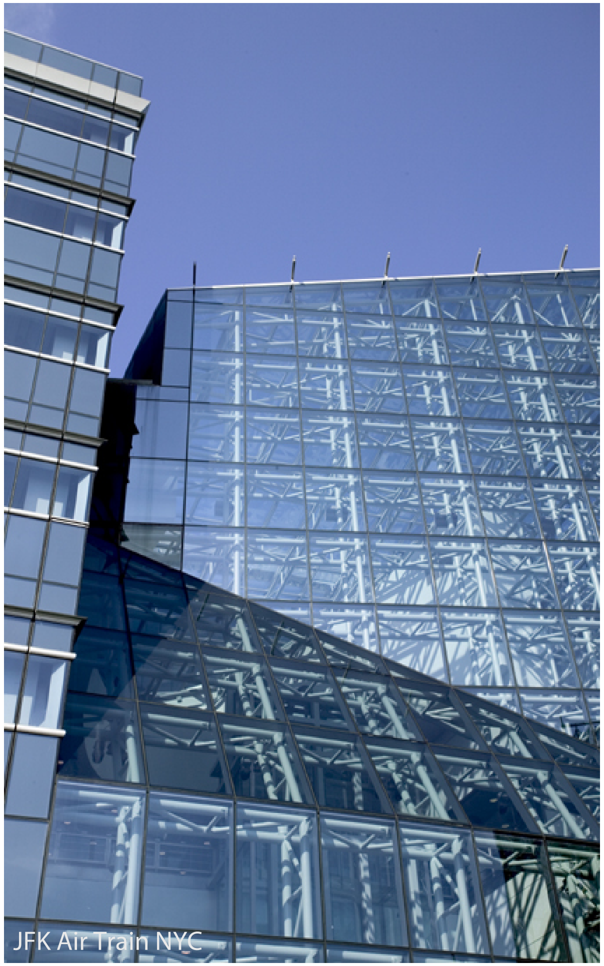
Source: "Tips for Daylighting with Windows" - LBNL

There are many ways to achieve a well-daylit building. Industry experts agree the best strategies involve balancing multiple technologies.

Sufficiently covering all technologies in one program is not feasible.

This program is focused on **glass**, and how it integrates into an effective daylighting strategy.

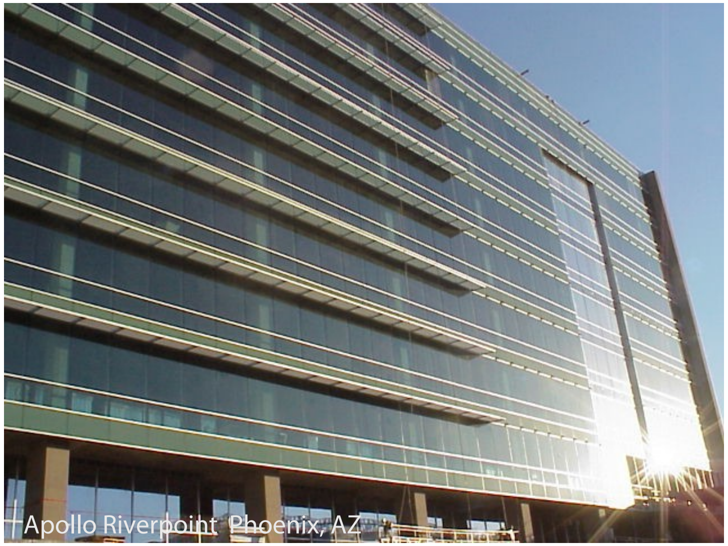
It is recommended that design professionals consult the many available publications, or organizations with daylighting expertise, such as the Windows and Daylighting Group at Lawrence Berkeley National Laboratory.



Section Two

Glass Properties

Glass Properties
and Options



U-Factor and U-Value
Solar Heat Gain Coefficient (SHGC)
Shading Coefficient (SC)
Visible Light Transmittance (VT)
Exterior reflectance
Ultraviolet transmittance
Colored substrates
Silk-screen patterns

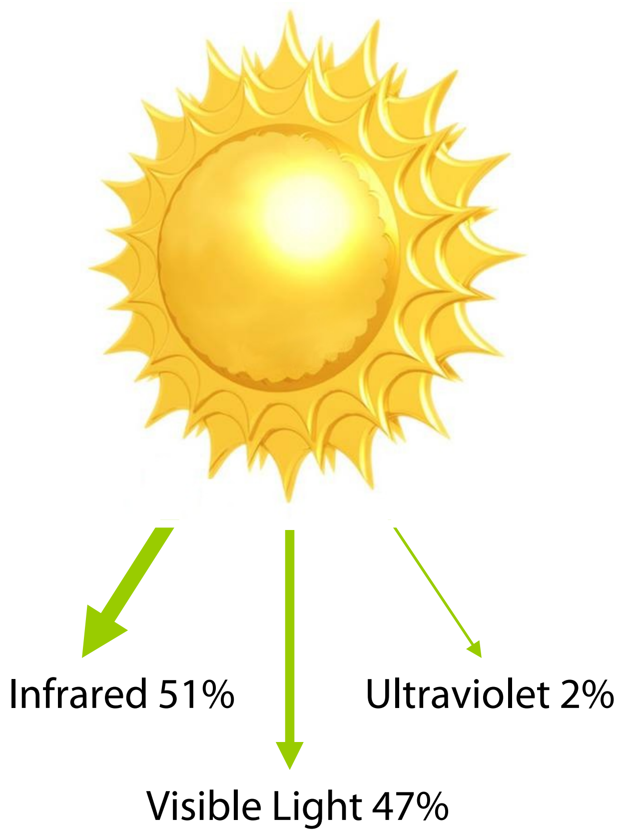
Glass options can seem endless.

It is important to understand terms such as these, used to describe glass options, which will be covered in upcoming information.

The terms are listed in no particular order, and as with designing a sustainable building, no one item is independent of the others.

Visible Light

Half of the Solar Spectrum



Visible Light Transmittance (VT, VLT or T_{vis}) is the percentage of visible daylight that the glass allows to pass.

Tinted substrates absorb a characteristic portion of the visible spectrum.

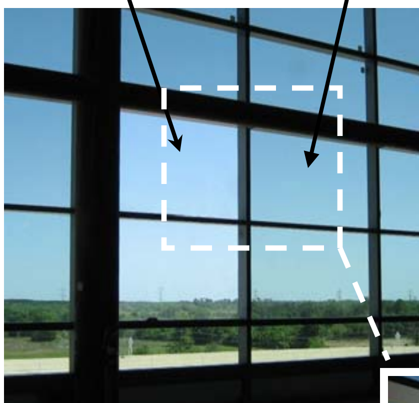
SHGC applies to the entire solar spectrum.

Both VT and SHGC are measured at normal incidence, i.e., solar radiation coming in at right angles to the plane of the glass.

Visible Light Transmittance

88% VLT
Single
Clear

62% VLT
Dual
Low-E
coated



Seemingly large differences in VLT can be subtle to the eye.

It can be difficult to tell the difference between two products that are not significantly different in color or reflectivity.

These photos were taken during construction.

The insulating glass being installed was 1" low-E coated. The exterior lite on two units was accidently broken, leaving a single ply of uncoated clear glass until replacements were available.

The visible light transmittance is 26% higher in the units with uncoated monolithic glass, yet the difference in appearance is quite minimal.

NOTE: The lower the visible light transmittance number, the darker or more reflective the glass.

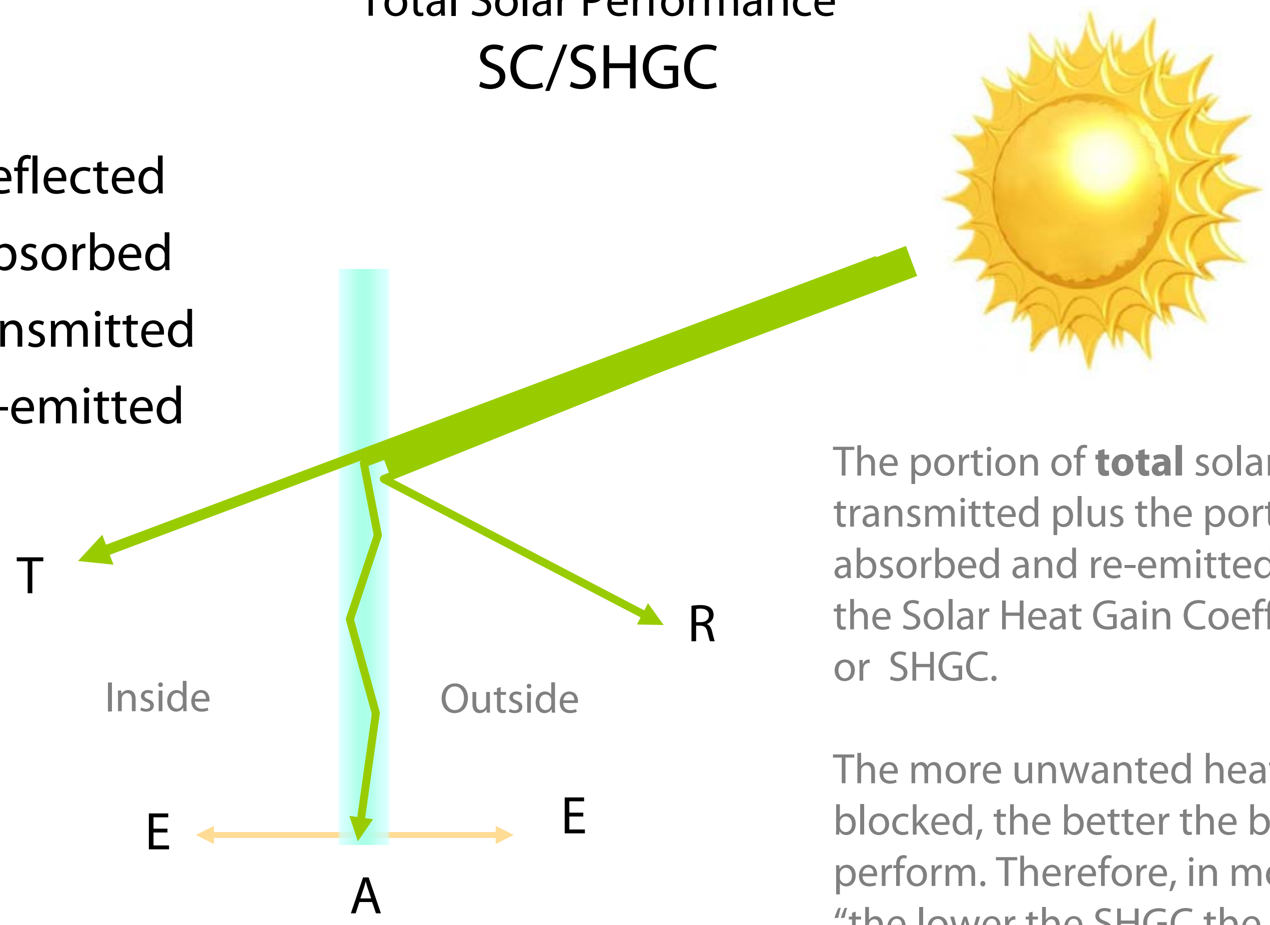
Total Solar Performance
SC/SHGC

R – Reflected

A – Absorbed

T – Transmitted

E – Re-emitted



The portion of **total** solar energy transmitted plus the portion absorbed and re-emitted determines the Solar Heat Gain Coefficient, or SHGC.

The more unwanted heat that can be blocked, the better the building will perform. Therefore, in most cases, “the lower the SHGC the better.”

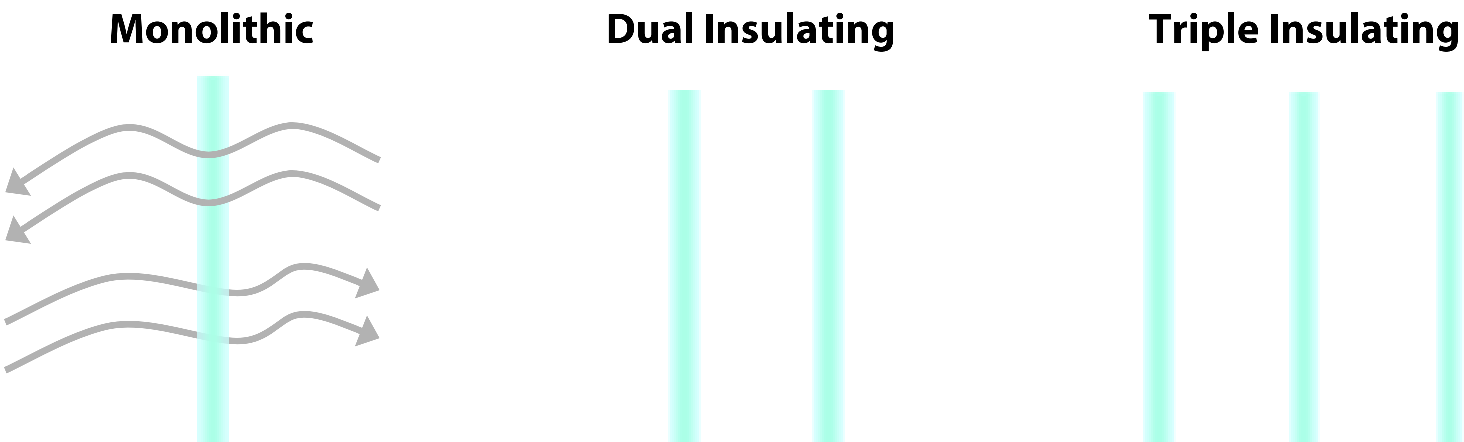
SC compares a specific glass product being reviewed to 1/8” clear glass. To convert SHGC to SC divide by 0.86, since 0.86 is the SHGC of 1/8” clear glass.

T + E = Solar Heat Gain Coefficient (SHGC)

SHGC / 0.86 = Shading Coefficient (SC)

Thermal Transmittance

Center-of-Glass U-Value



Monolithic Glass	Winter U = 1.02 BTU/hr.sqft.°F
Insulating Glass (IG) No Coating	Winter U = 0.47 BTU/hr.sqft.°F
IG No Coating with Argon	Winter U = 0.45 BTU/hr.sqft.°F
Low-E IG with Argon	Winter U = 0.25 BTU/hr.sqft.°F
Triple IG No Coating	Winter U = 0.30 BTU/hr.sqft.°F
Triple IG No Coating with Argon	Winter U = 0.28 BTU/hr.sqft.°F
(2) Low-E's Triple IG with Argon	Winter U = 0.13 BTU/hr.sqft.°F

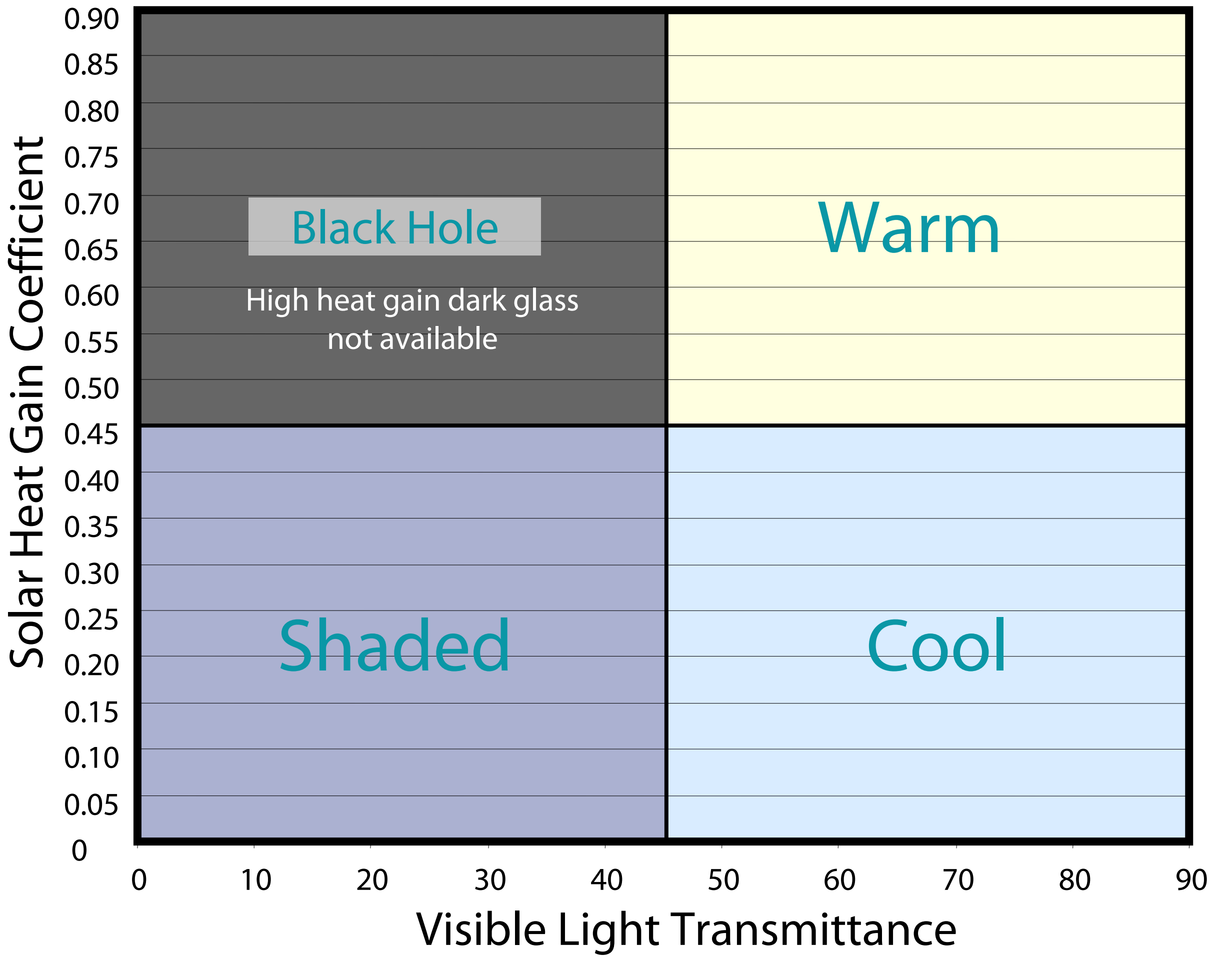
U-Value is measured at center-of-glass.
U-Factor is overall unit performance, with edge-of-glass and frame effects included.

U-Value is a measure of heat flow per unit time, area, and temperature difference. "Smaller is better."

U-Factor is the reciprocal of R-Value.

Unlike SHGC, U-Value is relatively independent of appearance.

Daylight Types



The grid shown here will be used to provide a graphic representation of the various daylight types. The vertical axis of the grid shows the Solar Heat Gain Coefficient while the horizontal axis shows the Visible Light Transmittance. The lowest values are the in the lower left corner and the values increase as you move **up** and to the **right** on the grid.

Warm Daylight

Typically high VLT,
with third surface low-E coatings,
or uncoated glass

Common **warm daylight** product applications:

Punched Openings
Historic Renovation
Storefront or Podium Level Wall
Point-supported Laminates
Low-rise Residential

As the name implies, warm daylight glazing allows significant solar heat gain.

In commercial and institutional buildings, these uncoated clear glass products, or third surface low-E coatings, are used only in limited areas, where heat gain is of secondary importance.

NOTE: Glass surfaces are numbered from the outside to the inside.

Shaded Daylight

Typically reflective coatings or silk-screen patterns, combined with other coatings or dark glass colors

Wyoming (MI) Police

Shaded daylight options provide great daytime protection from the sun, however at night, the glass can actually have a fairly high view, from the exterior in.

As the name implies, shaded daylight glazing minimizes solar heat gain, at the expense of visible light transmission.

This may be a viable trade-off in certain commercial and institutional buildings, especially in warm climates, or where interior lighting controls are not employed.

Cool Daylight

Cool daylight is a great place to start for sustainable "whole building design"

There are **many product options**. Narrow down the selection with performance or appearance criteria

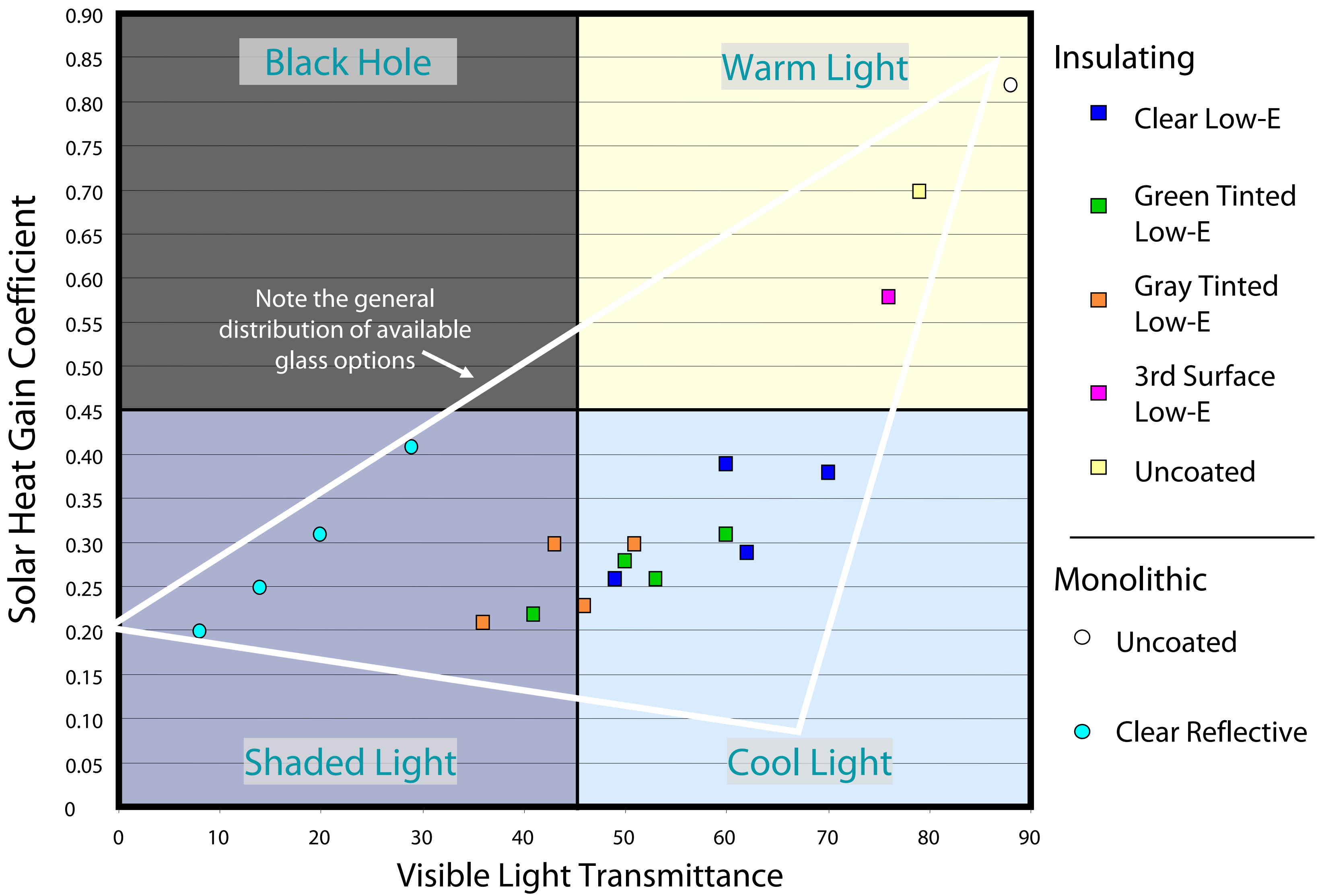
High Visible Light Transmittance > 45%
with
Low Solar Heat Gain Coefficient < 0.45

With the right "whole building" integrated design, cool daylighting products provide an excellent balance between light and heat.

Dozens of coating and glass combinations allow designers flexibility in color and reflectivity, while optimizing solar-optical performance to site, climate and building use.

Daylight Types

Available Glass Options



Daylight Types

Summary

Daylight Type	Visible Light Transmission **VT** or **VLT**	Solar Heat Gain Coefficient **SHGC**
Warm	High	High
Shaded	Low	Low
Cool	High	Low

With the right "whole building" integrated design, cool daylighting products provide an excellent balance between light and heat.


Armstrong World Industries

Section Three

Window Size and Configuration

Window Size and Configuration

Use **north- and south-facing vision glass**.

East- and west-facing vision glass introduces glare control issues.

Effective Aperture (EA) = WWR x VT
EA target = 0.30

Small, high-transmission windows, or large, low-transmission windows

Optimize glass selection by elevation, using clear substrates and coatings on north-facing façades, and “darker” glass on south, east and especially west façades.

Use darker glass in large view windows; use clearer glass in transom lites.

The concept of “effective aperture” can be useful in assessing the relationship between visible light and window size. Start with an EA of about 0.30 on the north and south elevation, minimizing glazing on the east and west whenever possible.

Look at the building program closely as it relates to natural daylighting. Make the need for daylight access a factor in laying out floor plans and assigning perimeter space.

Window Size and Configuration

All-glass façades can be designed with low WWR.

UPenn English House
Operable aluminum windows
WWR approximately 80%

ASU Communications Building
All-glass aluminum curtainwall
WWR approximately 15%

Only vision area and adjacent framing "counts" in calculation of glazed area percentage.

Windows can have high WWR, and curtainwall can have low WWR.

WWR is calculated from vision glass area only – Highly insulated spandrel glass areas do not "count" toward glazed area. This opens up many aesthetic possibilities for the envelope design.

Don't forget that silk-screened frit patterns in vision areas can drastically reduce solar heat gain, while still allowing for clear glass and natural daylight, and often creating interesting visual effects with direct sun and shadow.

Window Size and Configuration

For effective use of natural daylight:

High ceilings and tall window head heights - Daylight penetration is 1.5 times head height, 2.0 times with light shelves

Minimize vision area below sill height unless "downward" view is important

Add high-transmission transoms and clerestory windows

Atria and light wells

Clerestory windows can be used to increase the effective height of transom lites without increasing window-to-wall ratio (WWR).

Even relatively low WWR provides **more** than ample natural daylighting, if properly oriented and directed.

While tall conventional windows may work well in providing natural daylight to "shallow" perimeter offices, more complex strategies are necessary to achieve daylighting in "deep" south-facing spaces.

Strip windows work well to add uniformity to daylight in open plan perimeter spaces. Evenly distributing light is more difficult with punched opening windows.

In general, window area should be no different in a daylit building than in a conventionally-lit building.

Window Framing

Materials

Thermal barrier aluminum frames are durable and capable of long spans

Contain no toxic materials

Operable windows provide natural ventilation for occupant control

Lifetime, eco-friendly surface finishes are available; organic or anodic

Aluminum remains the framing material of choice for non-residential applications, when all design requirements are considered in balance.

Of course, there are many vinyl and fiberglass residential windows vying for market share, some making unrealistic claims regarding R-Value, and applicability to commercial and institutional projects. Consider ALL factors - from structural integrity to longevity to stiffness to heat build-up - before deciding on alternative materials.

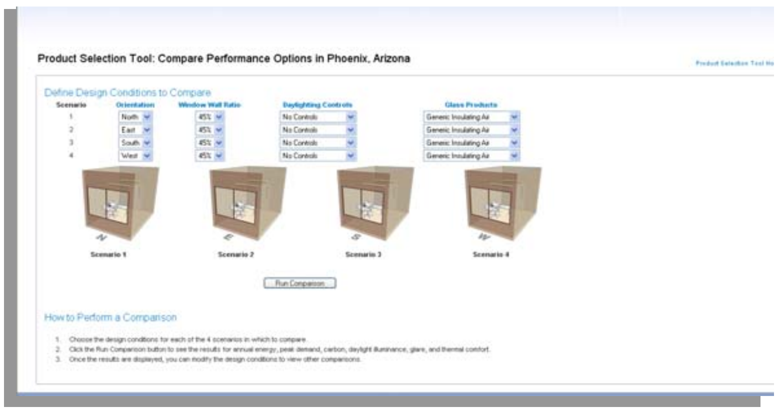
Systems using conventional thermal barrier aluminum window and curtainwall frames can achieve overall U-Factors below 0.20 (R-5), meeting needs for best-in-class envelope performance in any Climate Zone.

Analysis of

Alternatives

Always consider solar heat gain along with conductive heat loss in façade design (SHGC a**nd** U-Factor).

Whole-building energy modeling facilitates integrated design.



Use the Department of Energy Lawrence Berkeley National Laboratory's **COMFEN** software for easy façade optimization.

Leading manufacturers have developed selection tools based on DOE energy modeling software.

These tools guide design professionals through the available options, and optimize product selection, for the specific application and Climate Zone of their project.


Rainbow Bridge Customs

Section Four

Exterior Sun Shades

Interior Light Shelves

Sun Control

Sun Shades

Exterior shading devices designed to reduce solar heat gain and glare, while allowing natural daylight into the building

Light Shelves

Horizontal devices installed onto the interior of a window opening to redirect and redistribute natural light into the interior space of the building

Exterior sun shades and interior light shelves soften the light entering near the window and **redirect daylight deeper into the space**.

Exterior

Sun Shades

Primary benefits of exterior sun shades include added diffusion of sunlight, with reduced SHGC, glare, and cooling energy consumption.

Dramatic impact on building appearance

Secondary benefits can include increased occupant satisfaction and productivity, through comfort and increased light shelf performance.

Permanent shading projections reduce SHGC, by using a simple multiplier based on “Projection Factor” (PF), equal to the horizontal shading depth divided by the window height.

PF can be adjusted for louvered sun shades at any given solar altitude and azimuth position, but is typically calculated for mid-summer solar angles.

Exterior sun shades reject solar heat gain before it can impact building HVAC loads.

They can also be designed to “bounce” or redirect a portion of the incident light through a transom lite above the sun shade, as a natural daylighting strategy under clear sky conditions.

Fixed “brise soleil” sun shades are most effective on south-facing walls. Operable exterior sun shades introduce durability and maintenance concerns.

Sun Shade Types

Extruded blades:

Aerofoil

No-perch trapezoids

Round tubes

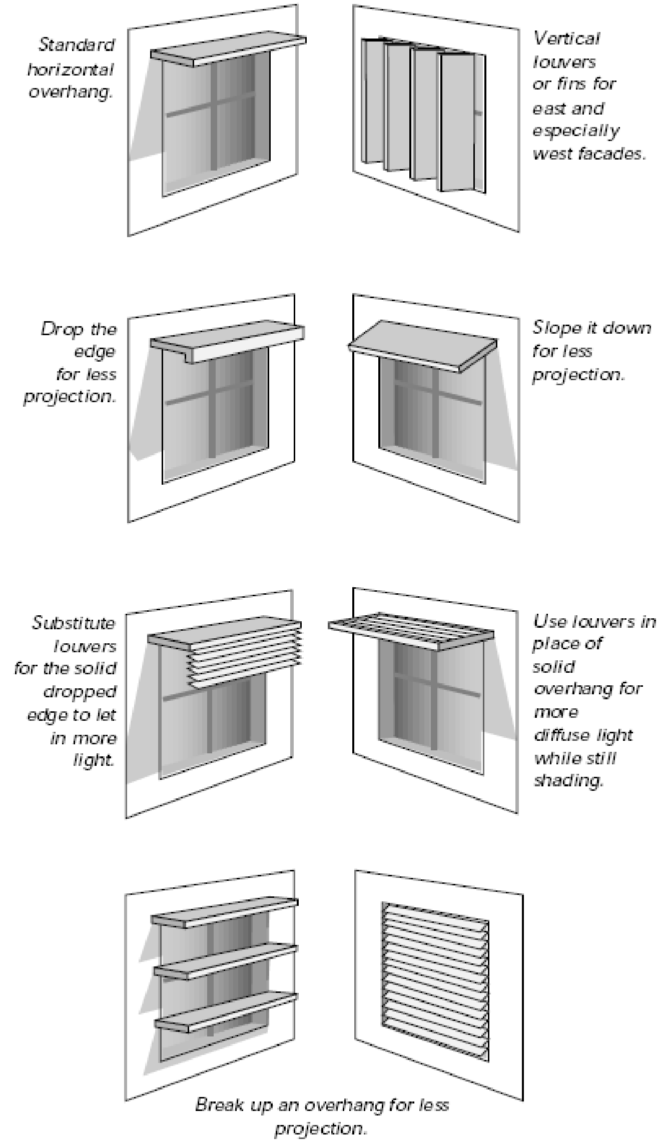
Zee blades

Perforated sheet

Catwalk grids

Solid shading

Unlimited creative choices



Graphic: Tips for Daylighting, LBNL, 1997

Sun Shades

Cautions

Sun shades are a relatively expensive means of controlling sunlight.

Consider glass coatings with a low SHGC as an alternative

Sun shades can inhibit access and add to cleaning and maintenance costs.

Sun shades **will** collect **snow and ice** – Protect areas below

Rigging for swing stages will need provisions to cantilever beyond the sun shades, and there is a risk of the equipment damaging the sun shades. Although sunshades are designed to handle incidental point loading by personnel, they cannot be economically designed to deal with impact loading of heavy equipment.

Sunshades are subject to buildup of snow, rime ice, and icicles. Eventually these **will** loosen and fall.

The pictures at left show a buildup of snow that fell on a canopy below. The canopy provided marginal protection, however, it could not be expected to handle the impact load of falling snow and ice.

Interior

Light Shelves

In conjunction with automatic lighting controls, light shelves can reduce building energy usage.

Depth varies, depending on transom height and perimeter room floor plan

Armstrong World Industries

Improved **daylight penetration** and distribution

Increased occupant satisfaction and productivity with natural daylight

Light shelves are horizontal projections below transom lites, used only on **south-facing** windows.

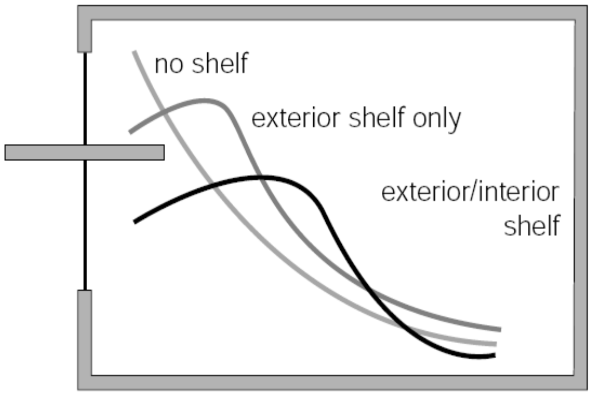
The top is provided with a diffuse light-colored surface, such as clear anodize or white paint. The underside is available in numerous finish options.

Light Shelves

Design Tips

A conventional window can daylight an interior space to a depth approximately **1.5 times** the window head height.

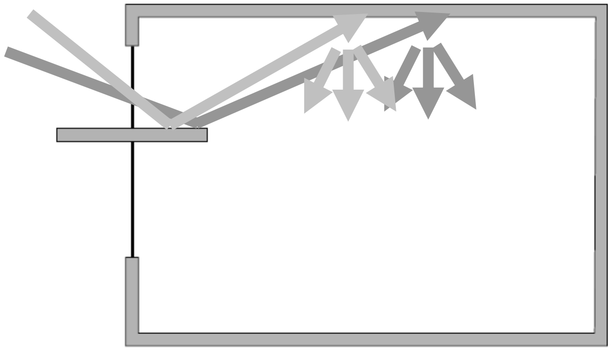
Daylighting systems such as light shelves can increase penetration to **2.0 or more times** the window head height, and improve light distribution.



A light shelf improves distribution of daylight. Notice the softer gradient with a light shelf.

The work plane near the window will see lower daylight levels, while the work plane further from the window will see higher daylight levels.

No unlike light bulbs, a dirty light shelf is an inefficient light shelf. They must be kept free of dust build-up.



Light shelves are usually not designed to support books, or other externally-applied loads. Deep light shelves can create a darker, somewhat intrusive, overhead projection.

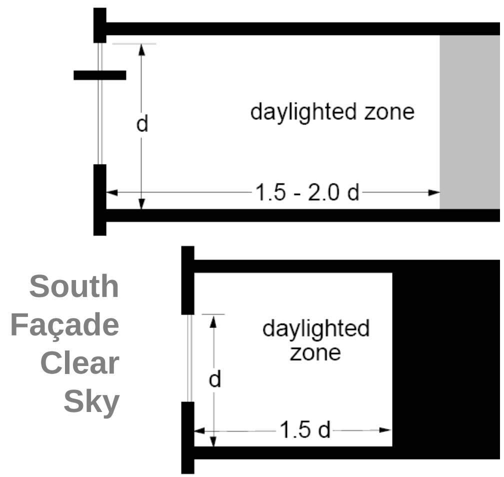
Graphics: Tips for Daylighting, LBNL, 1997

Light Shelves

Design Tips

Light shelves are most effective for relatively **clear** climates, at **mid-latitudes**.

They should only be used on **south-facing** façades.

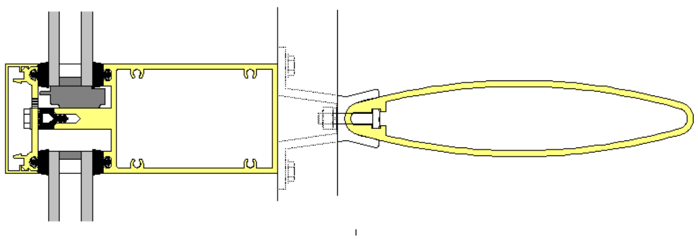


Depth should be roughly equal to the height of the clerestory window above the shelf.

Bright white paint or clear anodized finishes for the top surface will maximize performance

Graphic: Tips for Daylighting, LBNL, 1997

Light shelves result in reduced daylight factor on the work plane, near the window. The reduction in work plane illuminance is partly because of the extra obstacle in the light's path and partly a shifting of light to the interior.



A light shelf is just one component of a daylighting system. It can, depending on its design, location on the building, and the building's location on the planet, perform more than one task of a daylighting system. In only very limited situations will it provide all that is needed for successful daylighting.

A complete daylighting system provides shading from direct sunlight, glare protection, and daylight redirection.

The Clarendon Boston

Section Five

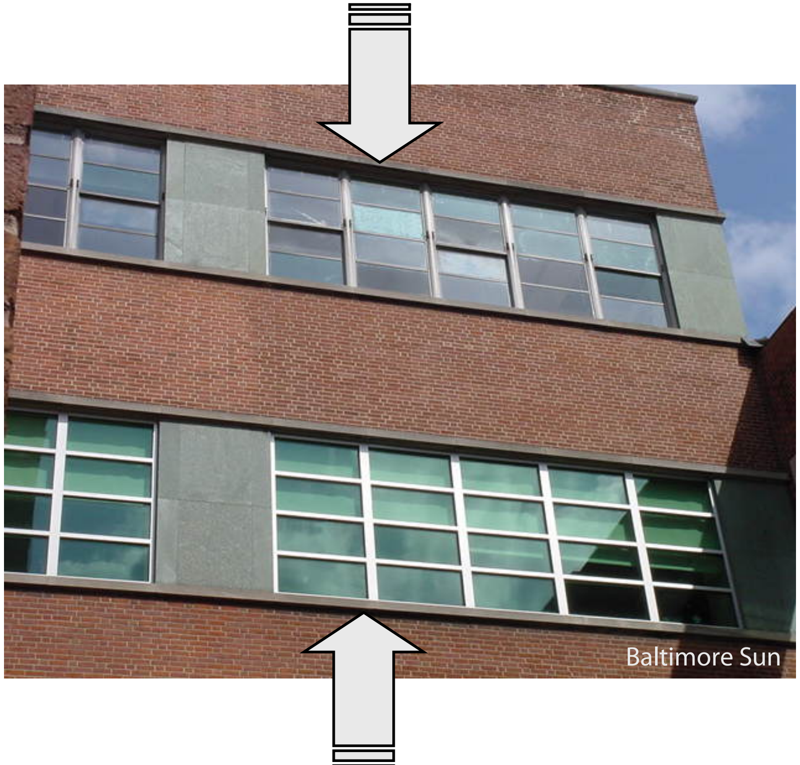
Glass Selection for Integrated Façade Design

Integrated Façade Design

Glass Selection

One case study:

A poor choice of glass led to applied film, and a "checker board" appearance.



Replacement glass selected with appropriate VLT improved the work environment.

Avoid glass that is "too dark" or "too light" for the site, climate and occupancy.

Low VLT dark glass exhibits lower SHGC, offers more privacy, and hides interior treatments. It can also disguise unoccupied spaces, but may require a larger percentage of vision area or increased artificial lighting

High VLT clear glass opens the work environment, providing full spectrum light. This means less artificial lighting and improved view. Clear glass usually requires glare control, as well as secondary privacy provisions.

Integrated Façade Design

Glass Selection

Don't forget the "practicalities" of architectural glass selection in façade design.

Baltimore Sun

Avoid glass lites that are too large, too small, or outside of conventional aspect ratio limits.

Glass lites that are too large for efficient manufacture and installation are costly. Optimum glass sizes are 30 to 40 square feet. Insulating glass units over 50 square feet require heat treatment.

Coating and heat treatment equipment limitations can come into play for oversized glass, which adds initial cost and makes replacement very expensive.

Equipment limitations apply to glass lites that are too small as well. Small lites also incur minimum "per piece" costs, reduced thermal performance for insulated glass units, and increased framing and labor costs. Cost per square foot can increase tenfold.

Glass lites with aspect ratio greater than 5:1 have an increased probability of breakage.

"Whole Building" Design

Attention to detail, in the careful selection and application of façade elements, will make a dramatic difference in building performance.

The façade, structure, and mechanical systems are critical, inter-dependent, systems in creating the "whole building" concept.

Interfaces between materials are key to overall building performance.

The façade design, materials, and components should be selected and optimized based on Climate Zone, building usage, and HVAC design requirements.

A high-performance glass in a low-performance framing system, or vice versa, reduces the benefit of the better product.

Variations in the plane of temperature gradients, vapor retarders, air barriers, and water seals, can over-complicate the wall design, and increase the risk of failure.

For long-term integrity over the building's life, the environmental and adjacent conditions, product durability, materials, and finishes, should all be considered during design stages.

Consider maintenance, repair, and replacement in façade design.

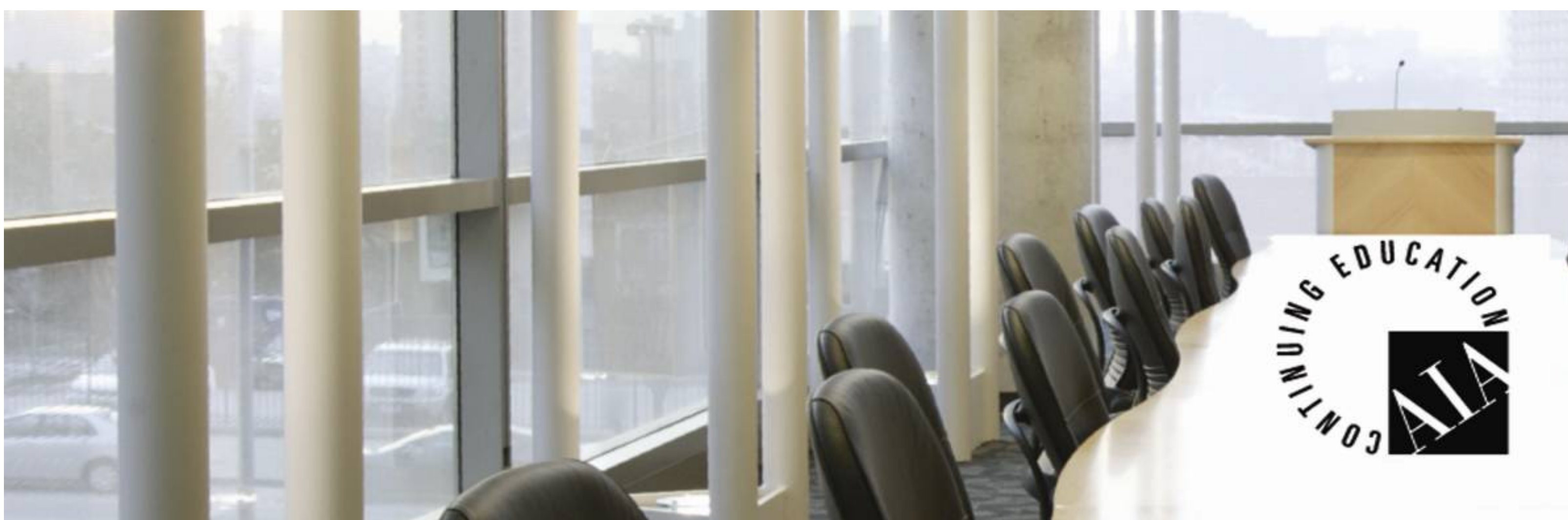
Section Six

Summary

DAYLIGHTING
and Integrated Façade Design

Learning Objectives

1. Identify the key variables, components, and benefits of Integrated Façade Design
2. Analyze glazing by "Daylight Types"
3. Discover how Integrated Façade Design can create successful daylighting with greater than 30% Window-to-Wall Ratio (WWR)
4. Describe appropriate window size and configuration for use with sun shades and light shelves



For buildings using windows or curtainwall as design elements, it is important to consult with an experienced manufacturer early in the process. Teamed with a reputable, local glazing subcontractor, manufacturers can provide design input, budget pricing, sequencing, and schedule information that will prove invaluable to the design team.

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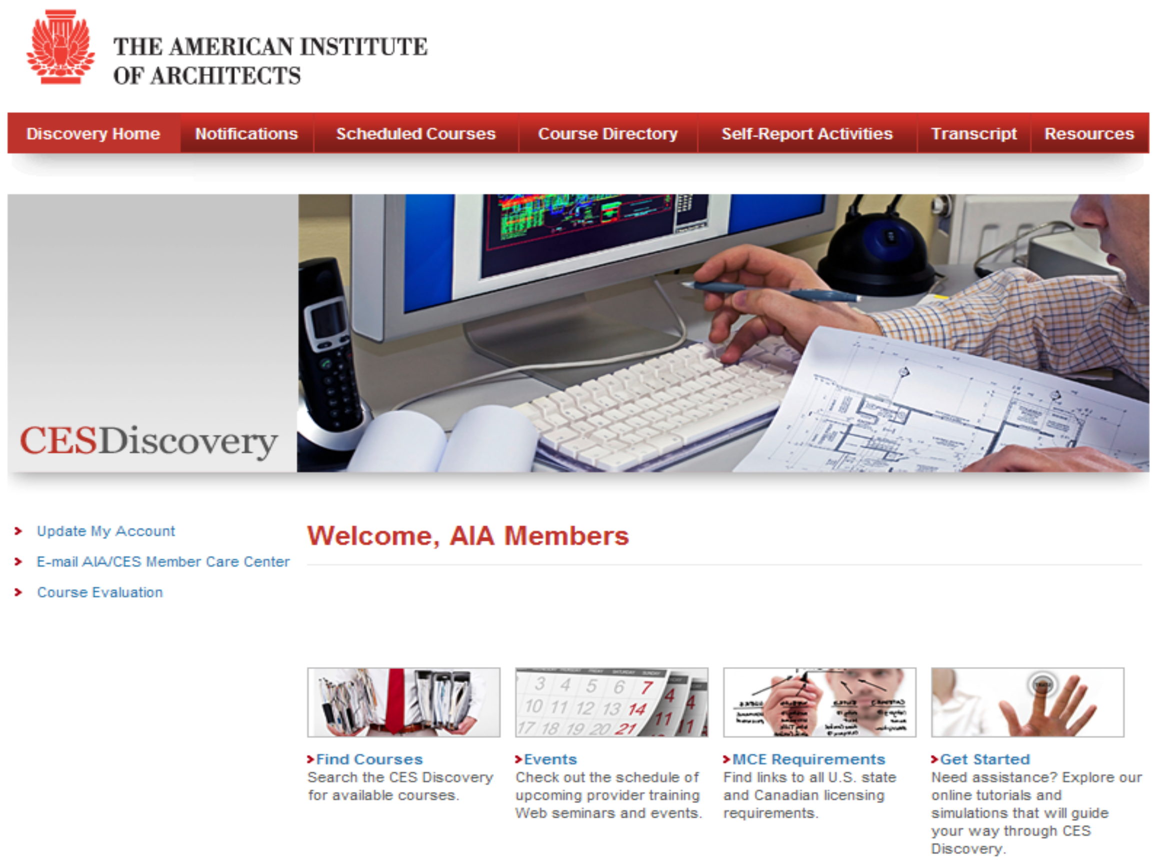

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