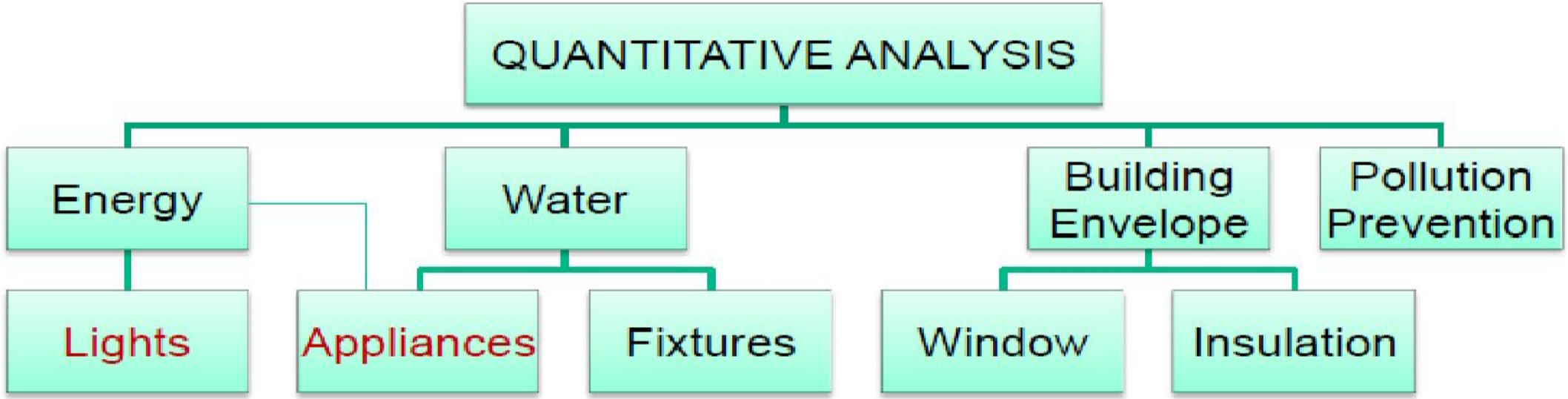
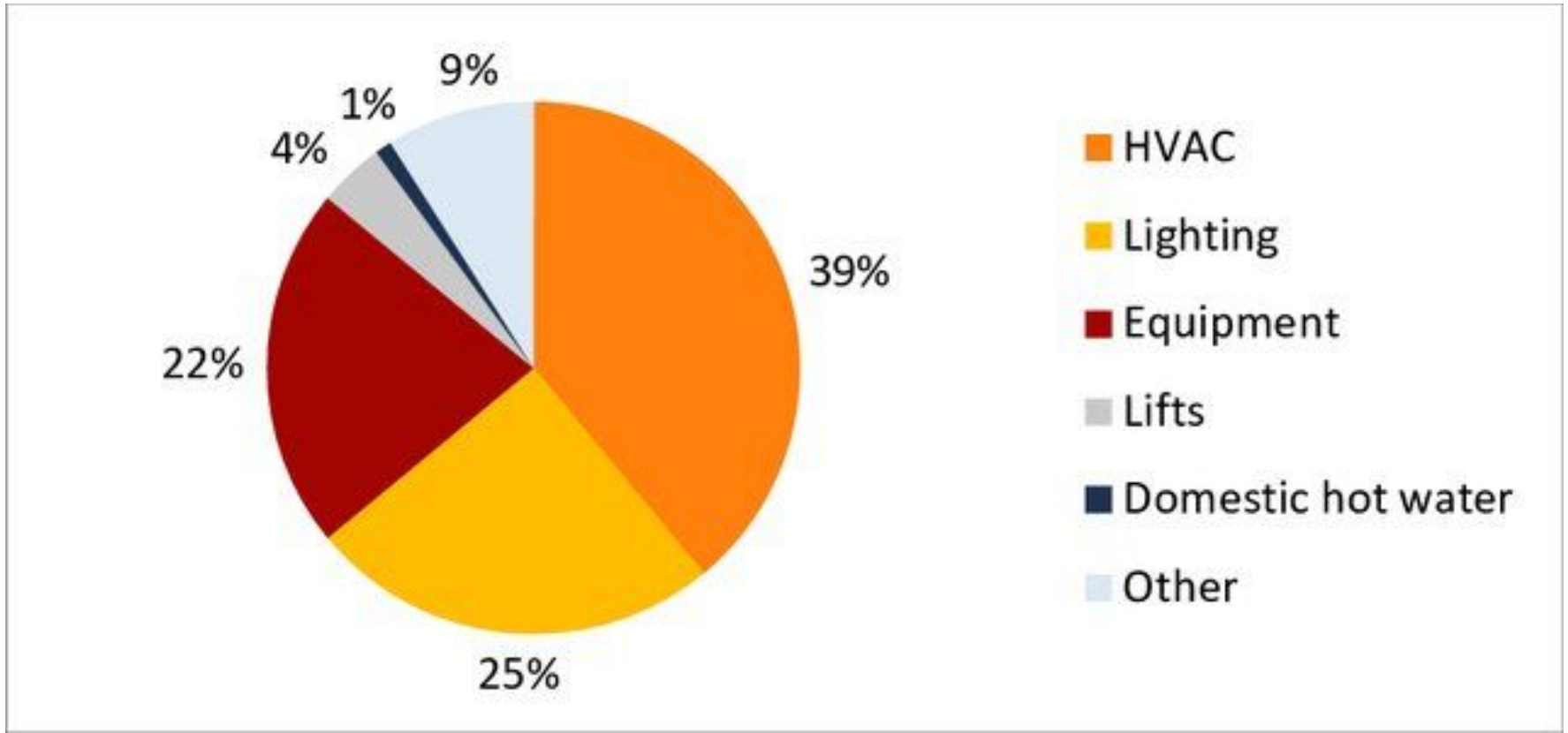
18MEO103T – Energy systems for Buildings

Unit – III Lighting Systems of Buildings

Lighting systems of buildings
9
Introduction to lighting systems of buildings
Glazing materials: Sources and concepts of optical materials
Concepts of day lighting
Components of daylight factors and Recommended daylight factors
Day lighting analysis
Electrical lighting and Illumination requirement
Selection of luminaries and performance parameters
Electric lighting control for day lighted buildings
Comparison of day and electrical lighting

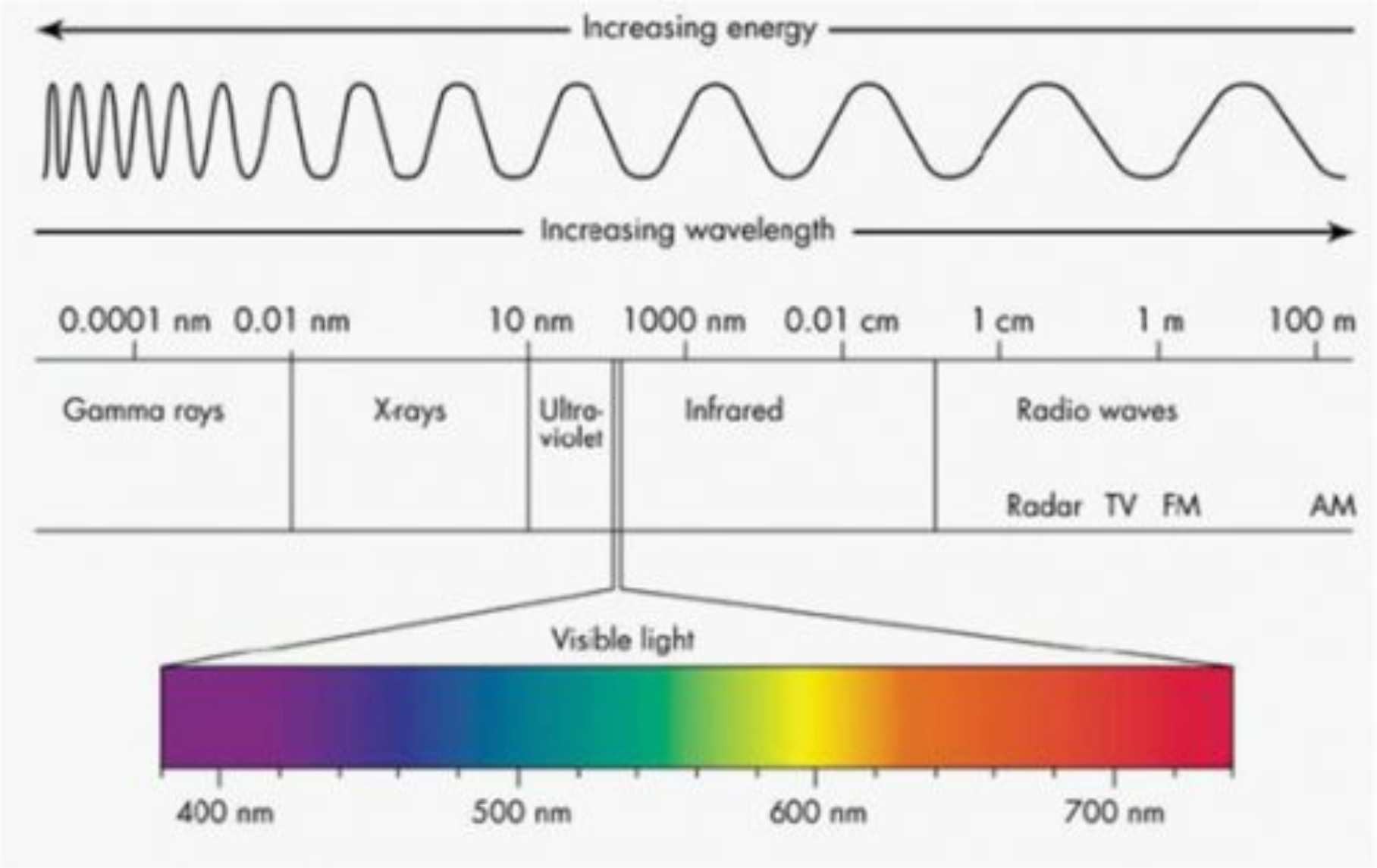

QUANTITATIVE ANALYSIS
Energy
Water
Building Envelope
Pollution Prevention
Lights
Appliances
Fixtures
Window
Insulation


9%
1%
4%
39%
22%
25%
HVAC
Lighting
Equipment
Lifts
Domestic hot water
Other

Energy efficient lighting is necessary

- To reduce electricity consumption thereby reducing the electricity bills
- To save electricity rather than wasting it in terms of losses
- To lower greenhouse emissions because conventional lamps cause CO_2 emissions
- To achieve peak load reduction.

Electromagnetic spectrum



About brightness and luminance of light

- **Brightness** is an attribute of visual perception in which a source appears to be radiating or reflecting light. Brightness is perceived and cannot be measured objectively (but scaled, e.g. in %).
- **Luminance** is the luminous intensity, projected on a given area and direction. Luminance is an objectively measurable attribute. The unit is 'Candela per Square Meter' (cd/m^2). So, different monitors can be adjusted to the same luminous intensity by measuring the luminance in cd/m^2.

Luminous Intensity

- Describes brightness of point source
- Measured in Candela

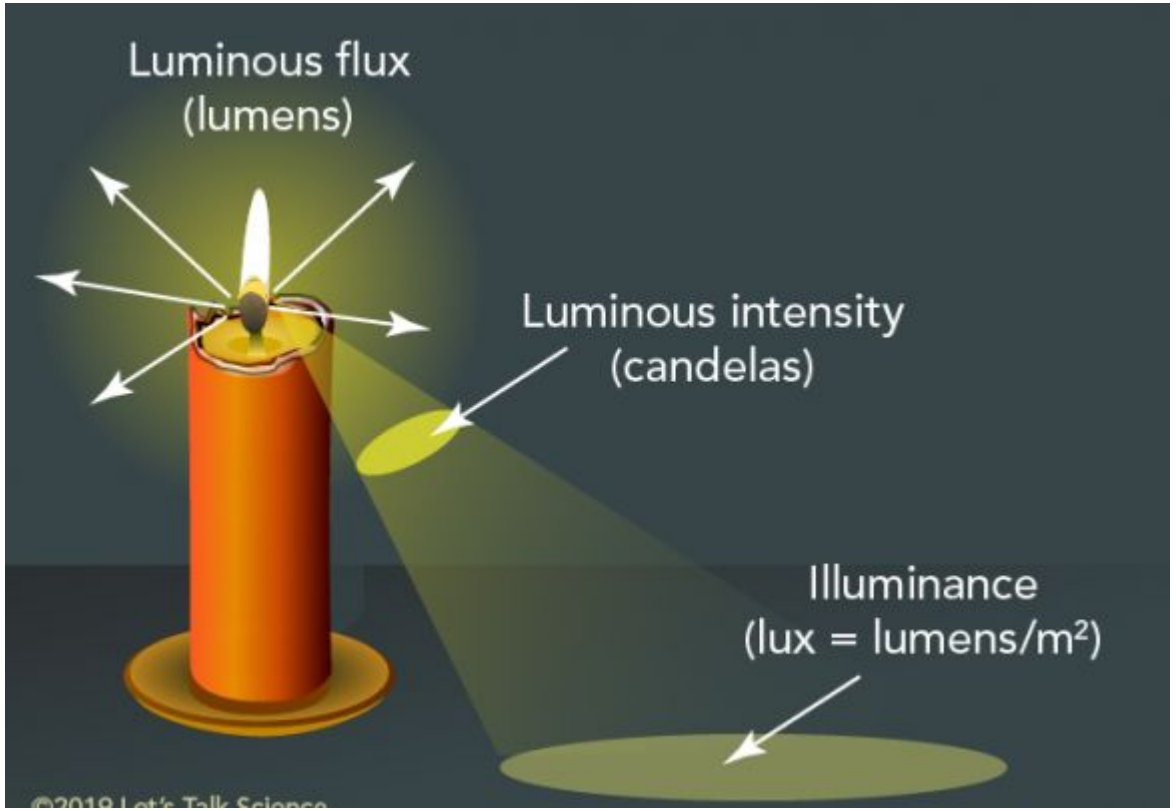
Luminous flux

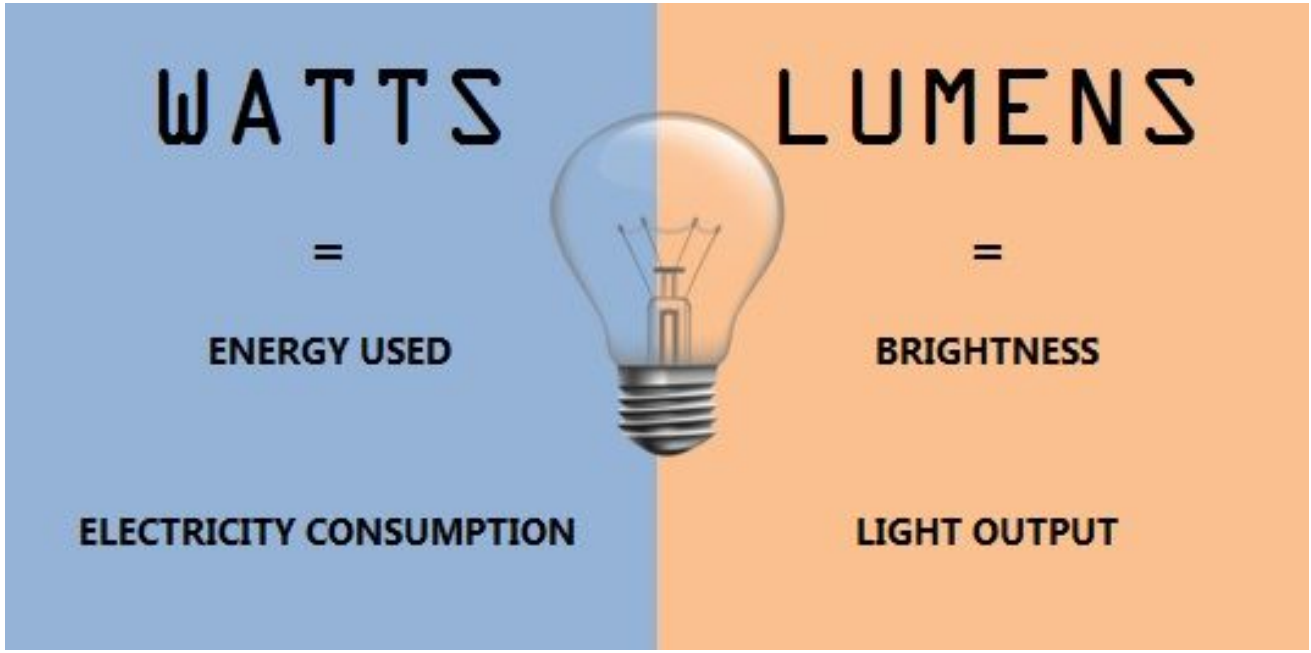
- Flow of light related to a unit of solid angle
- Measured in lumen

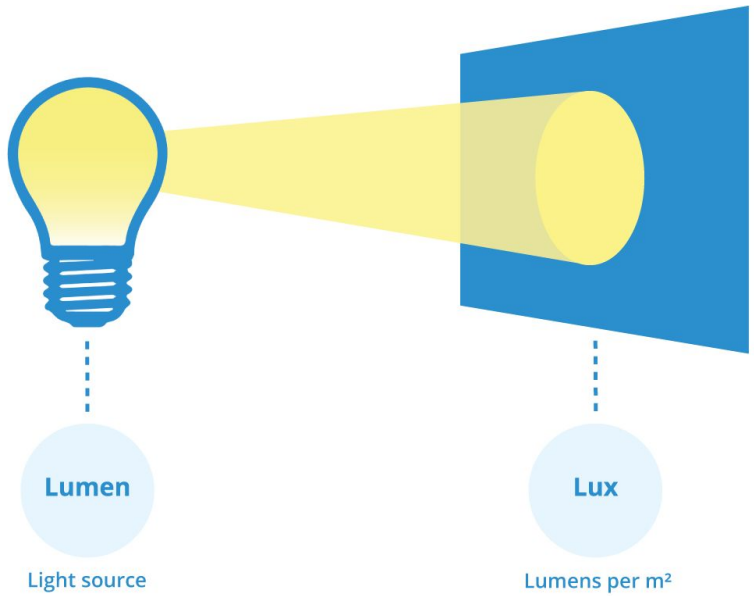
Illumination

- Amount of light reaching a surface
- Measured in lux per unit area

Part names




WATTS
=
ENERGY USED
ELECTRICITY CONSUMPTION
LUMENS
=
BRIGHTNESS
LIGHT OUTPUT


Lumen
Light source
Lux
Lumens per m²

Units of measurement

No	description	Quantity measured Name	recommended unit	Other units
1	Brightness of point source	Luminous intensity	Candela	Candle power
2	Flow of light	Luminous flux	Lumen	Foot candle
3	Amount of light reaching surface	Illumination or illuminance	Lux	Lumen/cm^2 (Phot)
4	Amount of light re-emitted by surface	Brightness or luminance	lambert	Foot Lambert Candles/cm^2

Lighting standards

- Illumination range – 0.1 lux to 100,000 lux
- Vision against illumination follows a curve
- 30 times higher than the minimum required
- Illuminating engineer society

Visual task	Illumination (lux)
Casual reading	100
General office work	400
Fine assembly	900
Very severe tasks	1,300 - 2,000
Watch-making	2,000 - 3,000

Lighting

Lighting within the indoor environment can be considered to have three basic purposes:

- **To enable the occupants to work and move about in safety.**
- **To enable tasks to be performed.**
- **To make the interior look pleasant.**

There are **two principle ways** in which a building can be **lit**. These are:

- **Naturally** - by **daylight** received from the sky.
- **Artificially** - by **electric lamps** or other **artificial light sources**.

Daylight as two distinct sources of light:

- **Sunlight –** That part of solar radiation that reaches the earth's surface as parallel rays after selective attenuation by the atmosphere.
- **Skylight –** That part of solar radiation that reaches the earth's surface as a result of scattering in the atmosphere.

Sunlight and **skylight** may therefore be considered as the **direct** and **diffuse** components of **daylight**.

Lighting or illumination is the deliberate use of light to achieve practical or aesthetic effects

- The provision of ample light in a building is of primary significance as it serves two purposes, namely, for illumination and for granting hygienic conditions.
- Lighting should be planned in a manner as to create mood or atmosphere and should be complete.

NATURAL LIGHT

- The primary source of lighting for daylighting is the sun.
- The light received by the earth from the sun consists of two parts, namely, direct solar illuminance and sky illuminance.
- For the purpose of daylighting design, direct solar illuminance shall not be considered and only sky illuminance shall be taken as contributing to the illuminance of the building interiors during the day.

Depends on the sky's illuminance

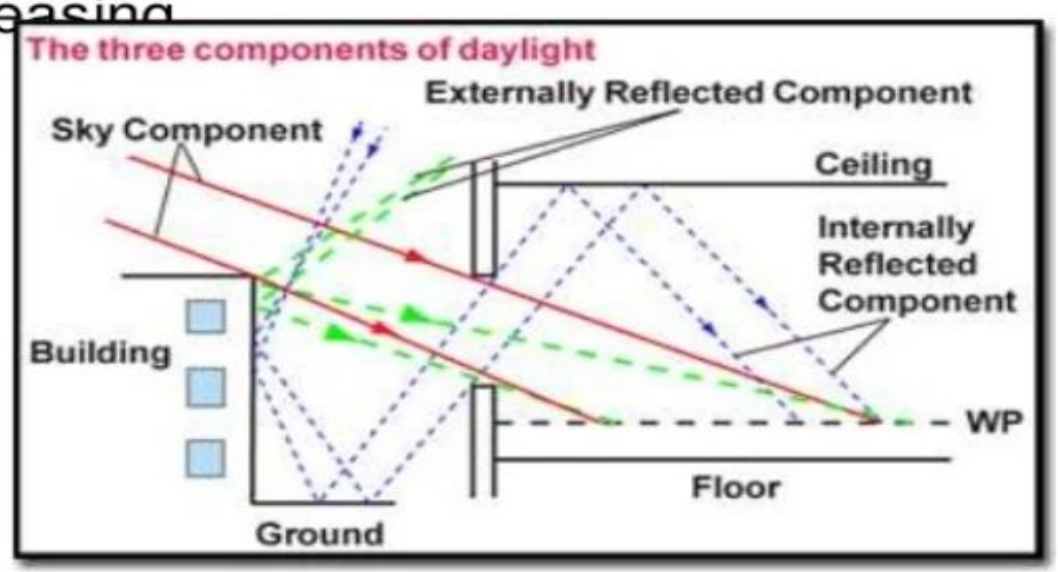
- Altitude of the sun
- Altitude of the locality
- The day of the year
- Time of the day

ARTIFICIAL LIGHTING

- Where the recommended luminance levels have to be obtained by artificial lighting only.
- To supplement daylighting when the level of illumination falls below the recommended value.
- Where visual tasks may demand a higher level of illumination.

What is Natural Lighting/daylighting?

- Day lighting is the controlled admission of natural light, direct sunlight, and diffused-skylight into a building to reduce electric lighting and saving energy.
- The components of a day lighting system are designed to bring natural light into a building in such a way that electric lights can be dimmed or turned off for a portion of the day, while preventing occupant discomfort or other building loads from increasing



Day lighting

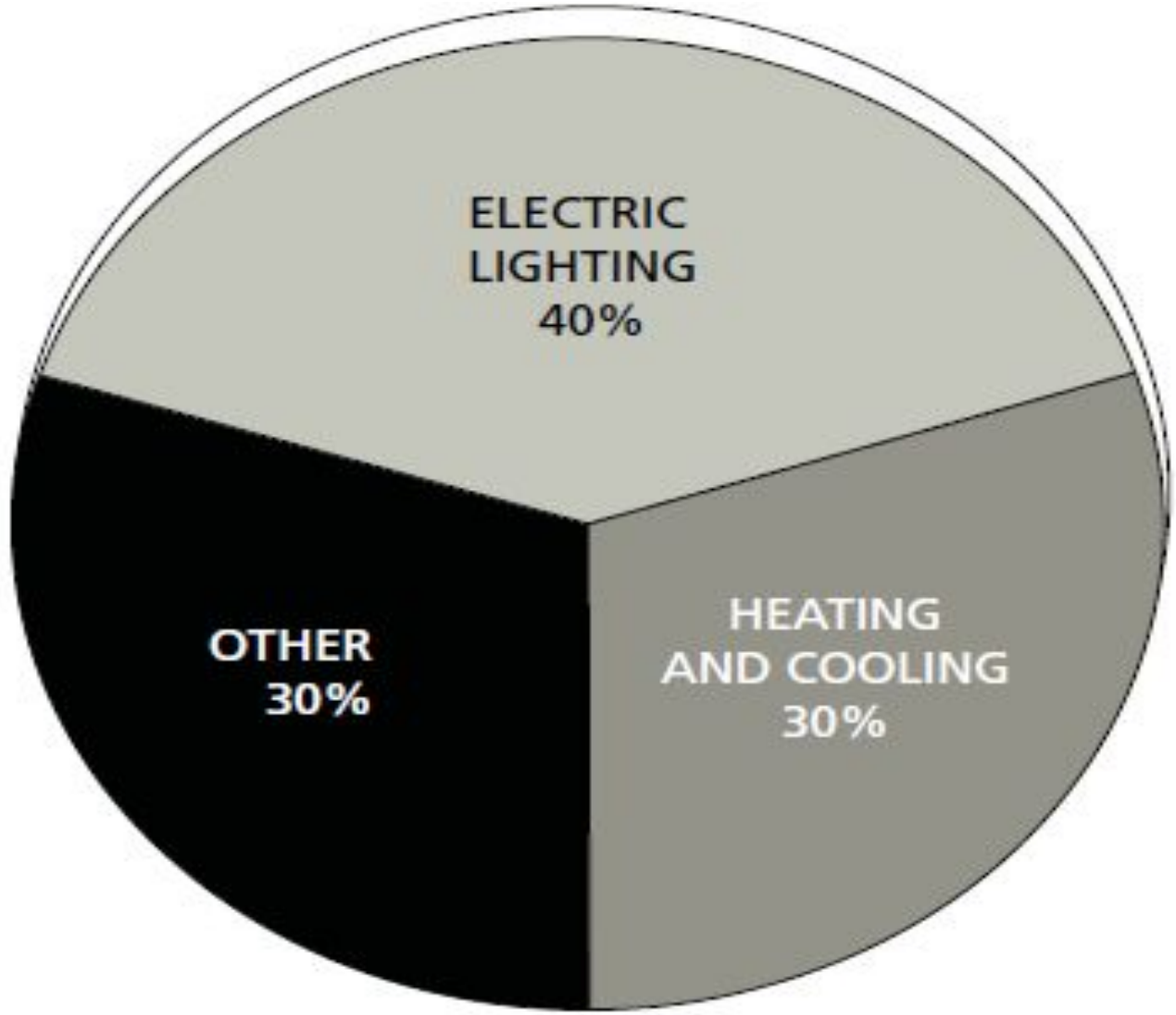
- The manner in which daylight enters and distributes itself in a room depends on the size and location of openings, type of glazing, configuration of the room, and reflective properties of walls, ceiling, and other surfaces.
- The intensity of daylight and the daylight factor also depends on the height and the location of the opening on a wall; the intensity reduces as the distance from the opening increases.

Benefits of Natural Lighting

- Occupant Satisfaction
- Occupant Comfort
- Occupant Health-Circadian rhythm
- Time orientation
- Colour rendition
- Colour Temperature
- Reduced electrical load
- Reduced internal heat gain

Basic Principles of Daylighting

- The ultimate source of daylight is the sun. By the time sunlight reaches the earth's surface, it has been subjected to atmospheric attenuation, scattering and reflection.
- The daylight received on the earth's surface is composed of direct light (from the sun) and diffuse light (light received from all parts of the sky due to atmospheric scattering and reflection). Light reaching a particular point inside a building may consist of,
- (1) **direct sunlight**, (2) **diffuse light or skylight**, (3) **externally reflected light** (by the ground or other buildings), and (4) **internally reflected light** from walls, ceiling and other internal surfaces light directly received.



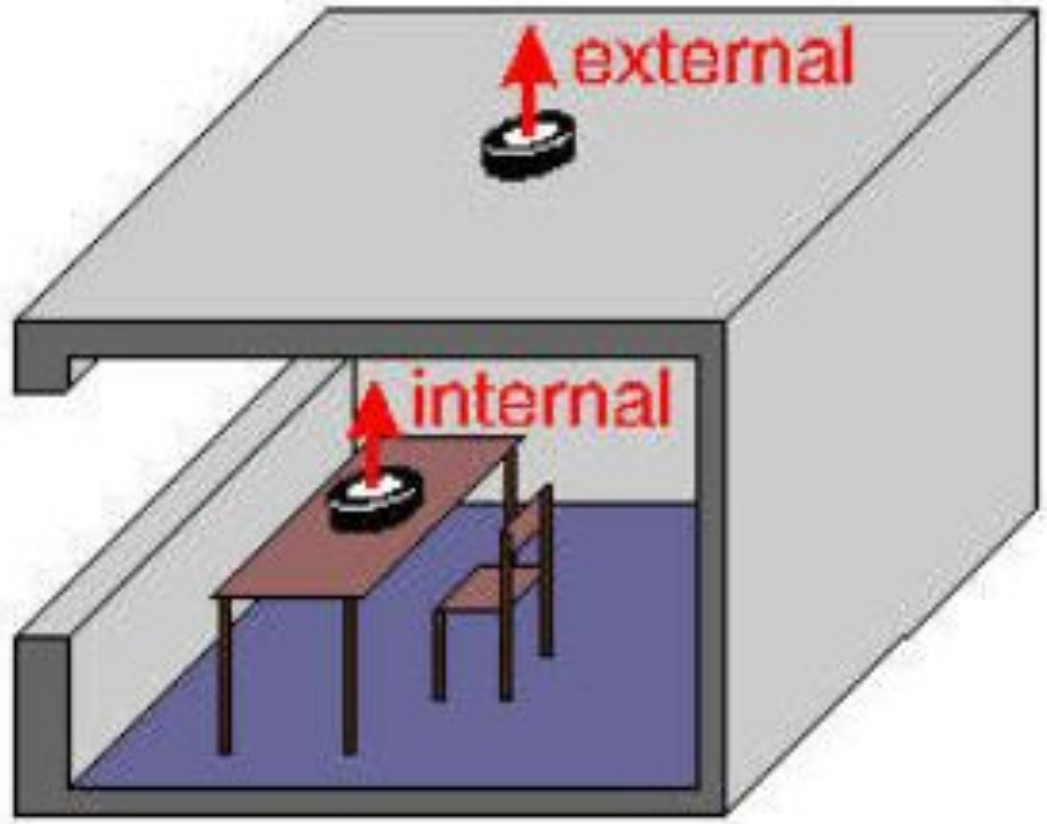
Typical distribution of energy use for buildings such as offices, schools, and many industrial facilities.

Some requirements of good lighting are given below:

- **Sufficiency:** Light need to be sufficient to see objects properly. It must provide adequate illumination. Insufficient lighting cause to eye strain.
- **Distribution:** The efficient vision without any eye stress is occurs by uniformity in light distribution
- **Absence of glare:** Glare is high contrast of light. For example; Torch lights. These lights are pointed and cause to glare. It is not possible to our eye for effective reading in glared light.
- **Absence of sharp shadows:** Shadows occur when any object takes place between the light source and field of vision. Shadows create stress and need to be clear for proper reading process. For example: Incandescent bulbs, it always causes to create shadiness but, florescent bulbs are proper to avoid shadows and effective reading.
- **Steadiness:** The term refers to stable condition of light. Light must be constant with constant contrast and constant intensity. Flickering lights are creating eyestrain and headache.
- **Color of light: I**t should provide light of suitable color.
- **Surroundings:** The term refers to background field of vision. As a requirement to good lighting background has a major role. The walls in your rooms and ceilings are creates reflection and its essential to accumulation of light. If you use glass walls or black backgrounds the efficiency of light should lost. Because glass walls emit the light outside and black background absorbs the light and don't possible reflection. So, surrounding should be in a normal condition by using proper materials cause to reflection.
- **Angle of lighting:** Light source should be established in a proper way that lead to effective lighting by reflection. If the light is established in an improper condition there should not reflection and the efficiency will lost.

Day light factor:

- A *daylight factor* (DF) is the ratio of the *light* level inside a structure to the *light* level outside the structure.
- It is defined as: DF = (Ei / Eo) x 100%



Building	Area/Activity	Daylight factor (%)
Dwellings	Kitchen	2.5
	Living room	0.625
	Study room	1.9
	Circulation	0.313
Schools	Class room	1.9 – 3.8
	Laboratory	2.5 - 3.8
Offices	General	1.9
	Drawing, typing	3.75
	Enquiry	0.625 – 1.9
Hospitals	General wards	1.25
	Pathology laboratory	2.5 – 3.75
Libraries	Stack room	0.9 – 1.9
	Reading room	1.9 – 3.75
	Counter area	2.5 – 3.75
	Catalogue room	1.9 – 2.5

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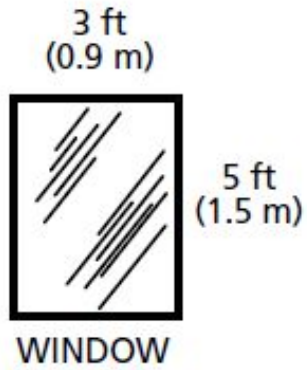
	Catalogue room	1.9 – 2.5

To get an indication of the energy and electrical demand savings possible with daylighting, this figure shows how many 60 W incandescent lamps would be required to produce the same amount of light as a 3 x 5 ft (0.9 x 1.5 m) window.



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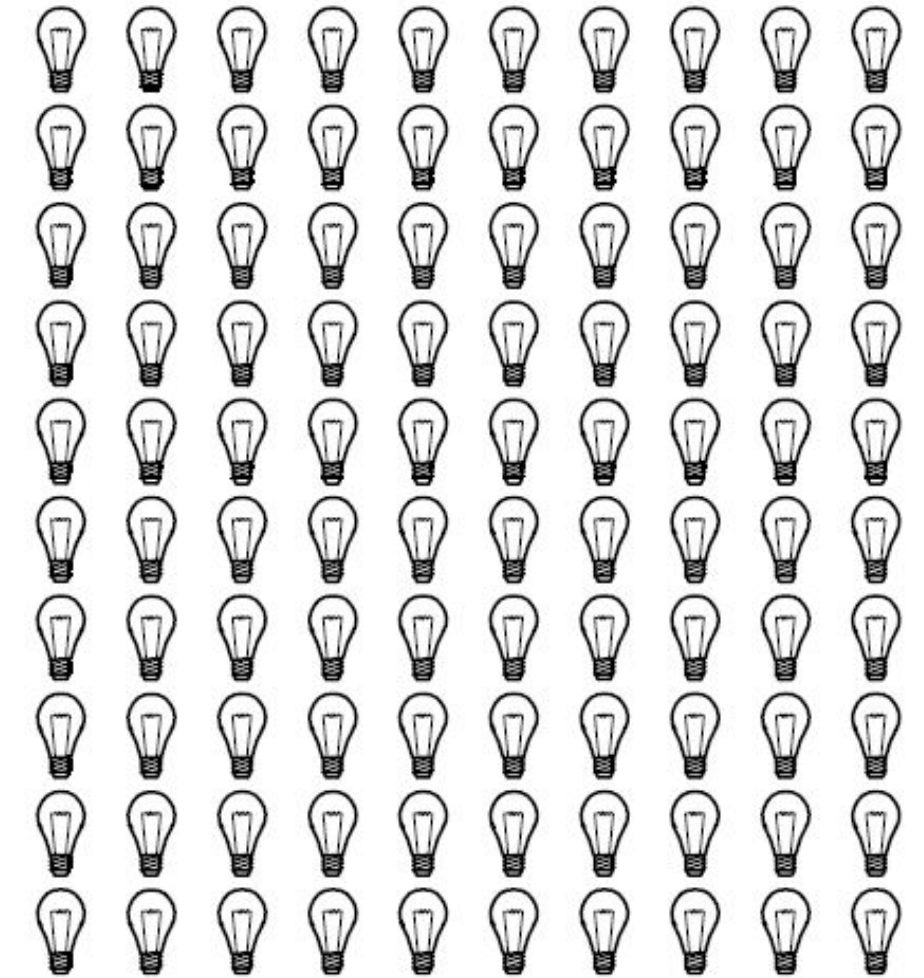


100 - 60 W LAMPS

The Requirements of good Light

- Good light is essential for efficient vision.
- Poor lightening lead to straining and eye fatigue.
- The following light factors are essential:
  1. SUFFICIENCY
  2. DISTRIBUTION
  3. ABSENCE OF GLARE
  4. ABSENCE OF SHARP SHADOWS
  5. STEADINESS
  6. COLOR OF LIGHT
  7. SURROUNDINGS.

1. SUFFICIENCY

- Sufficient light is essential to recognize the surroundings details without eyes straining.
- An illumination of 15-20 foot candles is accepted as a basic minimum for satisfactory vision.

2. DISTRIBUTION

- For efficient vision, lighting should be a uniform and of the same distribution all over the area without contrast; if not, eyes straining and fatigue occur.

3. ABSENCE OF GLARE

- Glare is excessive contrast.
- Glare may be from the direct light source or reflected from another object such a table tops and polished furniture.
- Glare causes annoyance.
- The eye can't tolerate glare because it causes acute discomfort and reduces critical vision.

- Glare is a result of excessive contrast, or of light coming from the wrong direction.
- The contrast between the bright outside environment viewed through a window and the darkness of the interior space creates glare.
- Glare results in discomfort and eye fatigue as the eye repeatedly readjusts from one lighting condition to another.

Glare

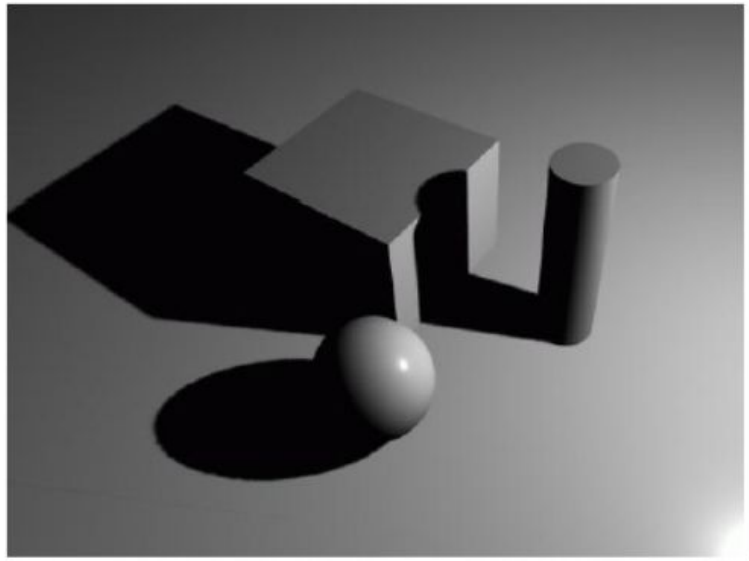
Glare is excessive contrast

Factors influence the degree of discomfort glare :

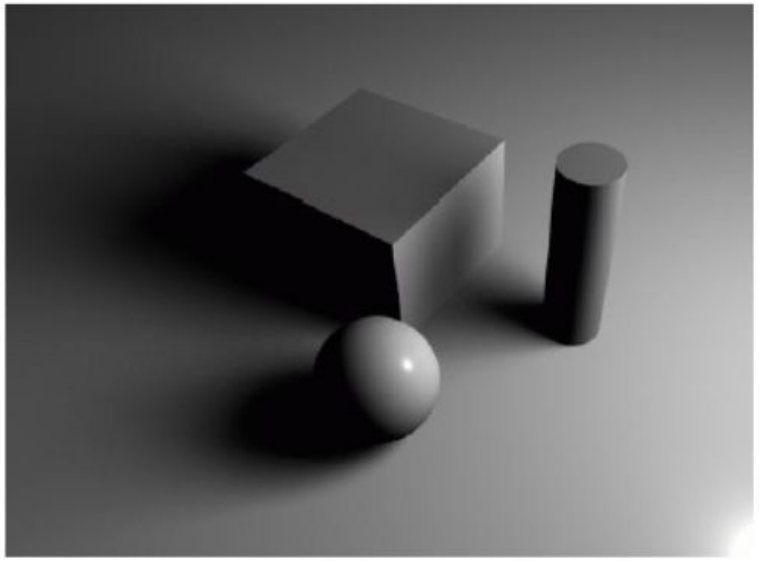
- luminance of the glare source,
- the solid angle of the glare source,
- the background luminance
- the position of the glare source in the field of view

4.ABSENCE OF SHARP SHADOWS

- Slight shadows are inevitable; but sharp and contrasting shadows are disturbing.
- Shadows causes confusion to the eyes and shouldn't be present in the vision field.



Hard Shadow

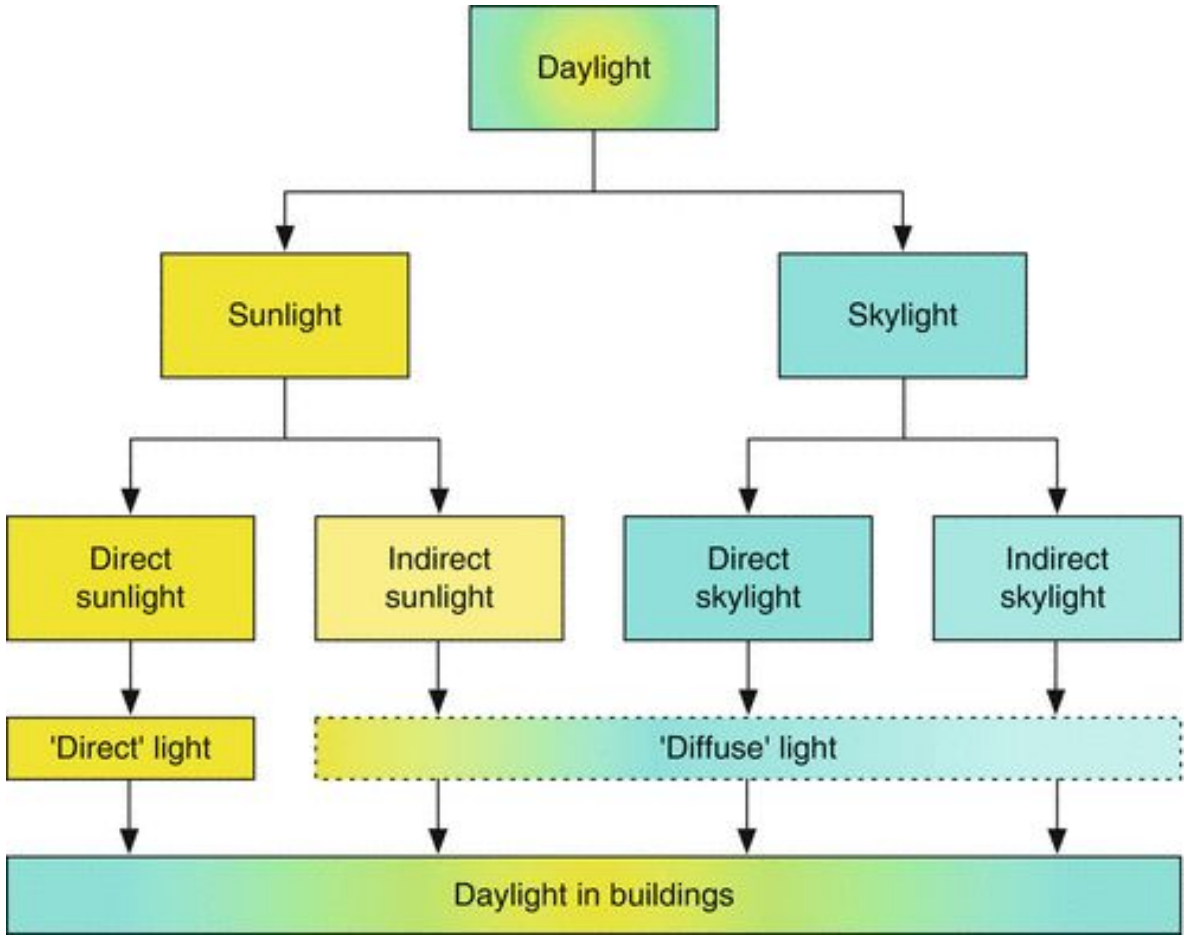


Soft Shadow

5. STEADINESS

- The source of the light should be constant; and it shouldn't flicker, because flickering causes eye strain and may lead to accidents.

6. Colour of light



7. SURROUNDINGS

- For efficient vision the colour schemes in rooms is very important.

ROOM ITEM	REFLECTION FACTOR
Roofs	80 %
Walls	50 - 60 %
Furniture	30 -40 %
Floor	≤ (10 – 20 %)

Lighting

Lighting energy use can be substantially reduced by:

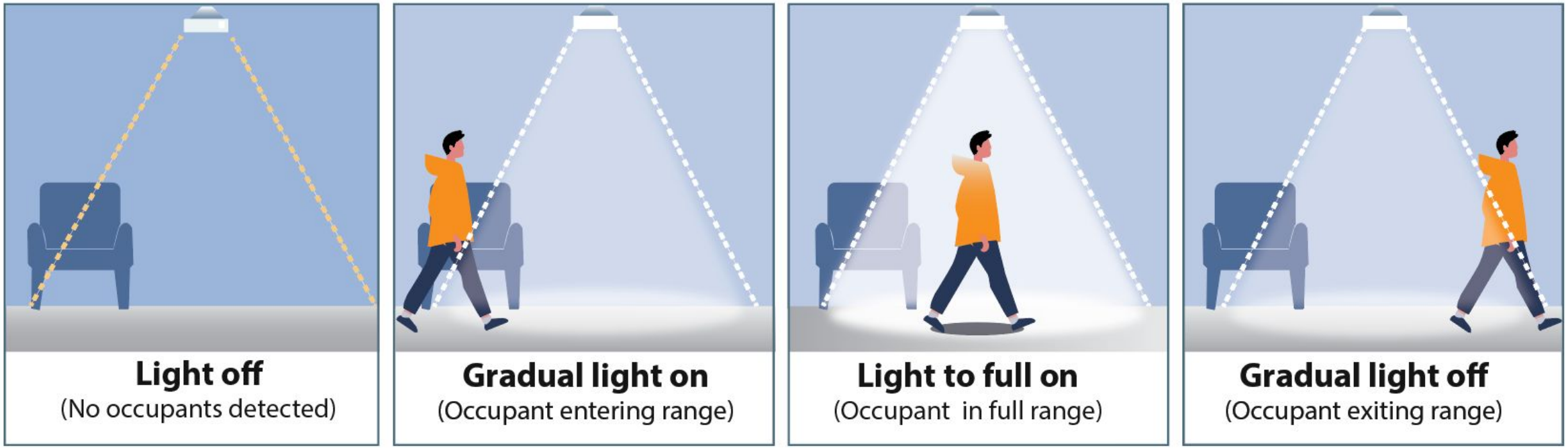
- **Day Lighting**
- Installing **efficient lighting devices** such as LED, CF, and fluorescent lights).
- **Task Lighting**
- **Controls:** Developing habits of turning off lights when not needed (or using motion, heat or light sensors to control when lights are on or off).

This effort has changed in three major directions:

1. The development of new energy-efficient lighting equipment
2. The utilization of improved lighting design practice
3. The improvement in lighting control systems.

Occupancy sensors serve three basic functions:

1. To automatically turn lights on when a person enters the room,
2. To keep the lights on while the controlled space is occupied
3. To turn the lights off within a predefined time interval if the room is unoccupied.



1 ON OFF Function

This sensor is a motion switch,which turns on the light on detection of peple movement,and turns off after a pre-selected holdtime when there is no people around.A daylight sensor is also built-in to switch off the light when there is sufficient natural light.

With sufficient natural light,the light does not switch on, even when movement is detected.

With insufficient natural light ,the sensor switches ON the light automatically when people enter into the detection range.

With insufficient natural light ,the sensor switches OFF the light automatically when no more movement is detected.

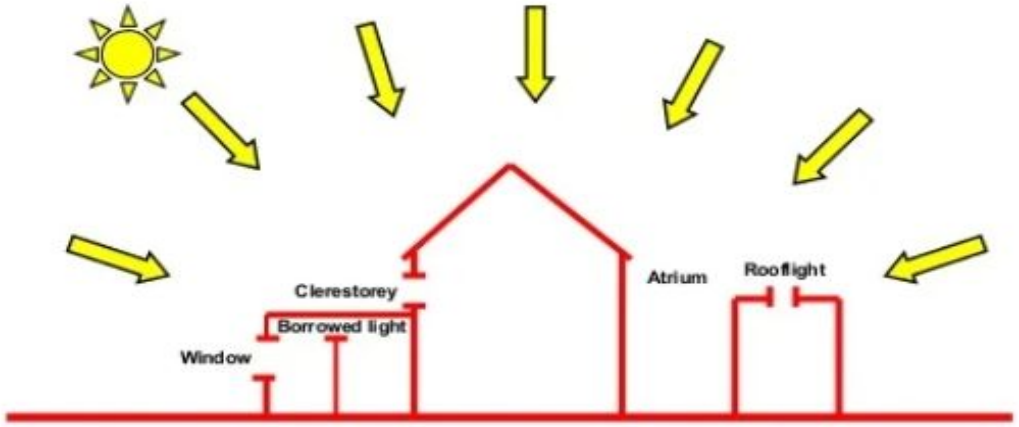

THREE-LEAF
GARAGE LIGHT
20-FOOT
MOTION SENSOR!

Concepts of day lighting

Daylight (both **sunlight** and **skylight**) is usually admitted into a building by the means of **windows** and **skylights.**

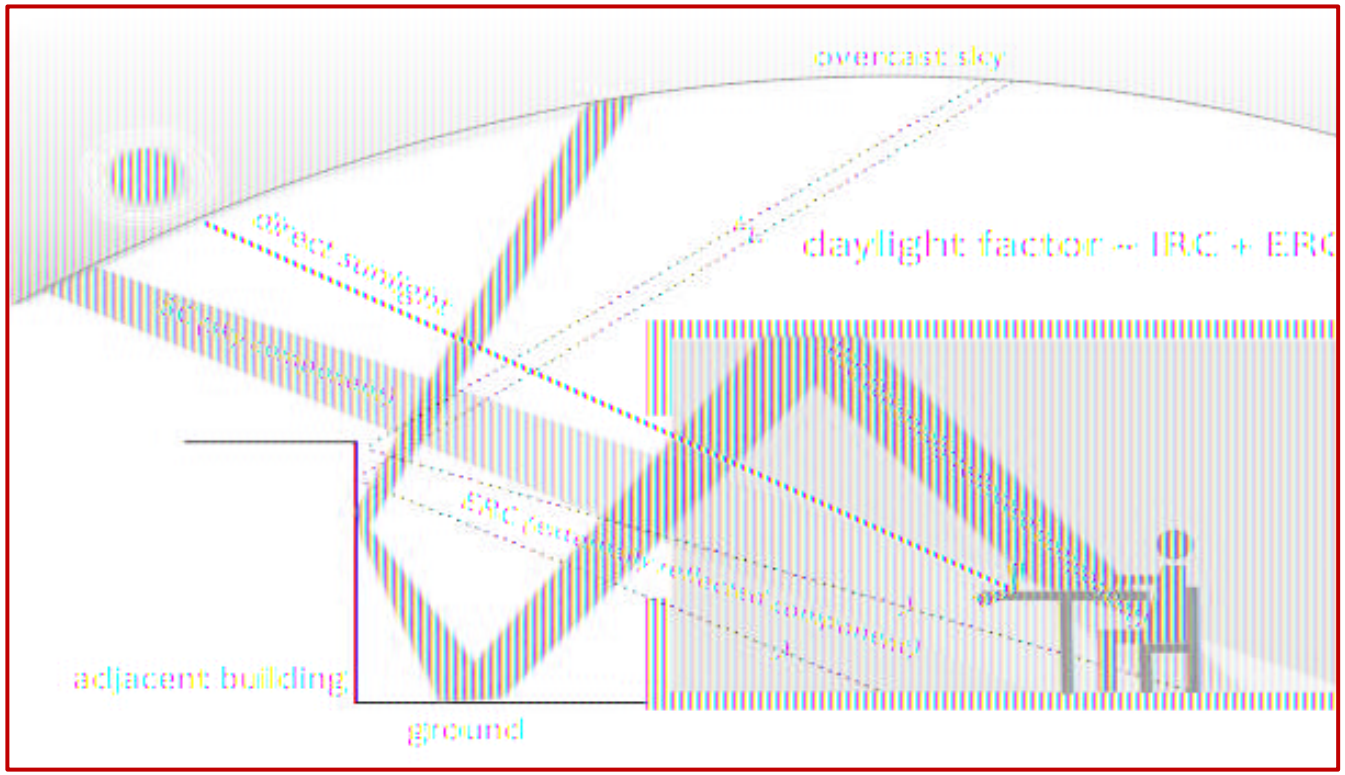
The quantity of **daylight** obtained within a room will be dependent upon:

- **The orientation, geometry and space planning of the spaces to be lit.**
- **The dimensions and orientation of the openings through which daylight will pass.**
- **The location and surface properties of any internal partitions which may reflect and distribute the daylight.**
- **The location, form and dimensions of any shading devices which will provide protection from too much light and glare.**
- **The light and thermal characteristics of the glazing materials used.**



Components of daylight factor

- Daylight Factor (DF) consists of three components: Sky Component (SC), External Reflection Factor (ERC), and Internal Reflection Factor (IRC).
  - Daylighting is usually considered on a horizontal plane since the work plane is horizontal (flooring, seating areas, work areas, etc.).
  - Factors in vertical planes are also considered for specifying daylighting values for special cases. For example, vertical daylighting is necessary for classrooms for illuminating noticeboards, blackboards, pictures, and paintings that are hung on the wall.



The daylight *factor in a particular building* space depends upon a number of design factors including

1. • **size of daylight apertures** (windows, skylights, etc.);
2. • **location** of daylight apertures (sidelighting, toplighting, etc.);
3. • **access** to daylight (considering the site, building, and room
4. contexts);
5. • **room geometry** (height, width, and depth);
6. • location of the point of interest relative to apertures;
7. • visible transmittance (VT) of glazing;
8. • **reflectances** of room surfaces and contents;
9. • **reflectances** of exterior surfaces affecting daylight entering the aperture;
10. • the effects of daylighting enhancements (such as light shelves).

Controlling daylight

A range of methods are available to **control** the amount of **daylight** that penetrates into the building.

- **Fixed external –** Permanently obstructs skylight and is maintenance free, but is architecturally dominating.
- **Variable external –** Allows the maximisation of skylight but can suffer from maintenance problems.
- **Variable internal –** Absorbs solar radiation and acts as a secondary heat source within the building. Effective for visual comfort.

Various methods of controlling daylight

In addition, further control can be provided by the choice of **glazing type**.

Glare from daylight

Glare from **daylight** can be **reduced** by:

- **Using solar control devices** - such as external screens and louvres, glass of low transmittance, or internal blinds and curtains
- **Other methods of decreasing the contrast between the interior and the view of the sky** - such as ensuring that the window wall is light coloured.

- **Designed to eliminate the use of artificial light on normal days.**
- **Average daylight factor of 2% over 80% of the office space.**
- **Atrium has rooflights which allow natural light to enter the building.**
- **PV façade designed to produce 25-33% of the offices electricity needs.**

- **Designed to achieve a minimum 2% daylight factor over the office area.**
- **Solar shading provided on South façade via motorised external translucent glass louvres.**

Innovative daylighting technologies

A number of **innovative daylighting technologies** are available which are capable of **redirecting** the incoming **sunlight** or **skylight** to the areas where it is required.

The technologies available include:

- **Sunlight tracking systems** - have mirrors and/or lenses that follow the sun and redirect its light to a required location.
  - **heliostat and light pipe systems.**
  - **mirror systems.**
- **Daylighting systems** - redirect diffuse skylight and usually sunlight as well. They generally modify or supplement an existing window or rooflight.
  - **light shelves.**

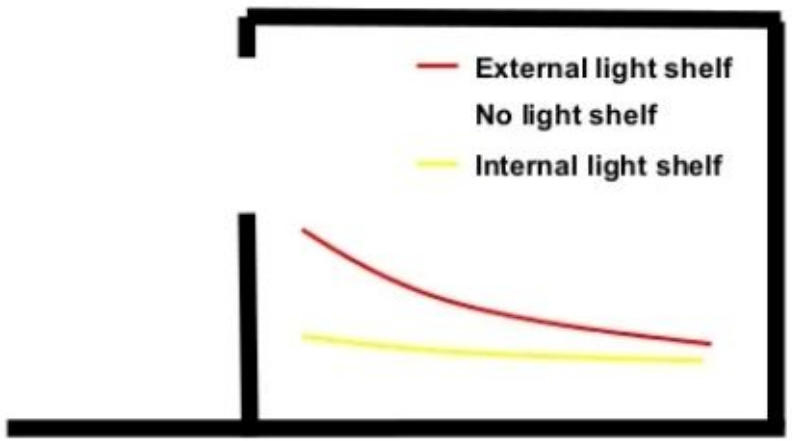
Innovative daylighting technologies

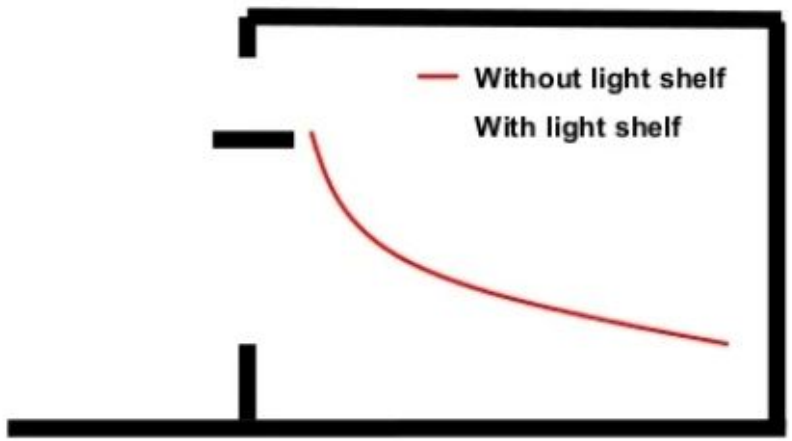
Light shelves

These can be used to **redirect sunlight** and **skylight** deep into a space. Both **interior** and **exterior light shelves** are available. **Exterior shelves** can also function as a **shading device**.

The **performance** of **light shelves** depends upon the **proportion** of the **shelf** which is situated **inside** or **outside** the space.

They can also be used to **control sunlight** and **reduce glare**.





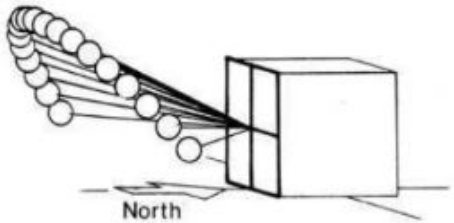
An Integrated Natural lighting System consists of-

- Daylight-optimized building footprint
- Climate-responsive window-to-wall area ratio
- High-performance glazing
- Day lighting-optimized fenestration design
- Skylights (passive or active)
- Daylight redirection devices
- Solar shading devices
- Daylight-optimized interior design (such as furniture design, space planning, and room surface finishes).

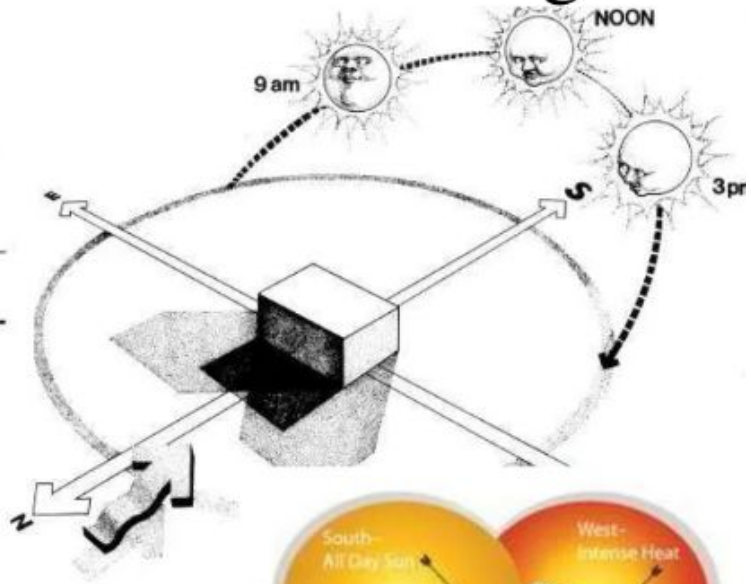
Principles of Effective Natural Lighting

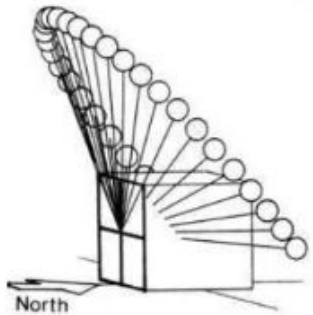
- 1. Orientation of the Building
- 2. Form of the Building
- 3.Glazing Ratio and specifications
- 4. Window Height and location
- 5. Overhead day lighting
- 6. Daylight Redirection

1. Orientation of the Building

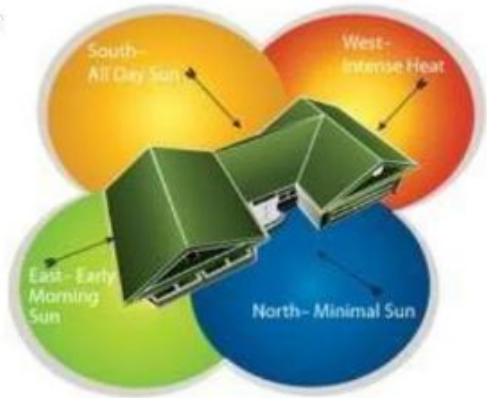


Winter sun angles on a south-facing surface

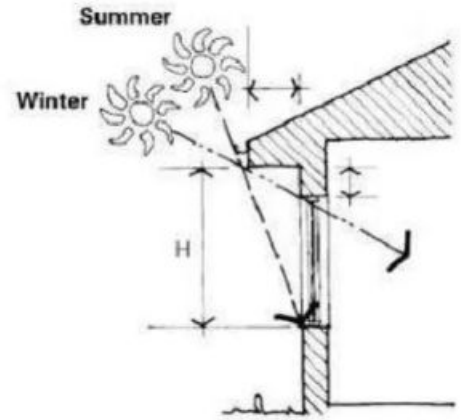




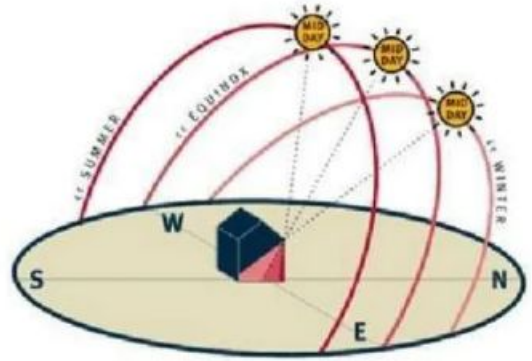
Summer sun angles on a south-facing surface



Sun angles

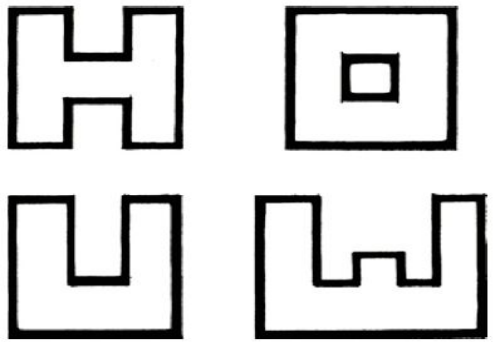


Sun angles

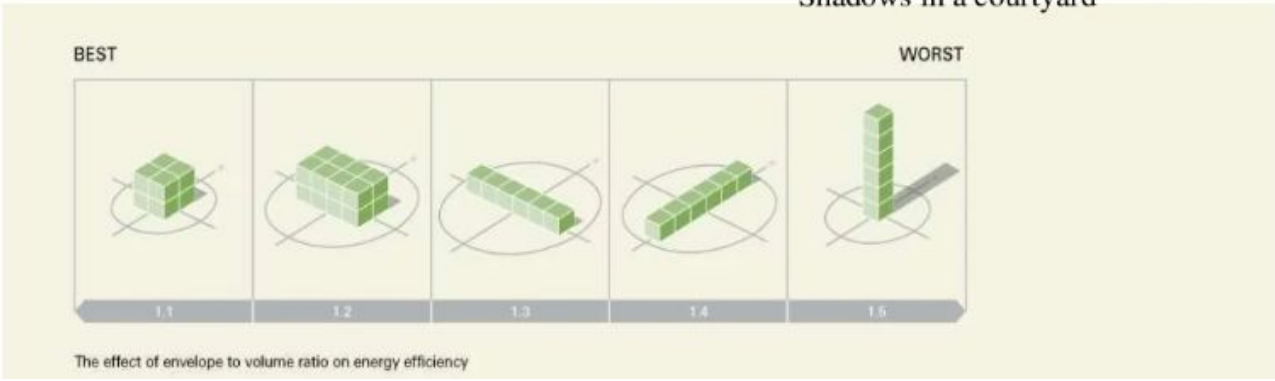


Natural light enters the building through angles of the sun

2. Form of the Building



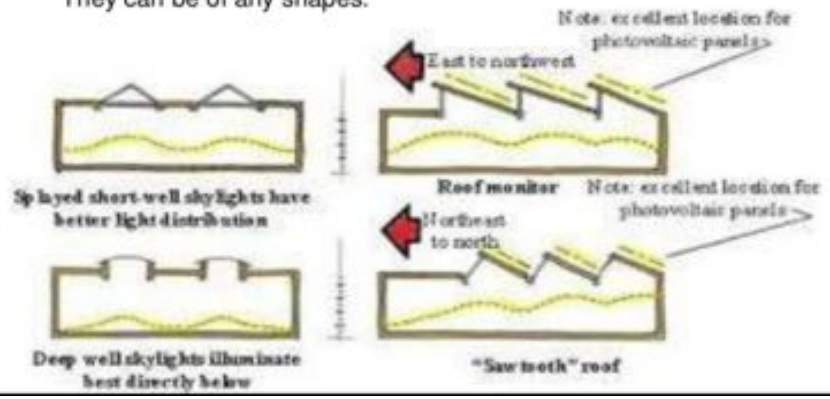
Shadows in a courtyard

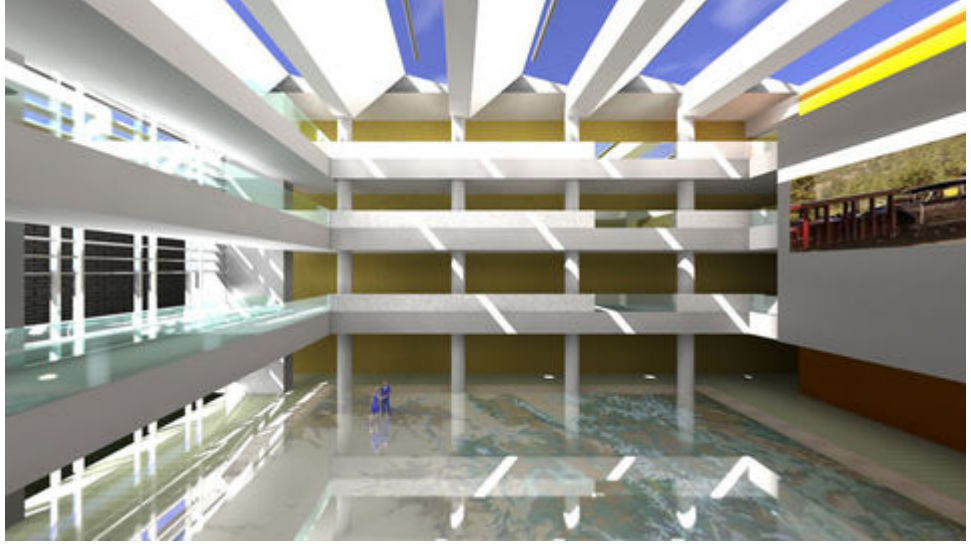


The effect of envelope to volume ratio on energy efficiency

5. Overhead day lighting

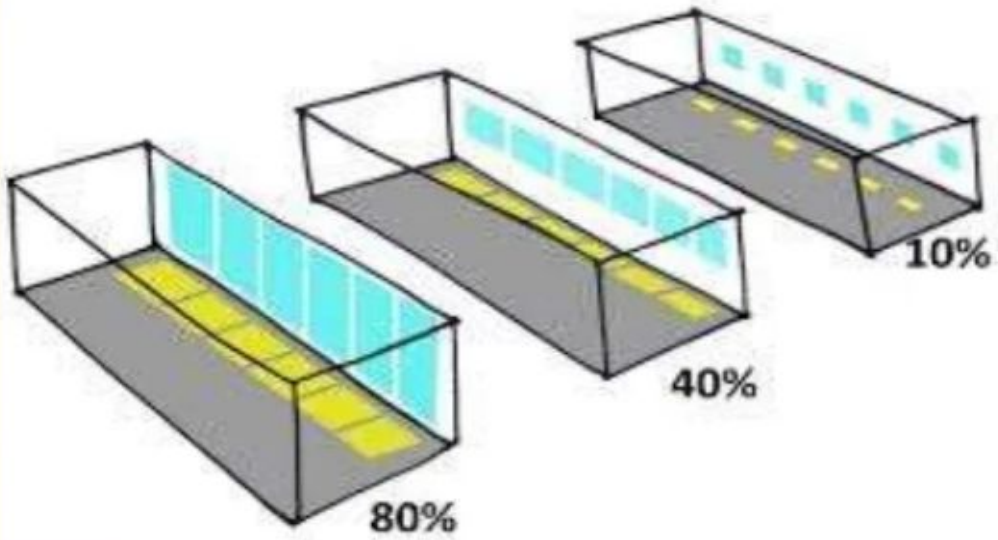
Skylights can be either passive or active, the majority of skylights are passive because they have a clear or diffusing medium (usually acrylic) that simply allows daylight to penetrate an opening in the roof. They are often comprised of a double layer of material, for increased insulation. They can be of any shapes.

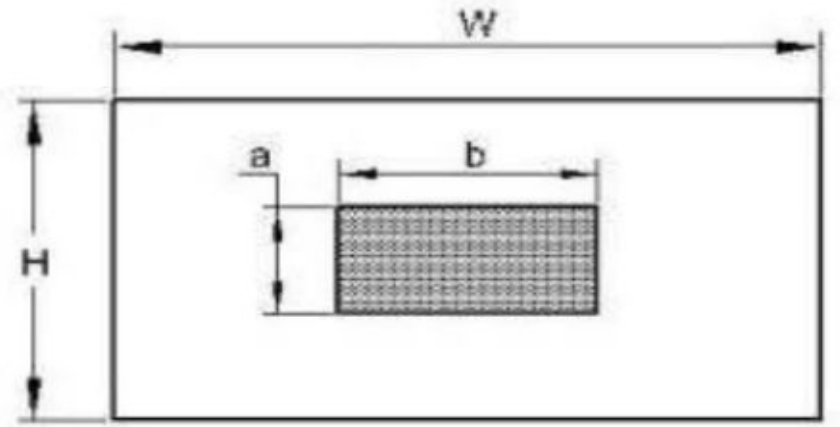




3.Glazing Ratio and specifications

- Glazing ratio= Area of glazing/area of external wall (25%-50%)
- The more the glazing ratio the more day lighting but more the solar heat gain
- Optimum glazing ratio depends upon the user requirement, building orientation, location, View of sky
- Triple glazing, tinted or reflective glass can reduce day lighting but increase thermal comfort.

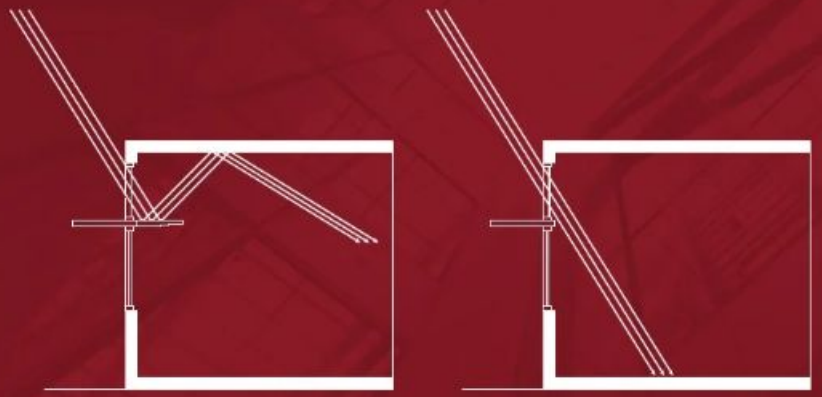




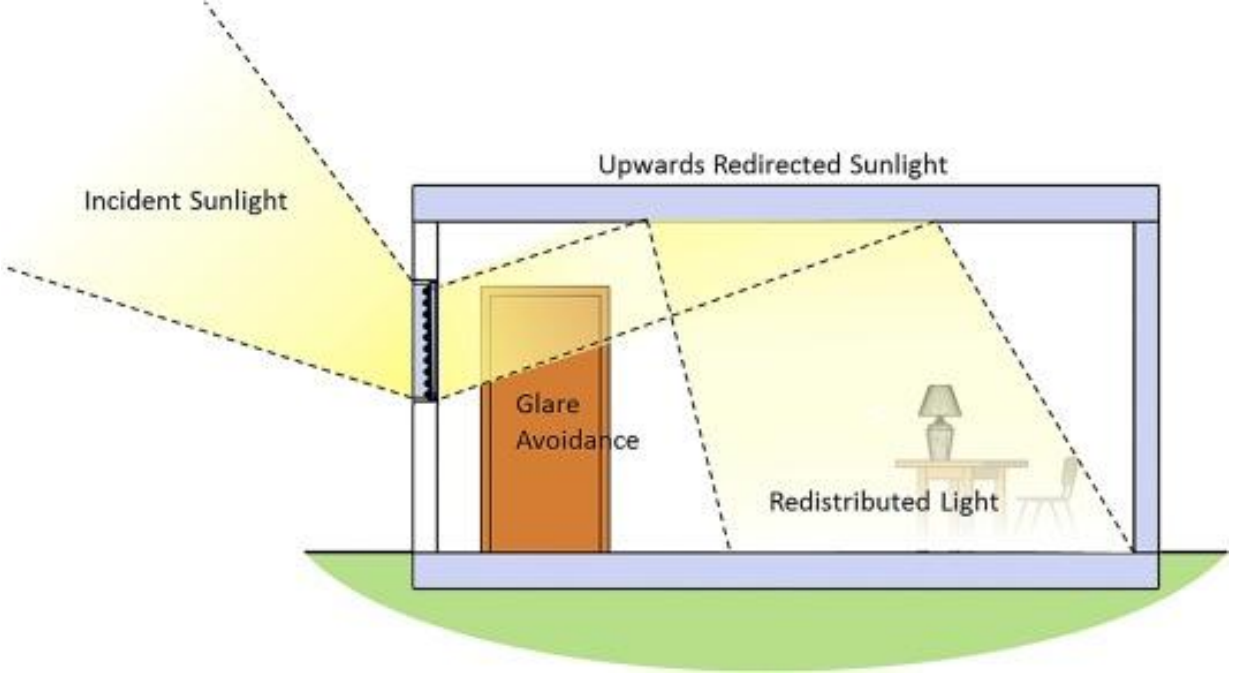
$$WWR = \frac{a.b}{w.h}$$

Daylight Redirection

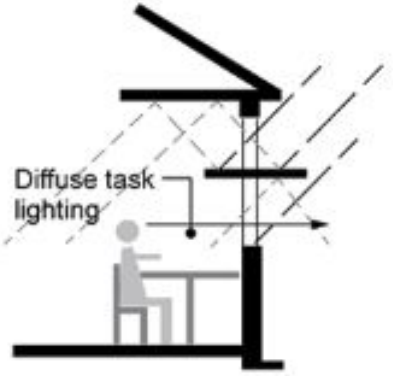
The result is more balanced daylighting with less glare and contrast between light levels in the interior.



Light shelves are horizontal projections placed on the outside and below a window to reflect sunlight onto the interior ceiling, making it a light-reflecting surface. At the same time, the light shelf shades the lower portion of the window, reducing the amount of light near the window, which is typically overlit.



Shallow external shelf results in deep light penetration and solar access

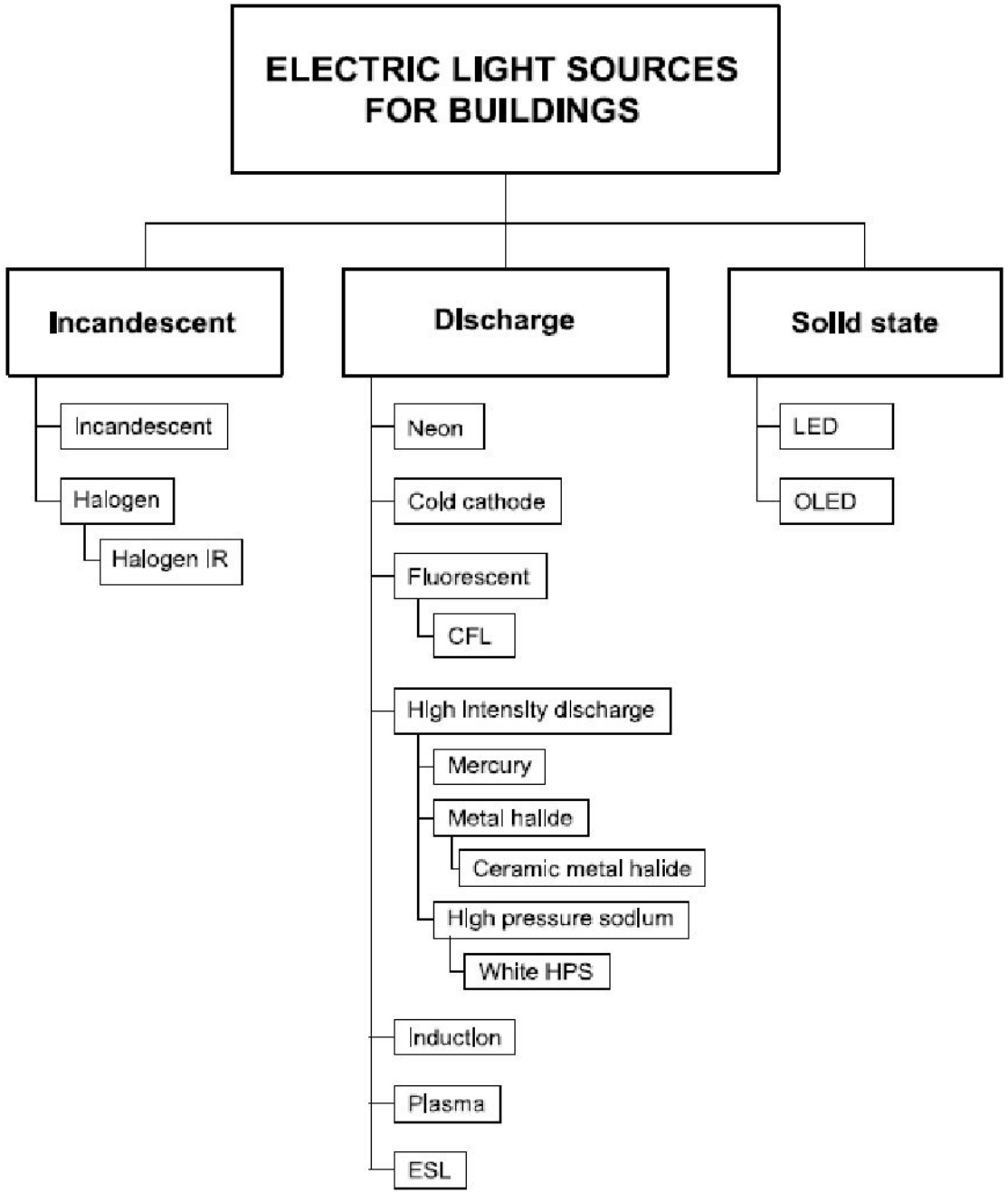


Internal/external shelf results in deeper light penetration and full shade

Types of Artificial Lighting

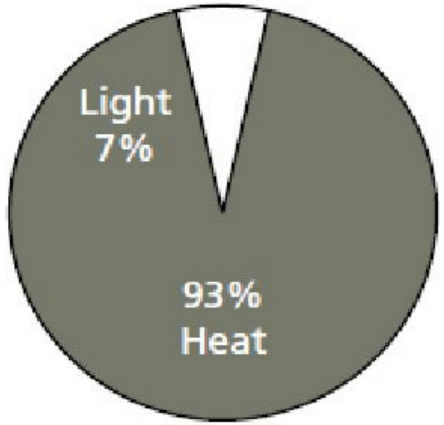
- Candles
- Oil Lamp
- Kerosene Lamp
- Gas Lighting
- Electric Lighting

LIGHT SOURCES

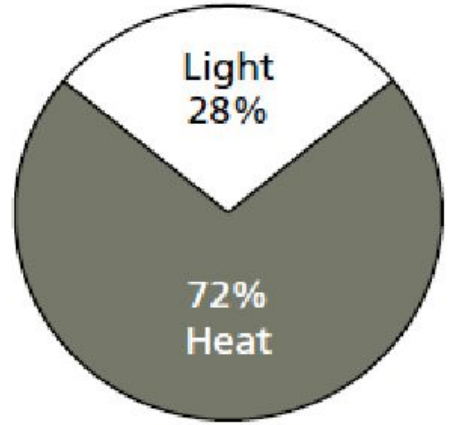


Abbreviations:

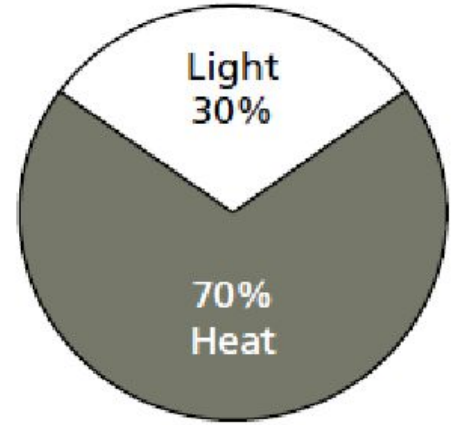
LED (light-emitting diode),
OLED (organic light-emitting diodes),
CFL (compact fluorescent lamp),
HPS (high-pressure sodium),
and ESL (electron-stimulated luminescence)



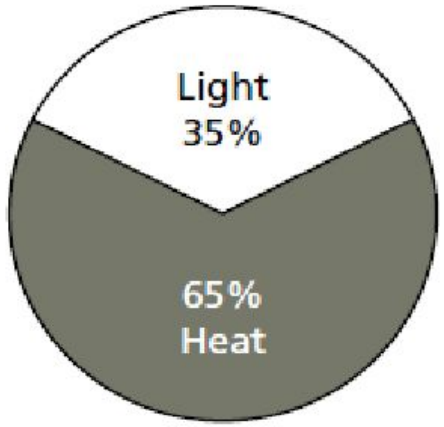
INCANDESCENT



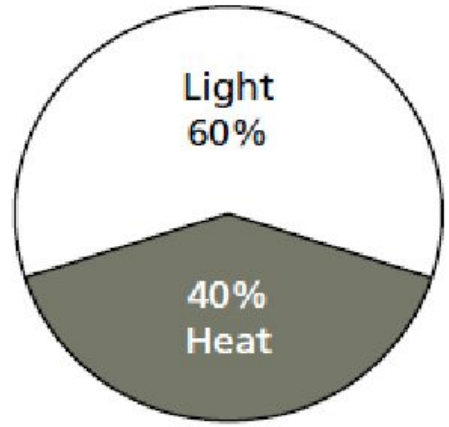
FLUORESCENT



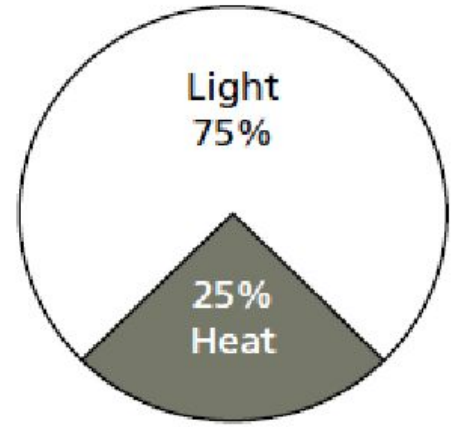
METAL HALIDE
& LED



HIGH PRESSURE
SODIUM

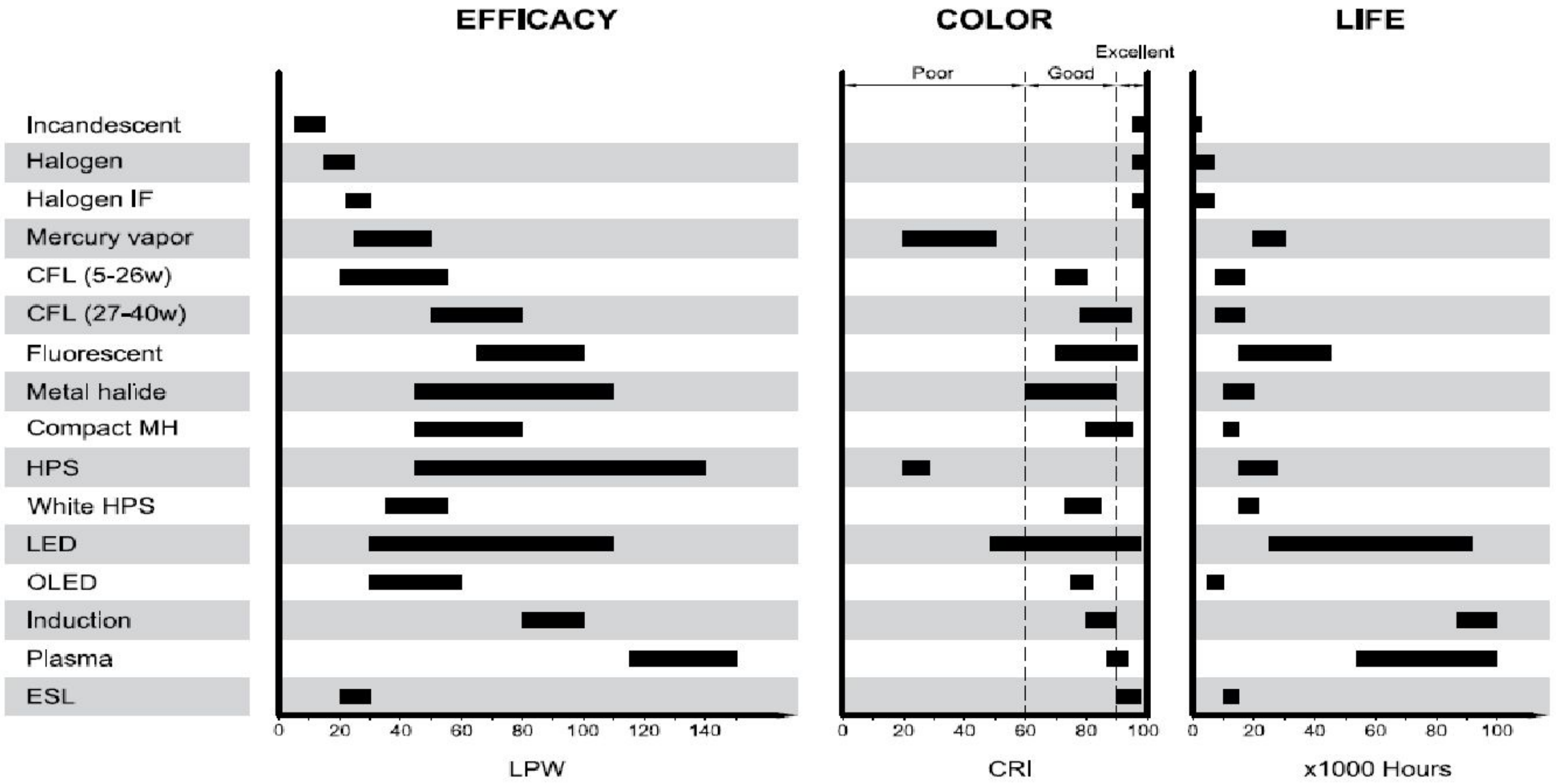


SUNLIGHT THROUGH
CLEAR GLASS



SUNLIGHT THROUGH
SPECTRALLY SELECTIVE
LOW-E GLAZING

In choosing a lamp, the three major characteristics are efficacy (lumens per watt), color rendering (CRI), and the life of the lamp. To make comparisons easier, all three characteristics are shown side by side.



The efficiency requirements of various codes for offices

Table 14.2 Maximum Lighting Power Density for an Office

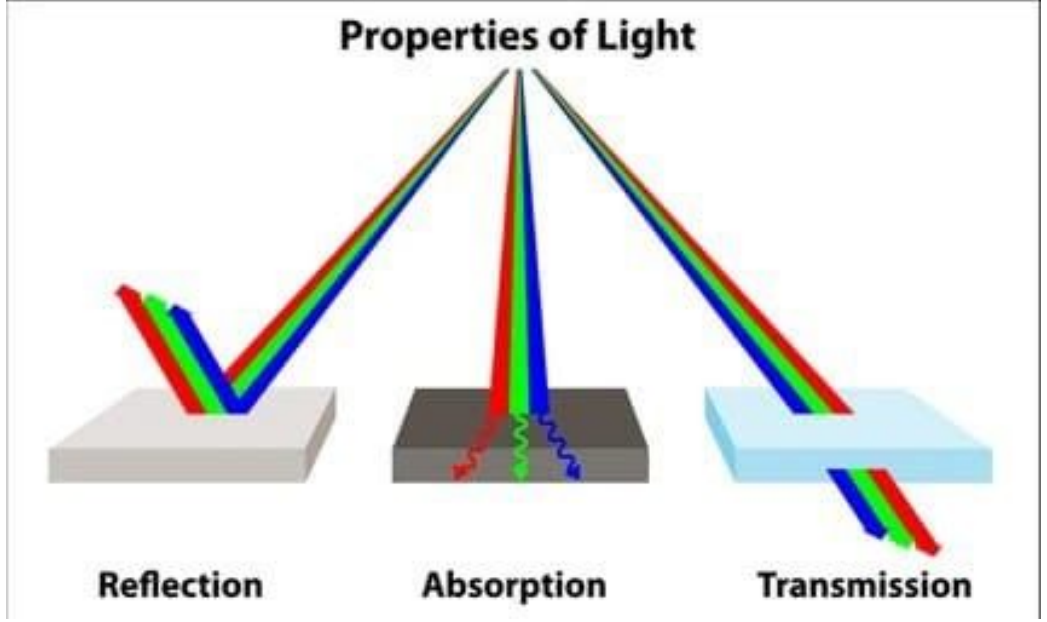
w/ft^2	w/m^2	Code
5	47	Typical before energy codes
3	22	ASHRAE 90.1-1999
1	9.3	ASHRAE 90.1-2004
0.9	8.4	ASHRAE 90.1 2010
0.8	7.4	LEED
0.45	4.2	Possible during the day if daylighting is used

Optical materials

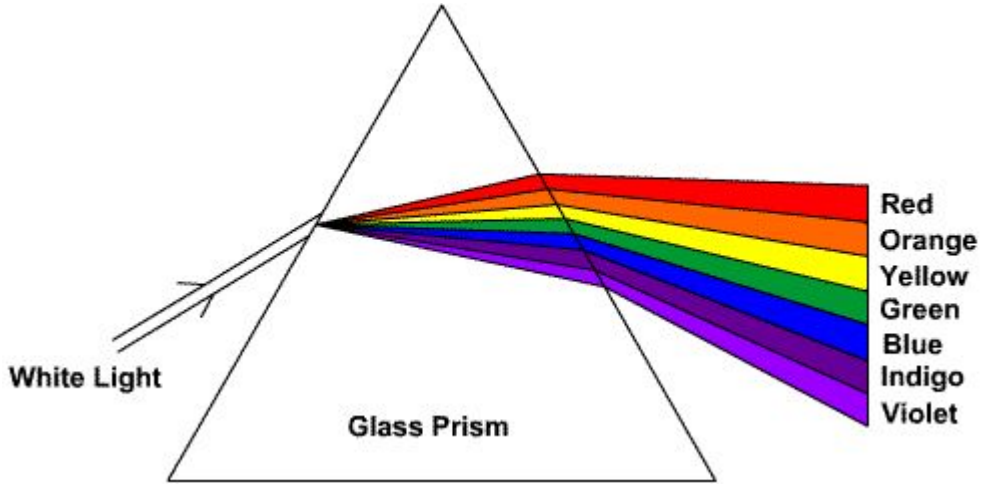
- Optical materials are **substances used to manipulate the flow of light**. This can include reflecting, absorbing, focusing, or splitting an optical beam. The efficiency of a specific material at each task is strongly wavelength-dependent.

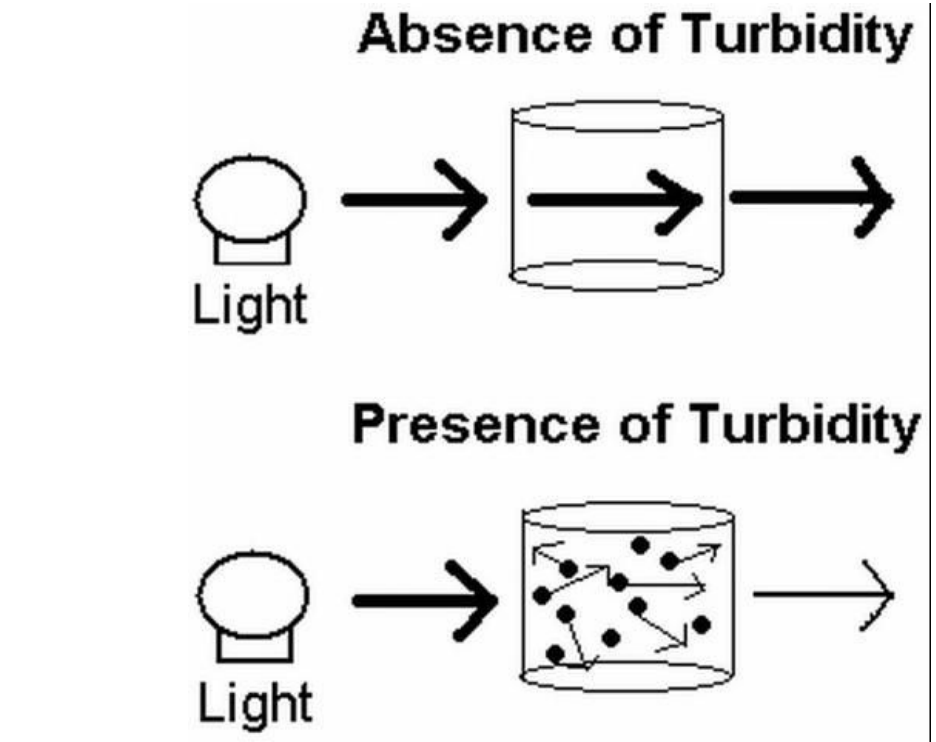
Optical properties of matter include:

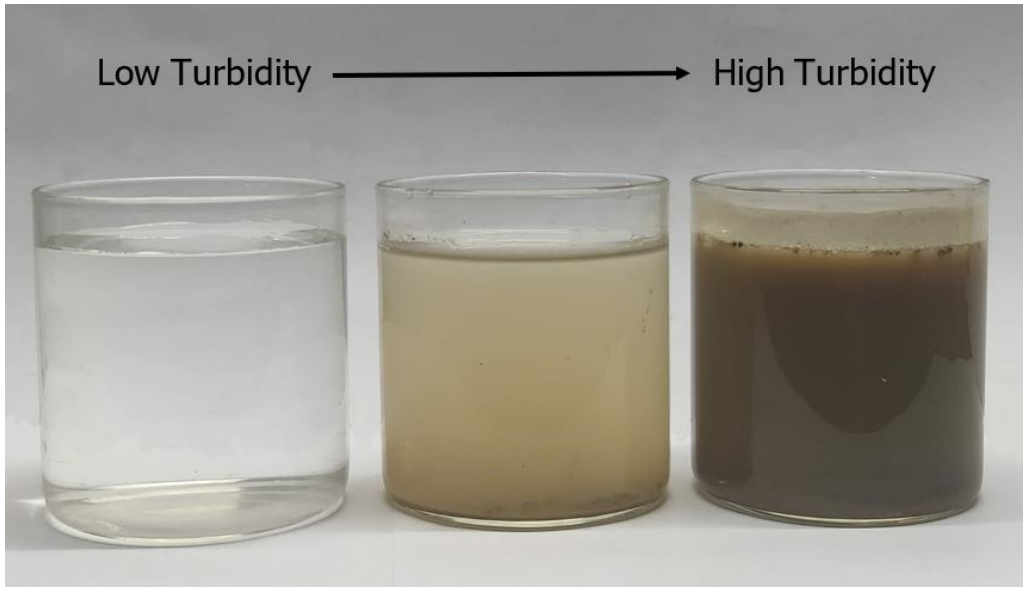
- Refractive index - the refractive index (or refraction index) of an optical medium is a dimensionless number that gives the indication of the light-bending ability of that medium.
- Dispersion – This phenomenon of white light splitting up into its constituent colors is termed as dispersion.
- Transmittance and Transmission coefficient - Transmittance of the surface of a material is its effectiveness in transmitting radiant energy.
- Absorption - Example: Absorption of water in a sponge.
- Scattering - A change in the direction of motion of a particle because of a collision with another particle.
- Turbidity - Turbidity is the measure of the relative clarity of a liquid.
- Reflectance and Reflectivity (reflection coefficient) - The reflectance of the surface of a material is its effectiveness in reflecting radiant energy.
- Albedo - Albedo is the portion of solar energy reflected from the surface of the Earth back into space.


Properties of Light
Reflection
Absorption
Transmission

Dispersion


White Light
Glass Prism
Red
Orange
Yellow
Green
Blue
Indigo
Violet

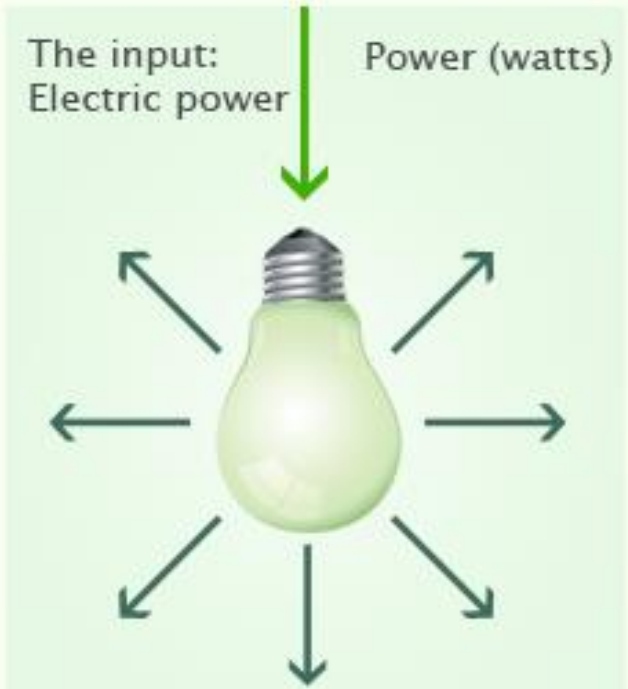

Absence of Turbidity
Light
Presence of Turbidity
Light

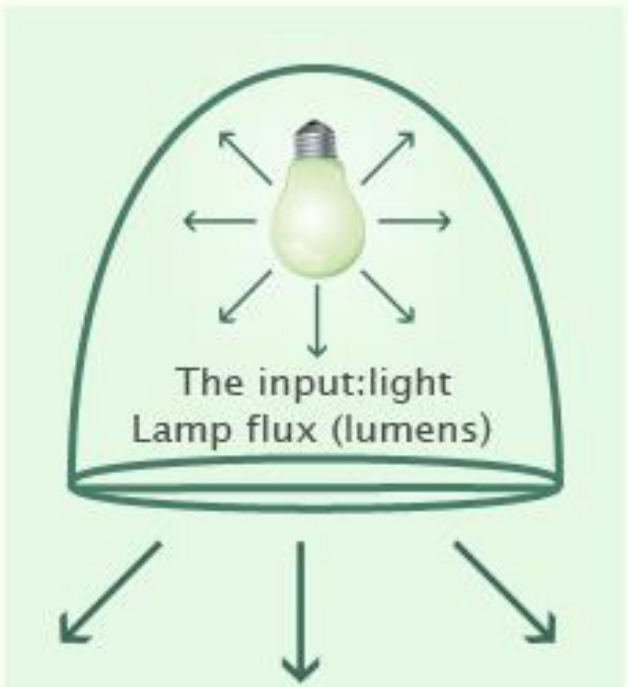

Low Turbidity
High Turbidity

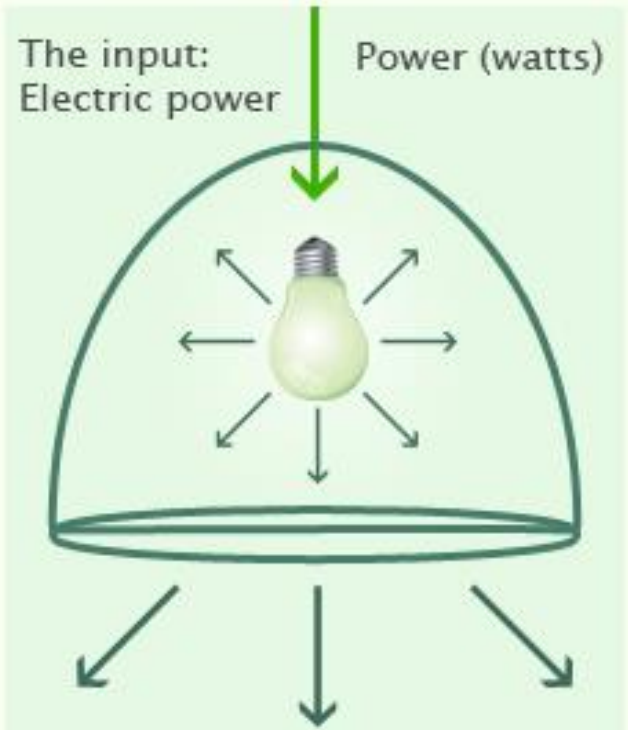
Factors affecting lighting system design

- Use of high-efficacy light source
- Use of more efficient luminaries
- Selective switching
- Utilization of daylight
- Luminaries of higher space-to-height ratio
- Higher reflectance surfaces of the room (caution)
- Visual task analysis
- Task-oriented lighting.

Efficacy







$$\text{Luminous efficacy of a source} = \frac{\text{lm}}{\text{W}}$$

$$\text{Luminarie efficiency} = \frac{\text{lm}}{\text{lm}}$$

$$\text{Luminarie efficiency} = \frac{\text{lm}}{\text{W}}$$

Lighting system design

Artificial Lighting Design

Artificial lighting may have to be provided,

- where the recommended illumination levels have to be obtained by artificial lighting only
- to supplement daylighting when the level of illumination falls below the recommended value
- where visual task may demand a higher level of illumination

A **lighting design** has several stages. Which are:

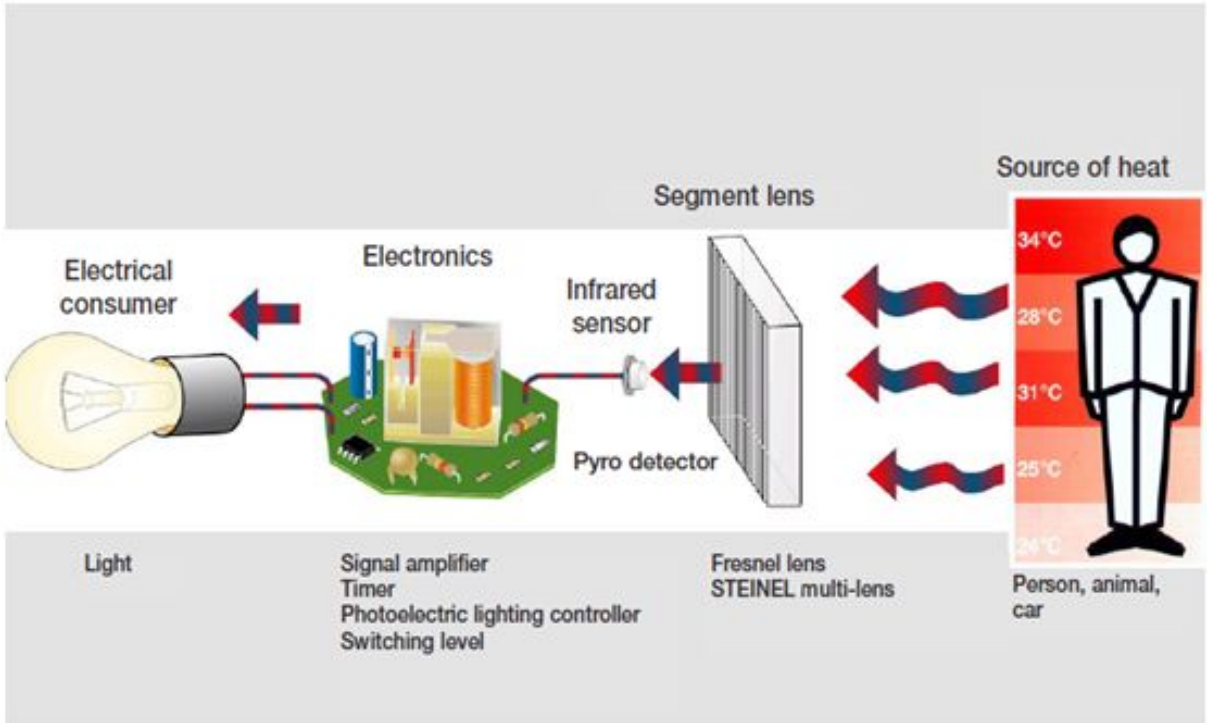
1. **Identification of the requirements** for the lighting system, illuminance levels, colour requirements, available space, etc;
2. **Selection of equipment, lamps, luminaires**: ***lamps,*** which influence the lighting level, colour characteristics and efficiency of the lighting system; ***luminaires*** affect the efficiency with which the light is distributed and so affect lighting efficiency and uniformity
3. **Design of the lighting system:** lighting systems are designed to achieve a reasonably uniform distribution of light on a particular plane (usually horizontal), avoidance of glare with a minimum expenditure of energy. The most rudimentary form of lighting design is done using a manual calculation – *the lumen method.* However lighting design is increasingly done by computer.
4. **System control:** once a lighting system has been designed it can be controlled in such a way as to make maximum use of available daylight, through selection of appropriate switching mechanisms and daylight responsive controls.

Types of Lighting Controls

Occupancy Sensors

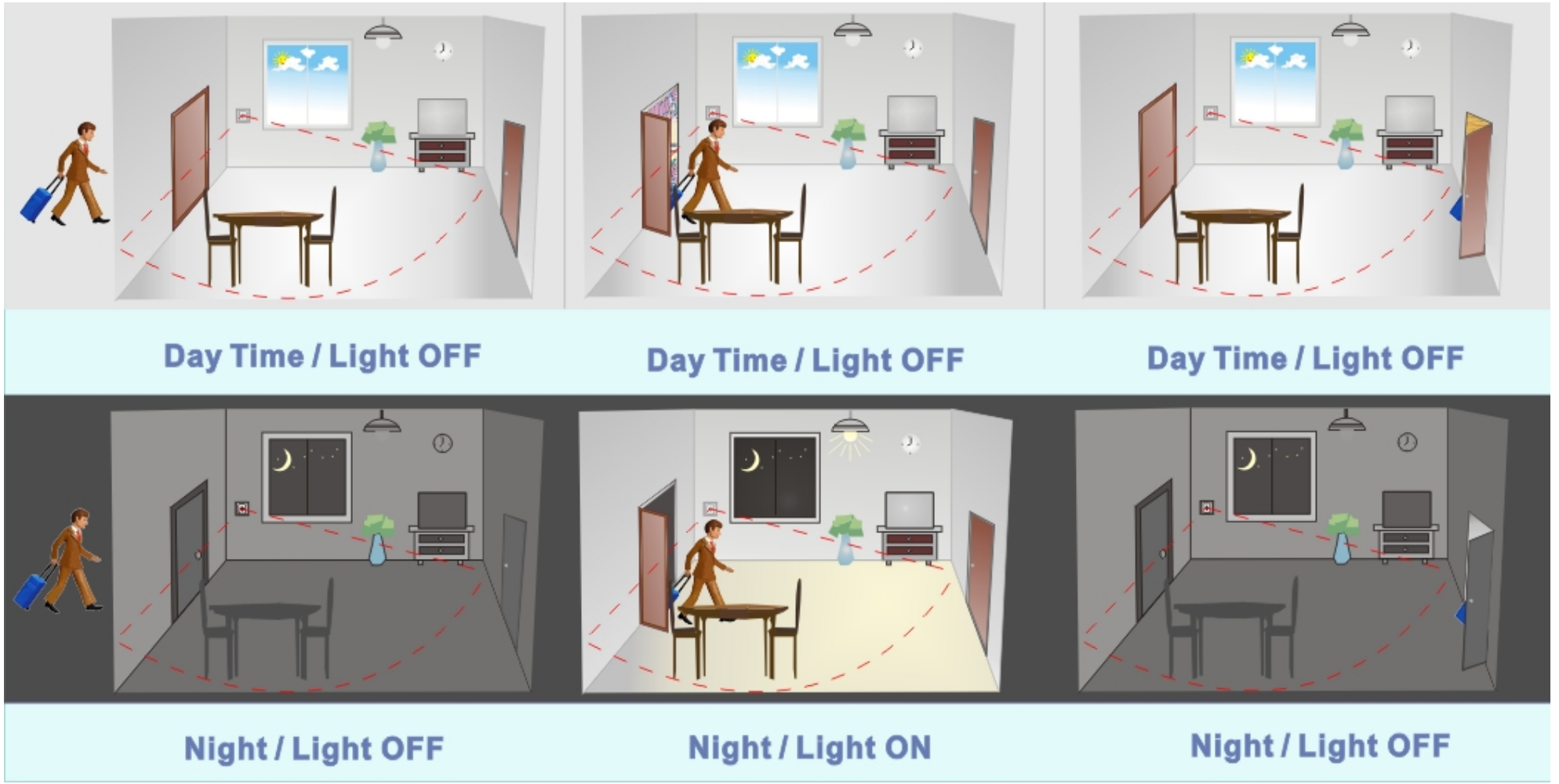
Occupancy sensors work off of sound or motion control – they automatically dim or switch lights off when an area has not been occupied for a specified amount of time and switch lights back on when motion is detected. This can result in 35-45 percent energy savings.

Passive infra-red (PIR) sensor that detects even slight motion. A Fresnel lens gives the sensor a panoramic view.



Types of Lighting Controls

Occupancy Sensors



Types of Lighting Controls

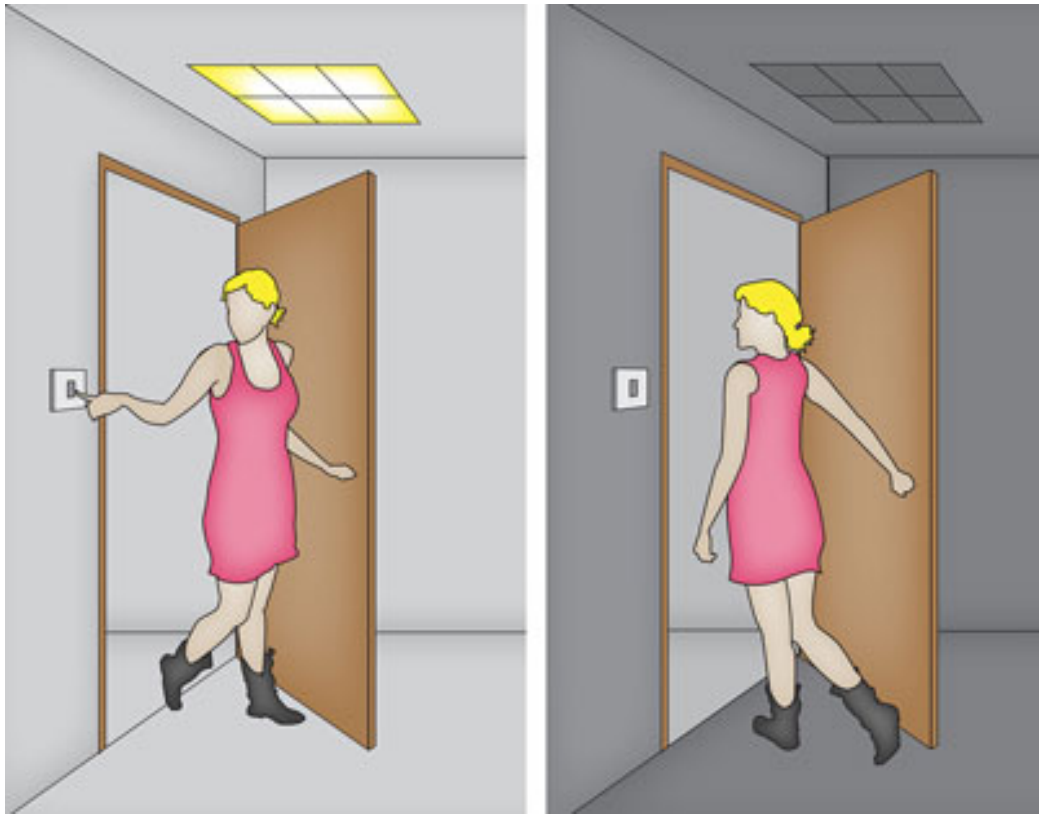
Task Lighting

Use different lighting system/lamps for different tasks

Types of Lighting Controls

ON/OFF

Switching off the light when not in use



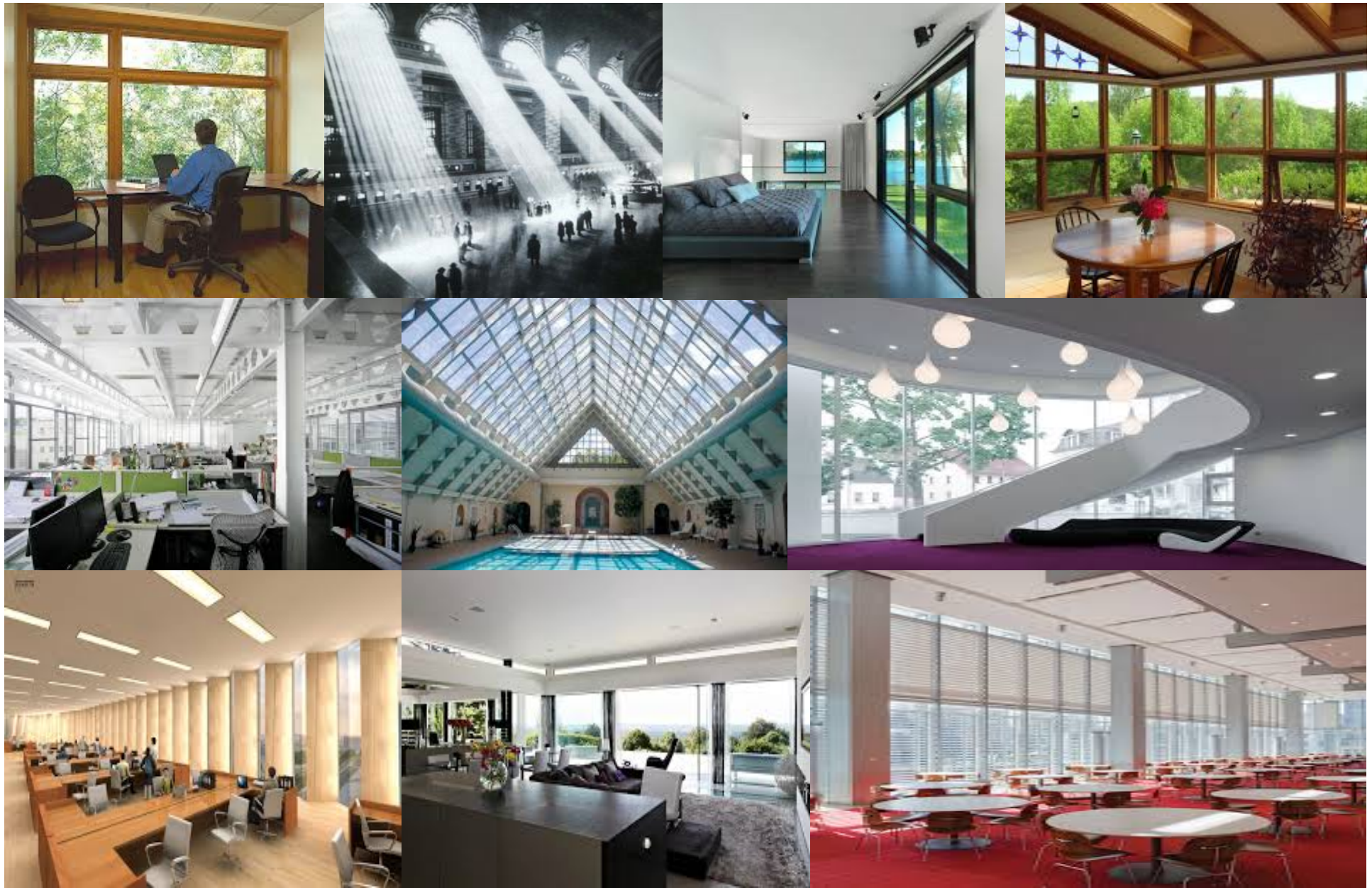
Recommended Illuminance level

INDUSTRIAL BUILDINGS & PROCESSES	Average Illuminance
I) General Factory Areas	
a) Canteens	150
b) Clock-rooms	100
c) Entrances, corridors, strairs	100
ii) Factory Outdoor Areas	
Stockyards, main entrances and exit roads, car parks,	20
internal factory roads	
iii) Aircraft Factories and Maintenance Hangars	
a) Stock parts productions	450
b) Drilling, riveting, screw fastening sheet aluminium layout	300
and template work, wing sections, cowling welding,	
sub-assembly, final assembly and inspection	
c) Maintenance and repair (bangars)	300
iv) Assemble Shops	
a) Rough work, for example, frame assembly and	150
assembly of heavy machinery	
b) Medium work, for example, machine parts, engine assembly,	300
vehicle body assembly.	
c) Fine work, for example, radio and telephone equipment, typewriter and	700

Recommended Illuminance level

Hotels	
Entrance Halls	50
Receptions, Cashiers & Porter's desks	200
Bars, Coffee base, dining rooms, Grill rooms, Restaurants, Lounges	50
Cloak Rooms, Baggage Rooms	50
Bed Room	30
Bath Rooms	50
Food Preparation & Stores, cellars, Lifts and corridors	100
Transport	
Air ports	150
Ticket Counters, Checking, desks and information desks	300
Departure Lounges, other waiting Areas	150
Baggage reclaim	150
Baggage Handling	50
Customers & Immigration halls	300
Concourse	150
Railway Stations	
Ticket Office	300
Information Office	300
General	50
Counter	150
Waiting Rooms	150
Concourse	150
Time Table	150
Ticket Barriers	150
Platforms (Covered)	30

DAYLIGHT INTEGRATED BUILDINGS



DAYLIGHTING SYSTEMS

Day lighting systems enhance the livability of interior spaces and extend the sustainability of the built environment through a reduced reliance on electric lighting.

SCOPE OF DAYLIGHTING

- Improved light quality
- Better occupant comfort and health
- Labor cost savings
- Light load reduction
- Energy cost savings

DAYLIGHT DESIGNING CONCEPT

Step 1 : Design basis

Step 2 : Building orientation and form

Step 3 : Daylighting the perimeter

Step 4 : Daylighting the core

Step 5 : Window and glazing selection

Step 6 : Shading and visual comfort

Step 7 : optimizing day lighting design

Step 8 : Mechanical co-ordination

Step 9 : Auxiliary lighting integration

Step 10 : Commissioning and maintenance

DESIGN BASIS

- It is necessary to define required light levels and lighting power densities (LPD) for each area in the building.

- Lighting Power Density (LPD) is a measure of the amount of electric lighting installed in a space. It is expressed in units of lighting power to be supplied by the luminaire (Watt) divided by the area of the space to be lit (m^2).

- Identify areas/zones where daylighting will be most beneficial.

BUILDING ORIENTATION

- The position of the sun varies according to the time of day and season.
- The building must be located and oriented to take advantage of this movement.
- Sun path charts show the variation in the sun’s position.
- These charts can be used to determine the impact of shading on a building.
- Site building to maximize daylight availability.

BUILDING ORIENTATION

- **Maximize southern exposure:** The south facade allows the most daylight access and the best control of excess solar gain in the summer. This is the most desirable fact for daylighting and is best suited for rooms where variability in light levels is acceptable.
- **Optimize northern exposure:** Although daylight exposure is less abundant on the north side, larger buildings where light uniformity and quality is key, large north-facing glazing areas can minimize electric light use.
- **Minimize east-west exposure:** It is difficult to control daylight penetration o the east and west facades because of low sun angles. Daylight variability is high since these orientations provide only half-day exposure to sunlight.
- **Use different glazing treatments on each facade:** If possible, vary the glazing selection by facade. For example, the use of a glazing with a lower solar heat gain coefficient (SHGC).

BUILDING FORM

- Place service areas in central core.
- Maximize perimeter exposure to daylight
- Select room depth to correspond with daylighting zone.
- Use low-rise buildings for greater daylight access.
- Use atria to maximize core daylight.
- Do not oversize atria.
- Use atria as buffer spaces.
- Place interior windows or openings into atria
- Place windows on two walls.
- Incorporate exterior features to increase daylight entry.
- Select light-coloured exterior surface materials

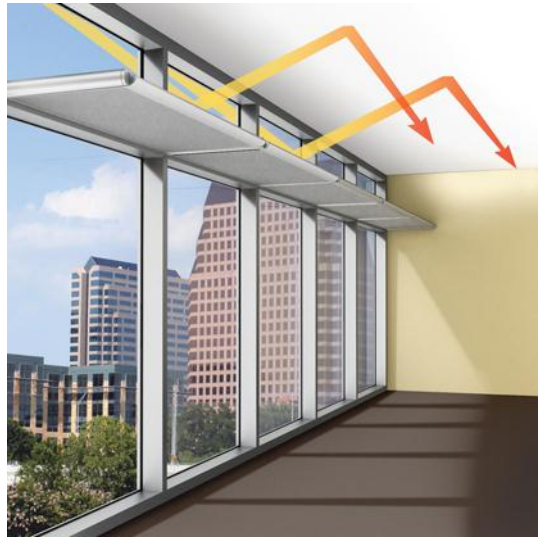
DAYLIGHTING THE PERIMETER

(A) WINDOW PLACEMENT

- Use strip windows for uniform office lighting
- Match location of work areas with windows.
- Use low-e argon-filled windows
- Use separate apertures for view and daylight.
- Do not oversize windows
- Use a sloped ceiling to increase window height
- Ensure glazing area is visible
- Use horizontal, not vertical, windows

(B) LIGHT SHELVES

- Use interior and exterior light shelves
- Use light shelves for shading.
- Use a light surface colour for ceilings and light shelf.

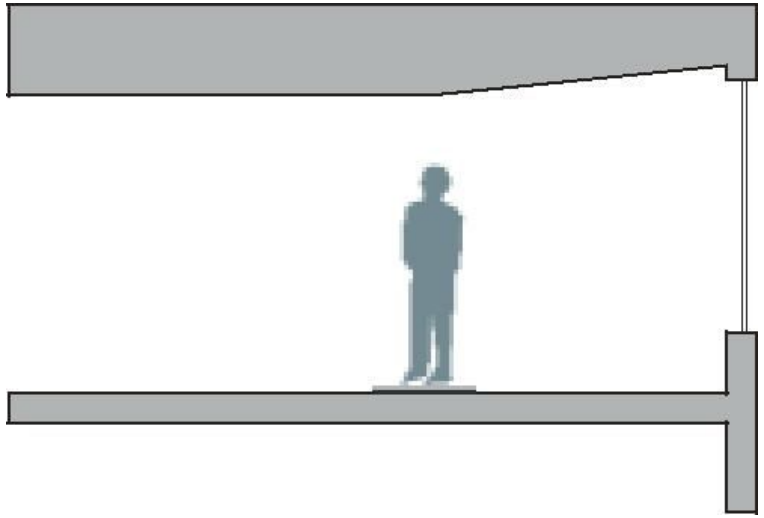


C) INTERIOR DESIGN AND SPACE LAYOUT

- Arrange furniture for maximum daylight access
- Position dividers/partitions to enhance daylighting
- Avoid using dark colours
- Avoid reflective surface finishes

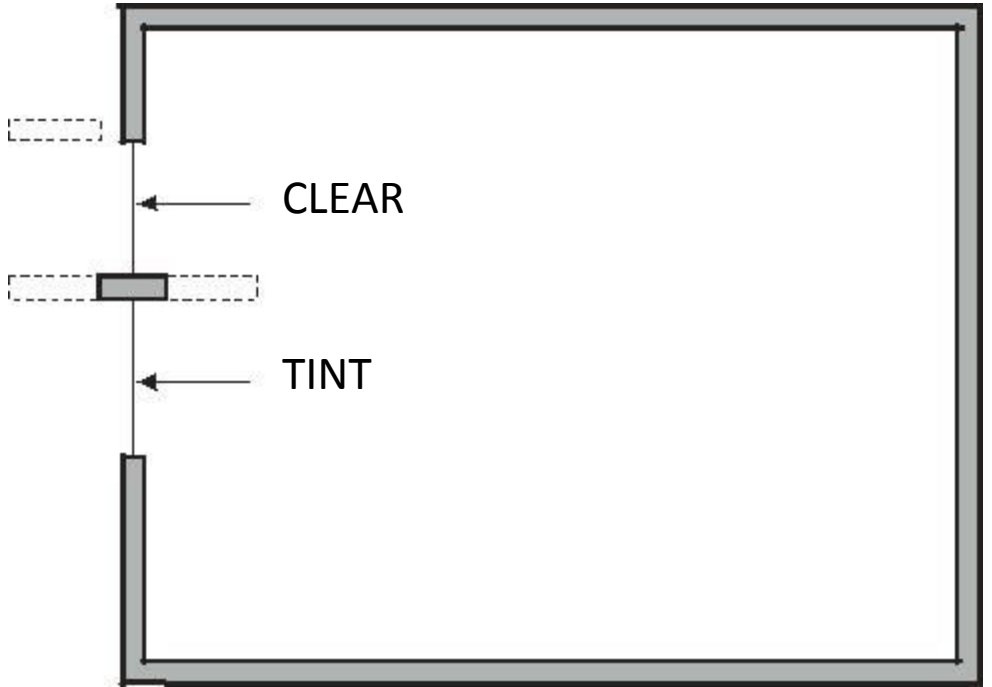
STRIP WINDOWS FOR UNIFORM LIGHTING

SLOPED CEILING PROVIDES MORE UNIFORM LIGHT



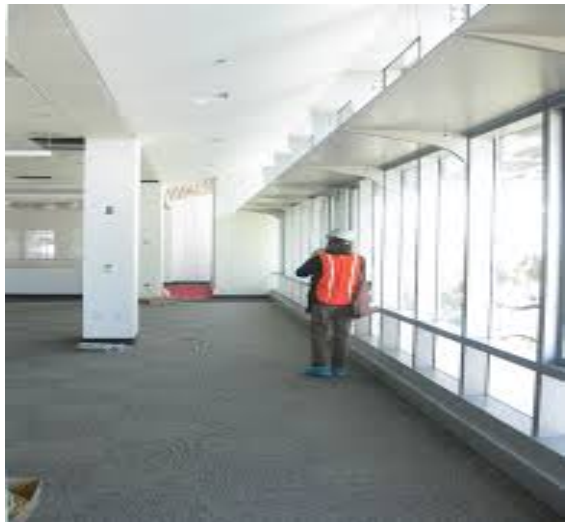
SEPARATE APERTURES FOR VIEW AND DAYLIGHT.

DIVIDED WINDOW PROVIDES FOR VIEW AND DAYLIGHT



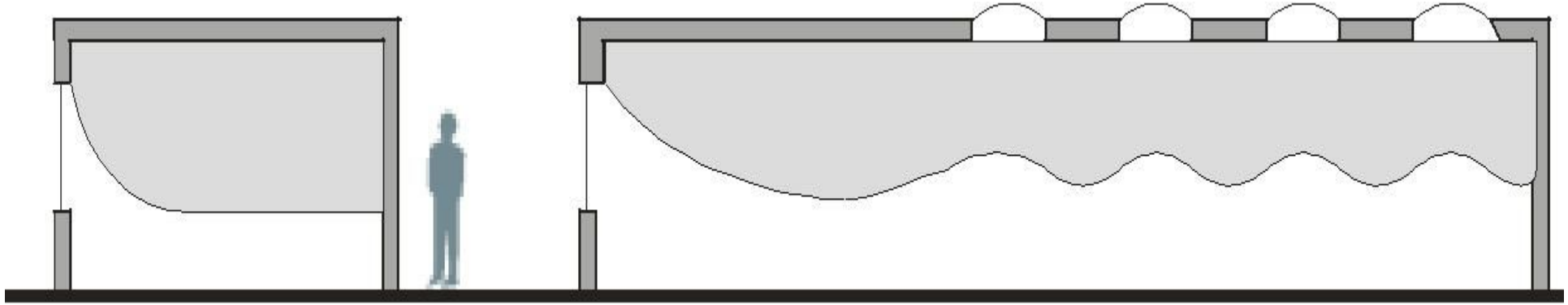
EXTERIOR LIGHT SHELVES

INTERIOR LIGHT SHELVES

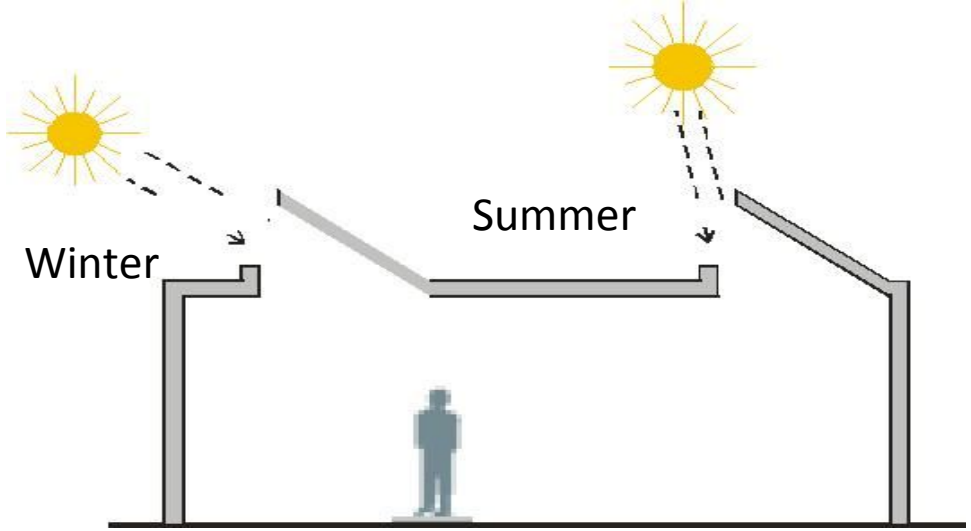


DAYLIGHTING THE CORE

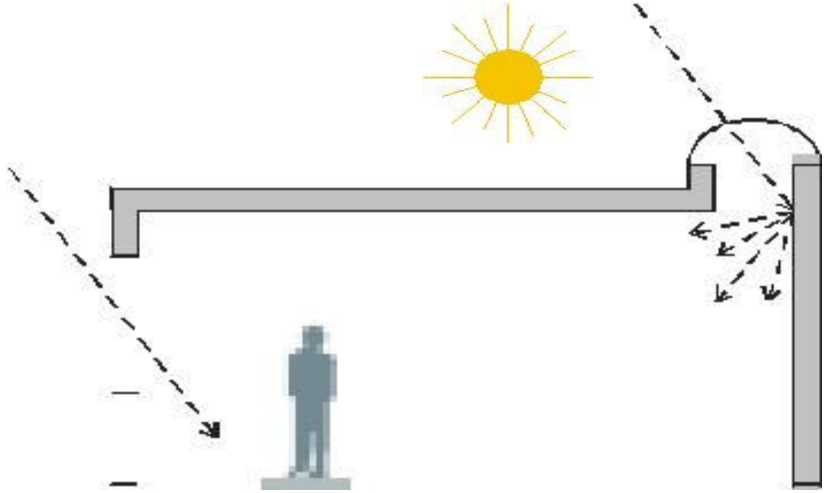
IMPROVED LIGHT DISTRIBUTION IN LONG SPACES WITH TOPLIGHTING



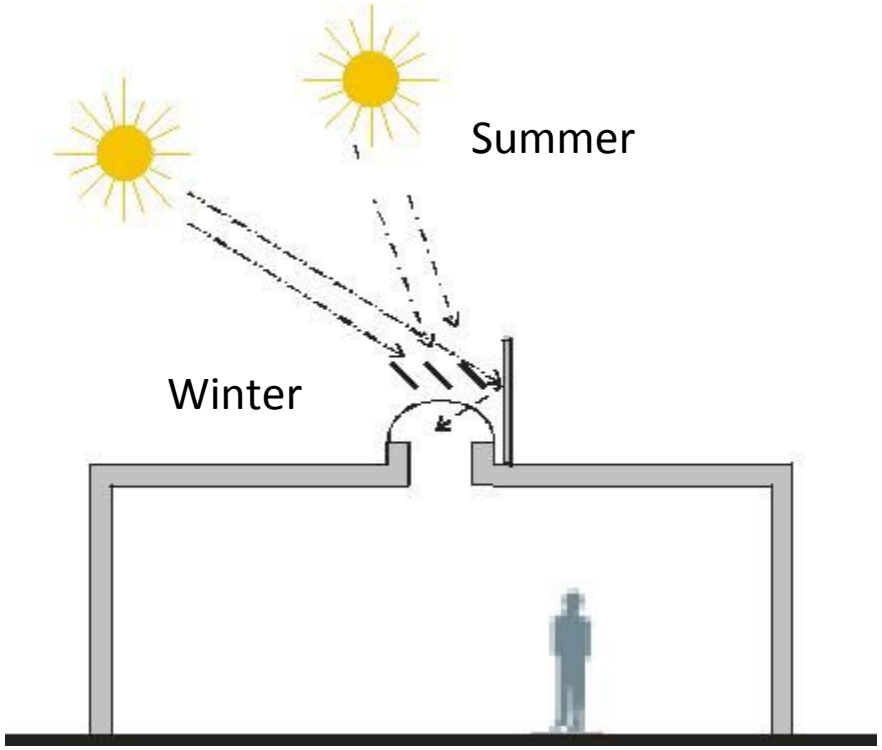
USE SLOPED SKYLIGHTS.



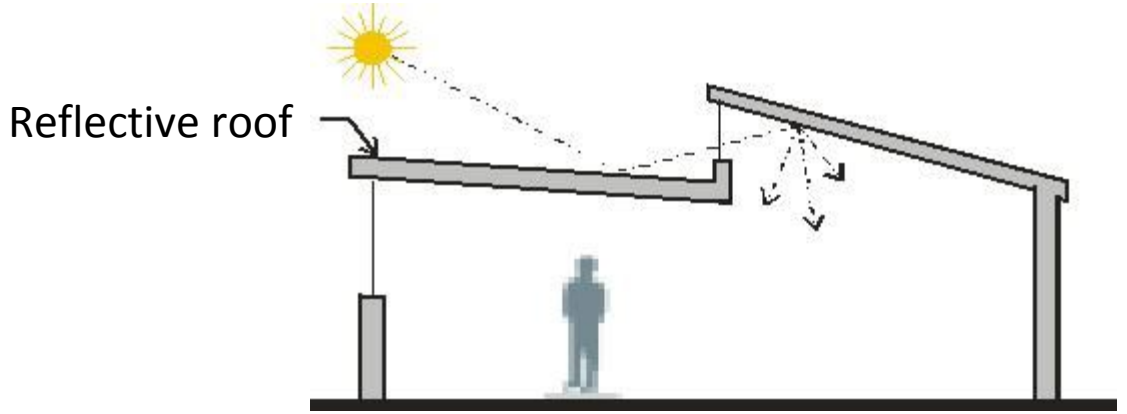
LIGHT DIFFUSION AFTER ENTERING SKYLIGHT



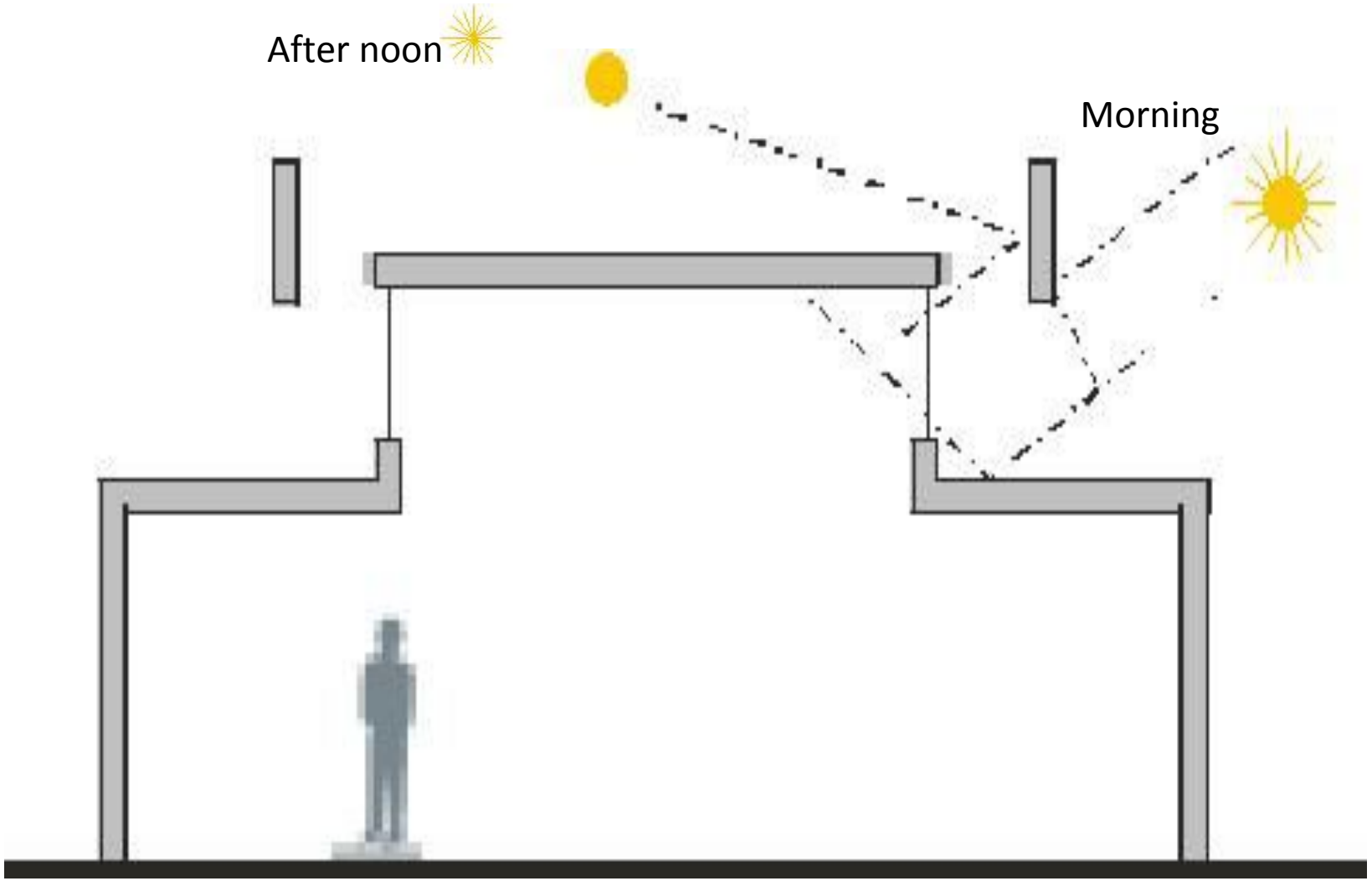
SEASONAL USE OF SHADES WITH SKYLIGHTS



REFLECTIVE ROOF USED WITH CLERESTORY



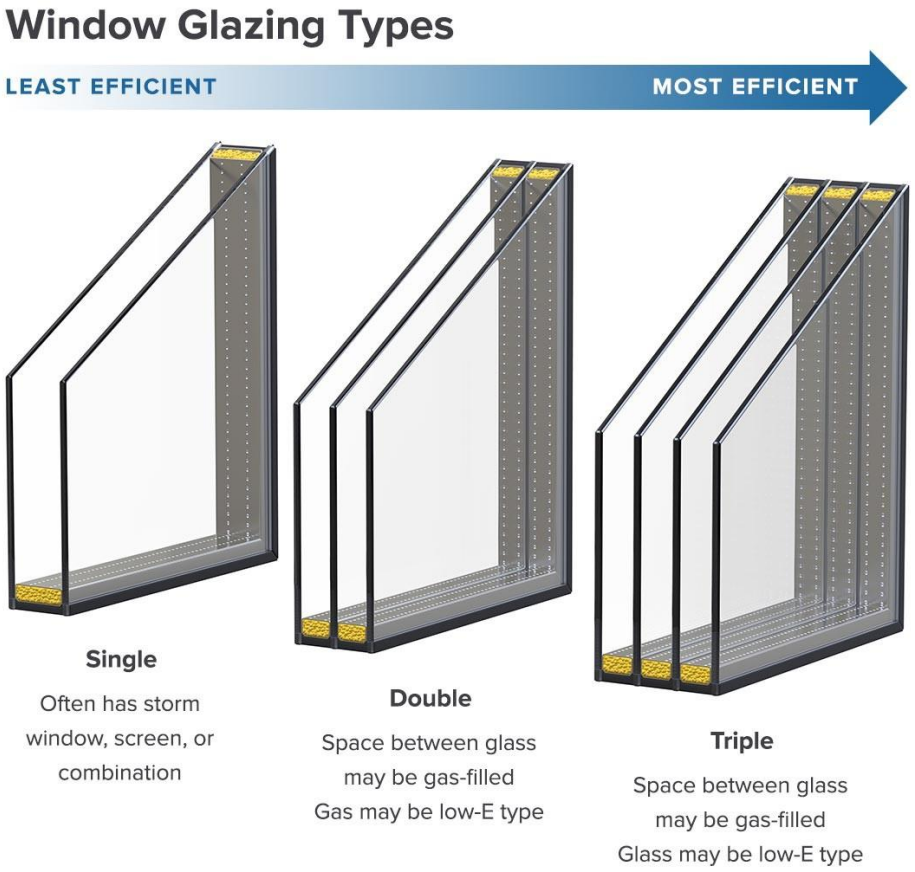
SUNCATCHER BATTLES WITH EAST/WEST CLERESTORIES



Structural Glazing can be simply defined as a continuous system of bonding specialized glass to an aluminum frame using specialized silicone sealants.

Advantage:

- In structural glazing the two materials predominantly used are glass and aluminum, which neither corrode nor decay when comparing other conventional building materials like wood, iron, steel, etc.
- Glass is an excellent material for thermal insulation, waterproofing, and energy conservation.
- The glass is a bad conductor of heat, hence it saves energy in the air conducting the building.
- An easy-to-clean surface



Structural glazing benefits

- Lightweight
- Excellent exterior characteristic
- Weather ability
- Vibration Damping
- Sound insulation
- Heat insulation

WINDOW AND GLAZING SELECTION

- Reducing Window U-value
- Use low U-value windows to reduce building heating load
- Use multiple layers of glazing.
- Consider the use of film technologies
- Use inert gas fills
- Use low-e coatings for most applications
- Use low U-V transmission glazing's where space contents are valuable
- Use blue/green or spectrally-selective glazings over grey and reflective glazings
- Avoid reflective glass

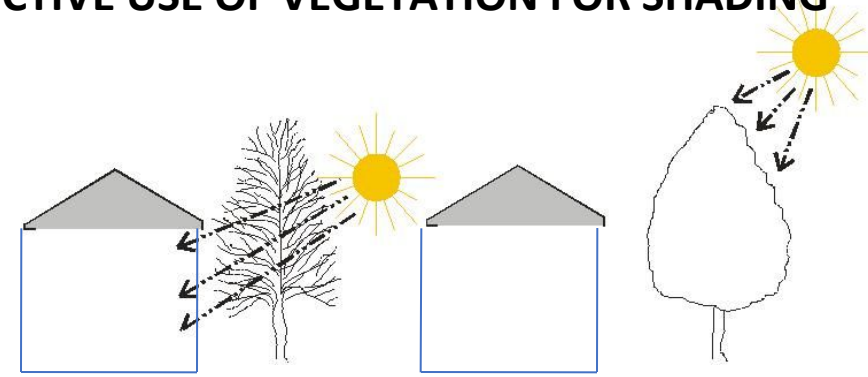
SHADING AND VISUAL CONTROL

EXTERIOR SHADING TECHNIQUES

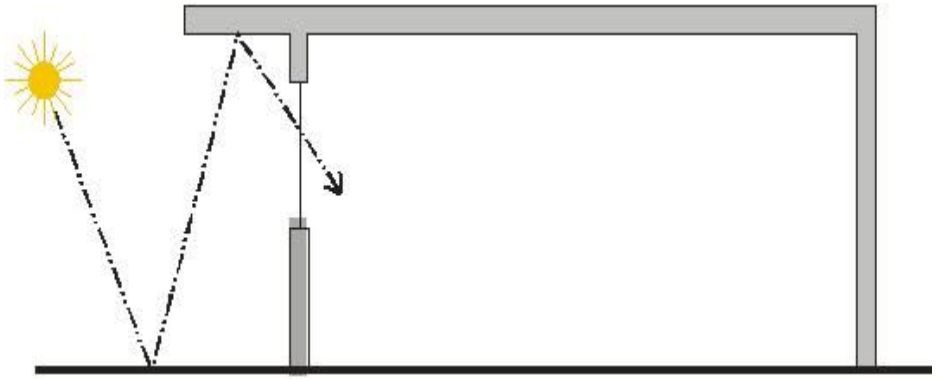
- Use exterior shading devices to control solar gains
- Use vegetation as seasonal shading devices
- Use screens to diffuse direct sunlight
- Paint overhangs white to reflect light
- Use vertical or horizontal louvers
- Use movable shading devices.

EXTERIOR SHADING TECHNIQUES

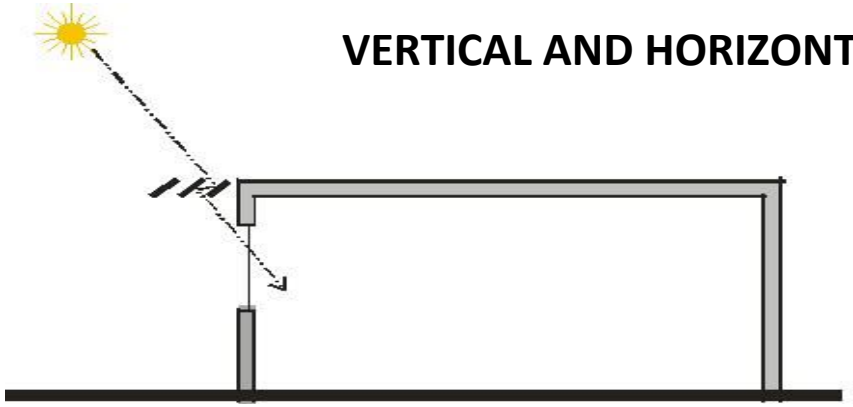
EFFECTIVE USE OF VEGETATION FOR SHADING

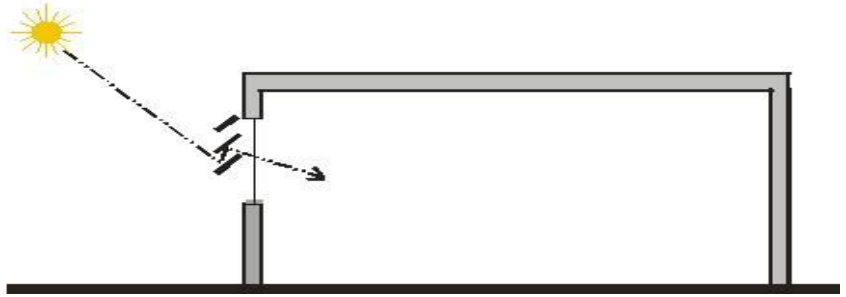


OVERHANG TO INCREASE LIGHT DIFFUSION



VERTICAL AND HORIZONTAL LOUVERS TO RE-DIRECT SUNLIGHT





INTERIOR SHADING TECHNIQUES

- venetian blinds or outdoor louvers
- Use light coloured shades

Luminaire performance parameters

1. Rated input power (P in W)
2. Rated luminous flux (Φ in lm)
3. Rated luminous efficacy (η in lm/W)
4. Rated luminous intensity distribution (in cd or cd/klm)
5. Rated correlated color temperature (Tcp in K)
6. Rated color rendering index (CRI)
7. Ambient temperature related to the performance of the luminaire (tq in ˚C)
8. Rated median useful life (Lx in hours with x for the associated rated luminous flux maintenance factor in %)
9. Rated abrupt failure value (in %)

Selection of lighting equipment:

- Light output (lumens)
- Total input wattage
- Efficacy (lumens per Watt)
- Lifetime
- Physical size
- Surface brightness / glare
- Colour characteristics
- Electrical characteristics
- Requirement for control gear
- Compatibility with existing electrical system
- Suitability for the operating environment

Lightning calculation method

Room Index- It is based on shape and size of the room. It describes the ratios of the room's length, width and height. It's usually between 0.75 to 5.

$$\text{Room Index (R.I.)} = \frac{l \times b}{h_{wc}\,(l + b)}$$

Where "***l***" is the length of the room,

"w" is the width of the room and,

h_{wc} is height between work plane i.e. Bench to Ceiling

Maintenance Factor:

It is ratio of the lamp lumen output after a particular interval of time as compared to when it was new.

$$\text{M.F.} = \frac{\text{Lumen o/p of Lamp after some time}}{\text{Lumen o/p of Lamp when new}}$$

It is less than or equal to 1.

Utilization Factor

Utilization factor (UF) is the ratio of total lumens received on the working plane to the total lumens emitted by the light source.

Utilization factor =Lumens received on the working plane/Lumens emitted by the lamp

It depends upon

- The efficiency of luminaire
- The luminaire distribution
- The geometry of the space
- Room reflectance's
- Polar curve

$$N = \frac{E \times A}{F \times UF \times MF}$$

N = number of lamps required.

E = illuminance level required (lux)

A = area at working plane height (m2)

F = average luminous flux from each lamp (lm)

UF= utilisation factor,

MF= maintenance factor,

EXAMPLE 1:
An office has a length of 20m, width=10m, and height=3m.
1) Ceiling to desk height is 2m.
2) Area to be illuminated to a general is 250 lux using a twin lamp 32-watt CFL Luminaire with an SHR of 1.25.
3) Each lamp has an initial output of 85 lumens per watt.
4) Maintenance factor is 0.63, Utilisation factor is 0.69
Determine the room index and the number of lamps required.

EXAMPLE 2:
The office measures 10*7 m with a floor-to-ceiling height of 3m. The working plane height is 0.8m. The office is being used for general office duties including some computer use. Determine the number of luminaires required in this office.