Daylighting strategies

Passive | Active

Submitted by,

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**Daylight**

Definition - Daylight or the ‘light of day’ is the combination of all direct and indirect sunlight outdoors during the daytime. Daylight is highly variable and varies with location, time and season. Both daylight and electric lighting control systems will be needed from time to time to adapt the lighting systems to the changing external light conditions.

The condition of ambient Daylight changes not only during the daylight hours but also changes drastically with the passing seasons.

<table>
<thead>
<tr>
<th>Illuminance</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>120,000 lux</td>
<td>Brightest sunlight</td>
</tr>
<tr>
<td>110,000 lux</td>
<td>Bright sunlight</td>
</tr>
<tr>
<td>20,000 lux</td>
<td>Shade illuminated by entire clear blue sky, midday</td>
</tr>
<tr>
<td>10,000 - 25,000 lux</td>
<td>Typical overcast day, midday</td>
</tr>
<tr>
<td>&lt;200 lux</td>
<td>Extreme of darkest storm clouds, midday</td>
</tr>
<tr>
<td>400 lux</td>
<td>Sunrise or sunset on a clear day (ambient illumination).</td>
</tr>
<tr>
<td>40 lux</td>
<td>Fully overcast, sunset/sunrise</td>
</tr>
<tr>
<td>&lt;1 lux</td>
<td>Extreme of darkest storm clouds, sunset/rise</td>
</tr>
</tbody>
</table>

Daylight entering into a built-form is not only accounting for the general Illuminance levels within the space but also accounts for some amount of heat gain, due to the solar radiations. In fact all sources of light, emit heat. Thus it is imperative that we understand the luminous efficacies of all sources of light either natural daylight or artificial lighting systems that run on electricity as a source of energy.
Research has shown that daylight is one of the most efficient sources of light, with the highest luminous efficacy.

Daylight has a strong impact not only on the performance of the built-forms in terms of their energy consumption but also has a deep impact on the occupant of these buildings. Some of the advantages of providing adequate daylight into a space is listed below.

**Human Psychology**

- **Effective stimulant to the human visual and the circadian systems.**
- **Daylight and external views are much desired.**
- **Increased User Productivity.**
- **Improve occupant satisfaction with indoor environment.**
**Energy Consumption**

- High luminous efficiency compared to artificial light,
  Reduction in cooling loads.
- Improved Life-Cycle Cost.
- Reduced Operating Costs, coincident peak electrical demand
- Reduced Emissions (reduced energy consumption)

**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.

**The aims of proper daylighting design**

- Bringing daylight to an occupied space
- Reduction of glare
- Balancing of heat gain and loss
- Adjusting to the variations in daylight availability

The built-forms are static components in daylighting, while the sun (source of daylight) is the most powerful and dynamic light source of all-whose useful daylight must be captured and distributed. To harness direct and reflected daylight and get it into the building where it's needed, we have transmission media, which include windows, glazing, skylights, light shelves, baffles, blinds, interior
surfaces and other media that directs, diffuses and reflects the sunlight. These daylighting systems capture and transmit daylight from the external into the internal spaces of the building.

**Capturing sunlight** - Capture daylight on a building’s roof or sidewall either *passively* (stationary/Fixed) or *actively* (mechanisms that tracks the angle of the sun throughout the day) using opaque surfaces or mirrored/prism elements.

**Transmitting sunlight** - The daylight captured on the roof or sidewall is transmitted into the desired area

1. **Directly by redirecting sunlight into a space using architectural features**

2. **Indirectly through tubes using mirrors to enhance light transmission or through fiber optics.**
## Daylighting Strategies in buildings

### Systems matrix

<table>
<thead>
<tr>
<th>Category</th>
<th>Type/name</th>
<th>Sketch</th>
<th>Climate</th>
<th>Location</th>
<th>Criteria for the choice of elements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gruve projection</td>
</tr>
<tr>
<td>1A</td>
<td>Primary using diffuse skylight</td>
<td><img src="image" alt="Prismatic panels" /></td>
<td>All climates</td>
<td>Vertical windows, skylights</td>
<td>D</td>
</tr>
<tr>
<td>1A</td>
<td>Prisms and venetian blinds</td>
<td><img src="image" alt="Sketch" /></td>
<td>Temperate climates</td>
<td>Vertical windows</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>Sun protecting mirror elements</td>
<td><img src="image" alt="Sketch" /></td>
<td>Temperate climates</td>
<td>Skylights, glazed roofs</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Andoic zenithal opening (→ 4.12, 4.13)</td>
<td><img src="image" alt="Sketch" /></td>
<td>Temperate climates</td>
<td>Skylights</td>
<td>Y</td>
</tr>
<tr>
<td></td>
<td>Directional selective shading system with concentrating Holographic Optical Element (HOE) (→ 4.11)</td>
<td><img src="image" alt="Sketch" /></td>
<td>All climates</td>
<td>Vertical windows, skylights, glazed roofs</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td>Transparent shading system with HOE based on total reflection (→ 4.11)</td>
<td><img src="image" alt="Sketch" /></td>
<td>Temperate climates</td>
<td>Vertical windows, skylights, glazed roofs</td>
<td>D</td>
</tr>
</tbody>
</table>

## Shading Systems

<table>
<thead>
<tr>
<th>Category</th>
<th>Type/name</th>
<th>Climate</th>
<th>Location</th>
<th>Criteria for the choice of elements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Game protection</td>
</tr>
<tr>
<td>1B</td>
<td>Primary using direct sunlight</td>
<td>Light guiding shade (→ 4.7)</td>
<td>Hot climates, sunny skies</td>
<td>Vertical windows above eye height</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Louvres and blinds (→ 4.4)</td>
<td>All climates</td>
<td>Vertical windows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Light shelf for redirection of sunlight (→ 4.3)</td>
<td>All climates</td>
<td>Vertical windows</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Glazing with reflecting profiles (Okasolar)</td>
<td>Temperate climates</td>
<td>Vertical windows, skylights</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skylight with Laser Cut Panels (LGP) (→ 4.7)</td>
<td>Hot climates, sunny skies, low latitudes</td>
<td>Skylights</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Turrnate lamellas</td>
<td>Temperate climates</td>
<td>Vertical windows, skylights</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Andolic solar blinds (→ 4.13)</td>
<td>All climates</td>
<td>Vertical Windows</td>
</tr>
</tbody>
</table>

Y = Yes, D = Depends, N = No, A = Available, T = Testing phase, "→ n" = See section number n
From the matrix above it is clearly seen that although passive fixed daylighting systems form a majority of the presently available and widely used systems, active systems involving digital controls operating a mechanical system through a predefined
ALGORITHM OR CONTROLLED ACTIVELY BY SENSORS TO TRACK THE
MOVEMENTS OF THE SUN THROUGH THE DAY AND THROUGH THE SEASONS OF
THE YEAR. THESE ACTIVE SYSTEMS HAVE BEEN SHOWN TO IMPROVE THE
OVERALL BUILDING PERFORMANCE AND THE DAYLIGHTING OF INTERIORS OF A
BUILT-FROM.
Daylighting - Passive strategies in Buildings

- Side lighting
  - Windows
  - Clerestories
  - Top lighting
  - Skylights
  - Roof monitors
  - Light-wells/tubes

- Overhangs and canopies
- Continental shutters and awnings
- Light shelves
- Horizontal louvers
- Vertical Louvers/fins
- Egg crate louvers
- External and internal roller blinds

Side lighting - Limitations

- Low winter sun angles, solar cut-off angle issues
- Varying sky conditions
- Reduced resource at higher summer sun angles, unable to light deep floor plates
- Orientation variations cause variation in lighting levels within the space
- Non uniform distribution of daylight
**Top lighting – Limitations**

- Peak solar heat gain occurs during summer months, adds to the peak cooling load
- Minimal solar heat gain during winter months, with corresponding greater heat loss
- Limited to upper floor of a building
- Roof openings prone to leaks

**Overhangs – Limitations**

- Poor summer performance
- Poor glare control

**Light shelves – Limitations**

- Obtrusive
- Medium daylight distribution (1-1.5x daylight zone)
- Winter glare (cut-off angle) issues

**Shades and blinds – Limitations**

- Poor daylight distribution,
- Manual operations under occupant controls, limited active participation by users leads to closed blinds even with favorable external lighting conditions causing increased use of artificial lighting.
Heliostats and tracking devices

A heliostat (from ‘Helios’, the Greek word for sun, and ‘stat’, as in stationary) is a plane or dish-shaped mirror/reflecting device that focuses sunlight onto a stationary second mirror or space. It dynamically re-adjusts the primary mirror to track the sun and maximize the capture and use of sunlight at all times of the day. The heliostat accomplishes this with the help of light sensors, pulse motors and a computer program that tracks all of the variables involved in following the sun. Once the light is captured, it is distributed, often with a light pipe.

Advantages

• Higher quality daylight
• Fewer holes in the roof
• Ability to engage low morning and evening sun, and also works well with the low winter sun angles
• Introduction of thermal barriers and diffusers can mitigate some of the issues related to these systems

Limitations

• Partial or complete obstruction of view to the outside
• Can produce extremely bright lines along the slats, causing glare issues
• Daylight may be reflected off the glossy slat surface directly into the field of view, adding to the glare problems
Adaptive Façade systems

Adaptive Façade systems are kinetic façade systems which physically adapt to changes in daylight, solar gain, airflow, and privacy by altering their configuration.

These Façade systems are automated, electronically controlled and mechanically operated, usually are linked to sensors that measure both internal and external ambient conditions not restricted to lighting levels to regulate façade for optimum performance.

Adaptive façade system technology has been adopted into the simple daylighting strategies such as

- Louvers
- Venetian blinds
- Roller blinds
- Light Shelves

New and emerging technologies such as

- Emergent surfaces
- Heliotrace (dynamic vertical and horizontal louver system)
- ADAPTIVE Fritting
- Permea
- Fluidic muscle technology
- Bio skins
- Philips Daylight Concept Active Glass
  [http://wn.com/Philips_Daylight_Concept_Active_Glass_Simplicity_Event_07](http://wn.com/Philips_Daylight_Concept_Active_Glass_Simplicity_Event_07)
Limitations

- These systems are technology driven and require a lot of systems integration and commissioning to be integrated into the building systems to enable them to perform optimally.

- Potentially new emergent technologies have never been field tested although life scale laboratory tests and simulation have validated their performance there might be a lot of integration issues that might need constant maintenance.

- Requires dedicated personal with adept knowledge of the systems to trouble shoot any small glitches in the working of the system.

- High costs are definitely a deterrent in widespread adaptation of these systems.

Louvers and Blinds Systems

Louvers and Blinds are one of the classic daylight systems that can be applied for solar shading, to protect against glare and to redirect daylight. Louvers are generally situated on the exterior of the façade whereas blinds are fitted inside or between the glazing.

Blinds are composed of multiple horizontal, vertical or sloping slats. These slats are usually made of galvanized steel, anodized or painted aluminum or plastic (pvc) for high durability and low maintenance.
Limitations

- Partial or complete obstruction of view to the outside.
- Can produce extremely bright lines along the slats, causing glare issues.
- Daylight may be reflected off the glossy slat surface directly into the field of view, adding to the glare problems.

Applications

In U.K., a study was conducted to determine the type of louvers and blinds to be used on the different facades of the building on the basis of the orientation of the windows.

<table>
<thead>
<tr>
<th>Performance</th>
<th>ACB</th>
<th>RB</th>
<th>VLB</th>
<th>HLB</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td>*</td>
<td>**</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>East</td>
<td>**</td>
<td>**</td>
<td>*****</td>
<td>***</td>
</tr>
<tr>
<td>West</td>
<td>**</td>
<td>**</td>
<td>*****</td>
<td>***</td>
</tr>
<tr>
<td>South</td>
<td>****</td>
<td>**</td>
<td>*</td>
<td>*****</td>
</tr>
</tbody>
</table>

**** = very good
**** = good
*** = average
** = poor
* = very poor

ACB – Awnings/Canopy Blinds
RB – Roller Blinds
VLB – Vertical Louver Blinds
HLB – Horizontal Louver Blinds
Light guiding - Louvers and Blinds Systems

Light Louver Daylighting system

A fixed light guiding louver system designed to be used in the clerestory part of the window and on the internal side of the glazing. It directs incident sun light at all the angles towards the ceiling.

When used in conjunction with a reflective ceiling material, it facilitates the daylight to permeate deep into the space, thus decreasing the use of electric lighting and thereby decreasing the cooling loads.

Limitations

• A separate daylight control system needed for the sunlight entering the space through the vision glazing.

• If used on the vision glazing, it would completely obstruct the view to the outside.

Okasolar Panel

A fixed light guiding louver system fitted between the glazing panes.

Due to its tridimensional direction-selective mirror profiles, Okasolar reflects high-angled sunlight and aims low-angled and diffuse daylight towards the ceiling, bringing it deeper in the room without any moving components.

As a fixed system, its predetermined design will condition its optimal application, typically a placement in vertical windows and skylights in temperate climates.
Limitations

• The geometry of the louver cross section allows partial transparency dependent on viewing direction (the distance between louvers is 17mm (0.67’)).

• Its capability to protect from glare can be insufficient in some particular applications.

Ecklite Panel

An operable light guiding louver system fitted in-between or on the internal side of the glazing panes.

The DS Ecklite Evolution is a zoned system – in the upper part of the glass it relies on louvers with a concave section for active light re-direction and in the vision area it uses louvers with a convex section for solar and glare control.

The main objective of these light-redirecting blinds is to provide light control combined with good vision through the system, which allows the blinds to remain mostly open.

A gradual adjustment of the blinds is possible, which allows multiple louvers to be moved simultaneously, either individually or in groups, as a function of sun angle and lighting conditions.

The system can be automatically operated via a switch or a remote control.
Appendix

Sundolier
http://www.sunflowerdaylighting.com/

SunTracker
http://giralight-europe.com/flash/giralightDemo.htm
Raytracing diagram illustrating performance under all sun angles

**Daylight Glazing**
- HIGH V₁
- LOW SC

**LightLouver Units**
- 100% SOLAR CONTROL
- GLARE-FREE

**Vision Glazing**
- LOW V₁
- LOW SC

[Link to website: HTTP://LIGHTLOUVER.COM/LIGHTLOUVER-DESCRIPTION/](HTTP://LIGHTLOUVER.COM/LIGHTLOUVER-DESCRIPTION/)
Reference case (clear glass)  Okasolar Panel  Normal view outside

Solar
Altitude:  25 degrees

Solar
Azimuth:  45 degrees

Solar
Altitude:  30 degrees

Solar
Azimuth:  45 degrees

Solar
Altitude:  75 degrees

Solar
Azimuth:  45 degrees

http://www.o-lite.org/page/okasolar_panel_p68.php
Glass unit:
1. Low E glass 6mm (0.24")
2. Cavity 25mm (1.14")
3. Flexible aluminum alloy louver 0.17mm (0.006")
   sandblasted or color coated
4. Outer glass

ECKELT GLASS ECKLITE PANEL

HTTP://D-LITE.MIT.EDU/PGO/ECKLITE_PANEL_PB1.PHP?PRF10=32&PRF10=81&TOTALHEX=0&PRVISIBLE=
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    By, Ulrich Knaack, Tillmann Klein, Marcel Bilow & Thomas Auer
17. http://www.adaptivebuildings.com/systems.html