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INTRODUCTION TO LIGHTING

Outline

- ① Lighting & Lighting Terminology
- ② Lighting Technologies & Efficiency
- ③ Daylight & Controls
- ④ Standards & Labels

Insight.....Lighting

- World around us is perceived through **Light**, either natural or artificial.
- **Light** is probably the **most important element interfacing** human & surroundings.
- **Light** provides **Life** to the occupancy zone.
 - Occupants performance, mood, safety, security and decisions.
- **Lighting** also has strong health, social and emotional significance.

Synergetic Requirements

⦿ Human Needs

- Visual performance, visual comfort, health, safety, mood, well being

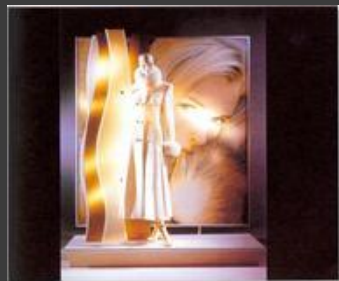
⦿ Economics & Environment

- Installation, operation & maintenance energy and cost, affordability, sustainability

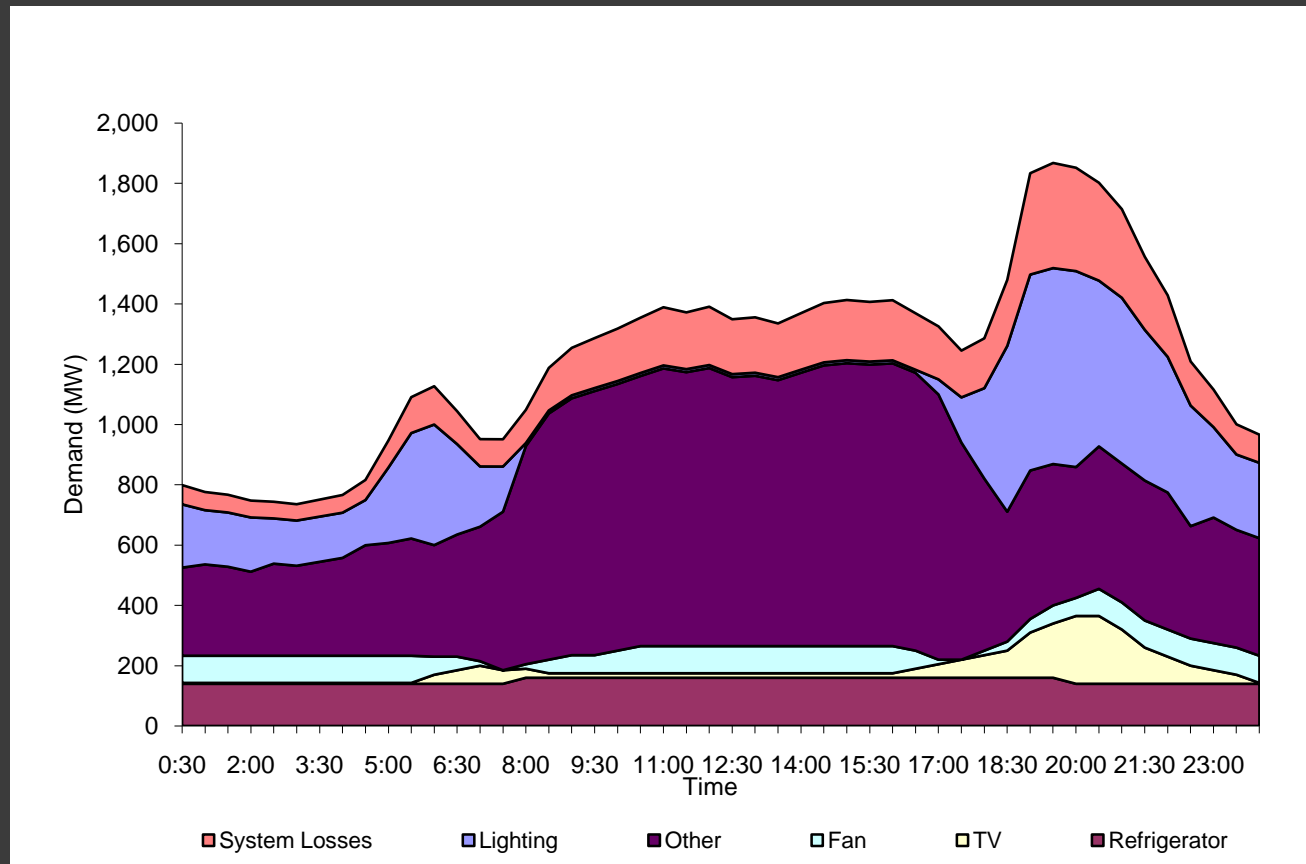
⦿ Technical & Architectural

- Design, form, technology, codes & standards

Aspects.....



End Use Electricity Demand



Unpublished Load Research Results 2009-Personal Communication

About Light....

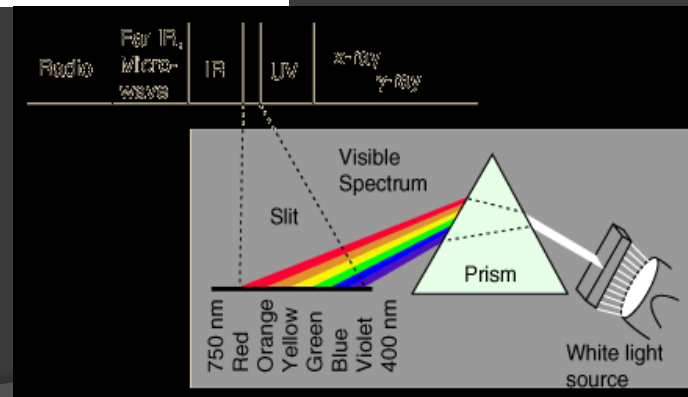
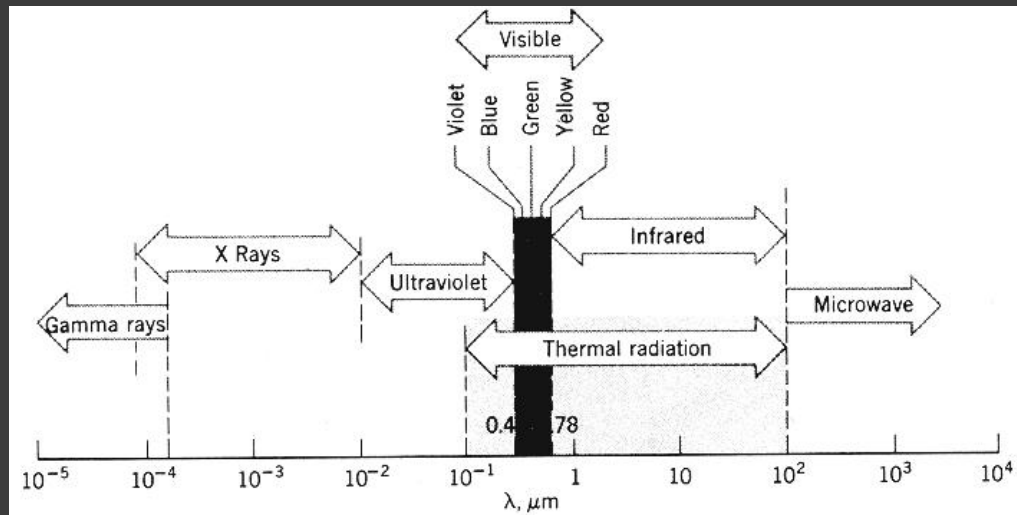
- What is Light?

From Electromagnetic Theory:

- Radiant energy in the form of electromagnetic *waves* capable of exciting the retina and producing the Visual Sensation (380-780 nm wave length)
-
- Radiant energy that excites the human eye is produced by
 - Incandescence (Incandescent body)
 - Fluorescence (Gas discharge)
 - Solid-state device (Semi-conductor)

About Light....

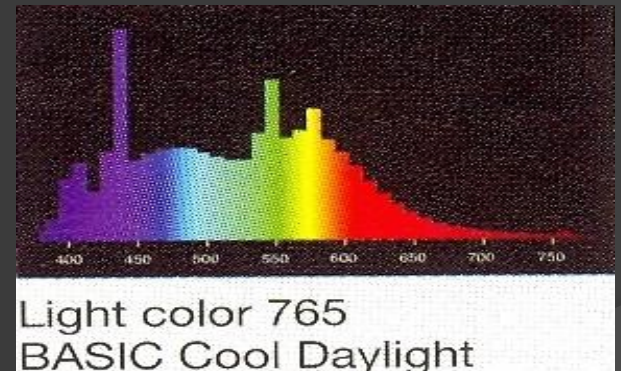
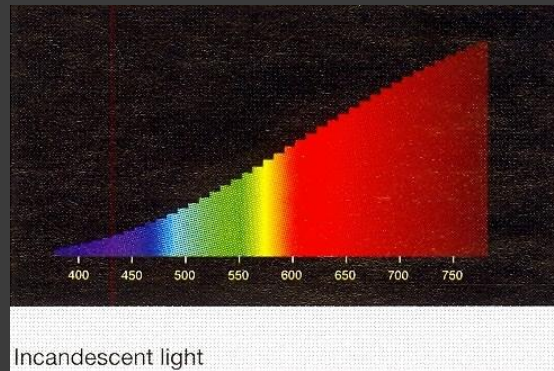
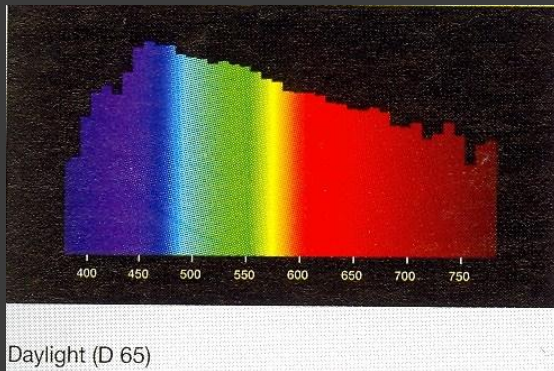
- Visible range in the Electromagnetic spectrum



Spectral Power Distribution

Spectral Power Distribution (SPD)

- A pictorial representation of the radiant power emitted by a light source as a function of the wave length of the visible range

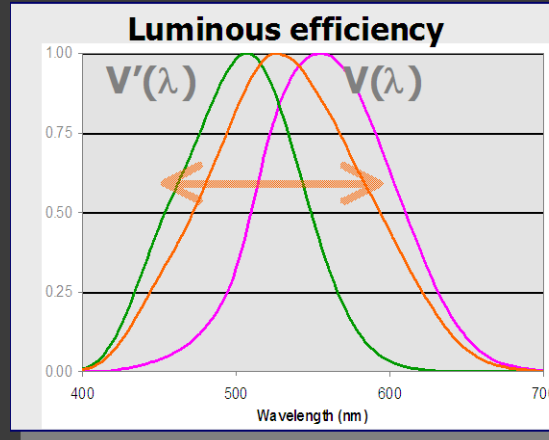


Source: *Indoor & Outdoor Lighting 2008/2009 - OSRAM*

Lighting Terminology

- Light output
 - Time rate flow of Light emitted by a source in ALL directions, Measured in Lumens (lm)
 - Value may depend on temperature or position and depreciates with time

Light Output Changes from Starlight to Daylight surroundings



Human Eye Sensitivity

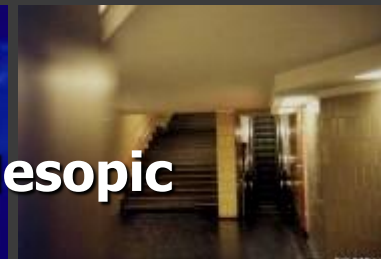
Starlight

Moonlight

Dim interiors

Office lighting

Daylight



Source: LRC of RPI, NY

Lighting Terminology

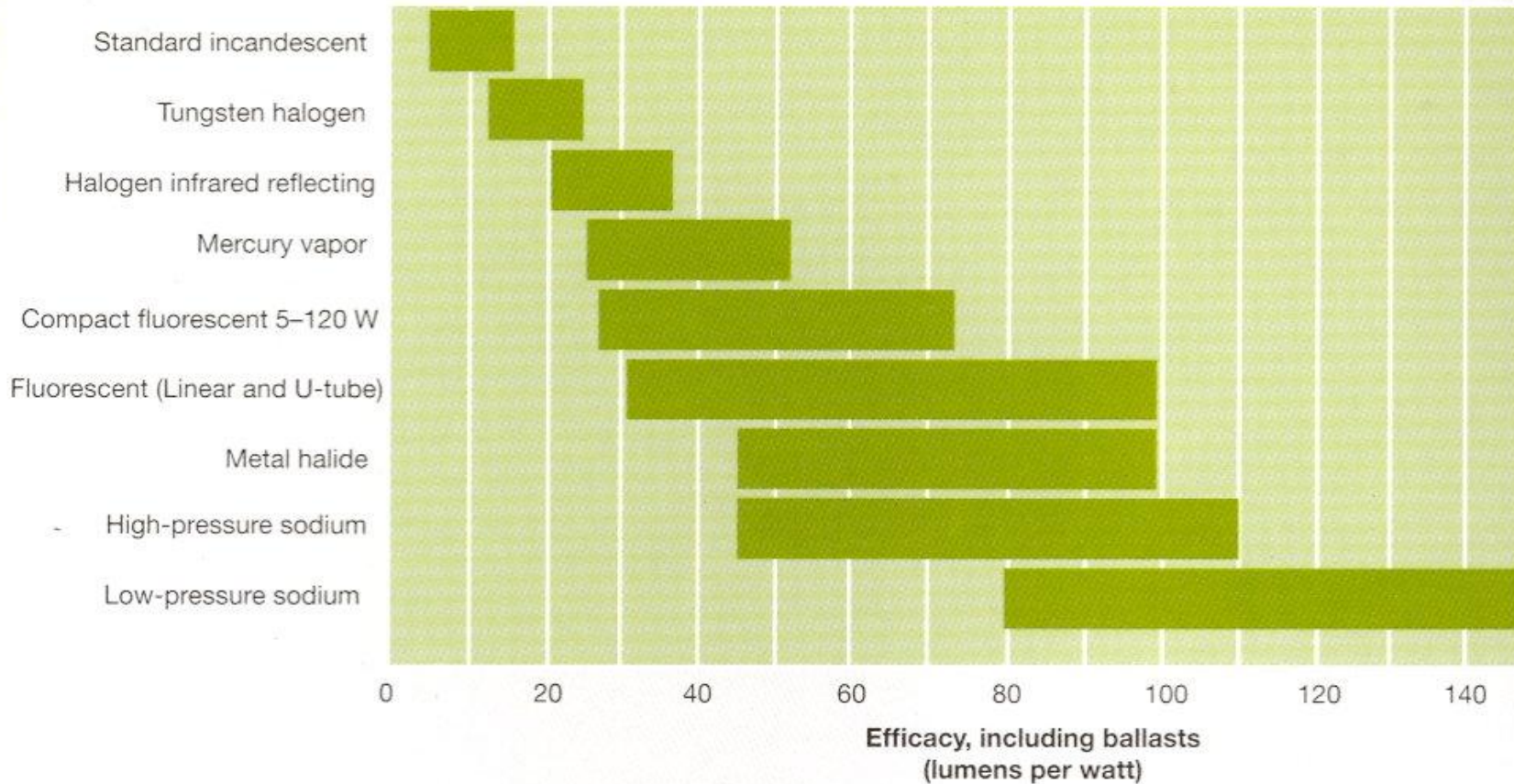
- Luminous Efficacy (lm/W)
 - Ratio of the total Light Output of a lamp/fitting to its total power input (i.e. lm/W)
 - Gives an indication of the energy added (as heat) into the space where the lamp is placed
 - An important parameters for comparison or selection of lamps

Lighting Terminology

Source	Efficacy (lm/W) including Ballast
Standard Incandescent	5-15
Tungsten Halogen	10-25
Halogen Infrared Reflecting	20-35
Fluorescent (linear & U-tube)	25-100
Compact Fluorescent Lamp	25-70
Mercury Vapour	25-50
Metal Halide	45-100
High Pressure Sodium	45-110
Low Pressure Sodium	80-150
Natural Light	105
LED	50-150*

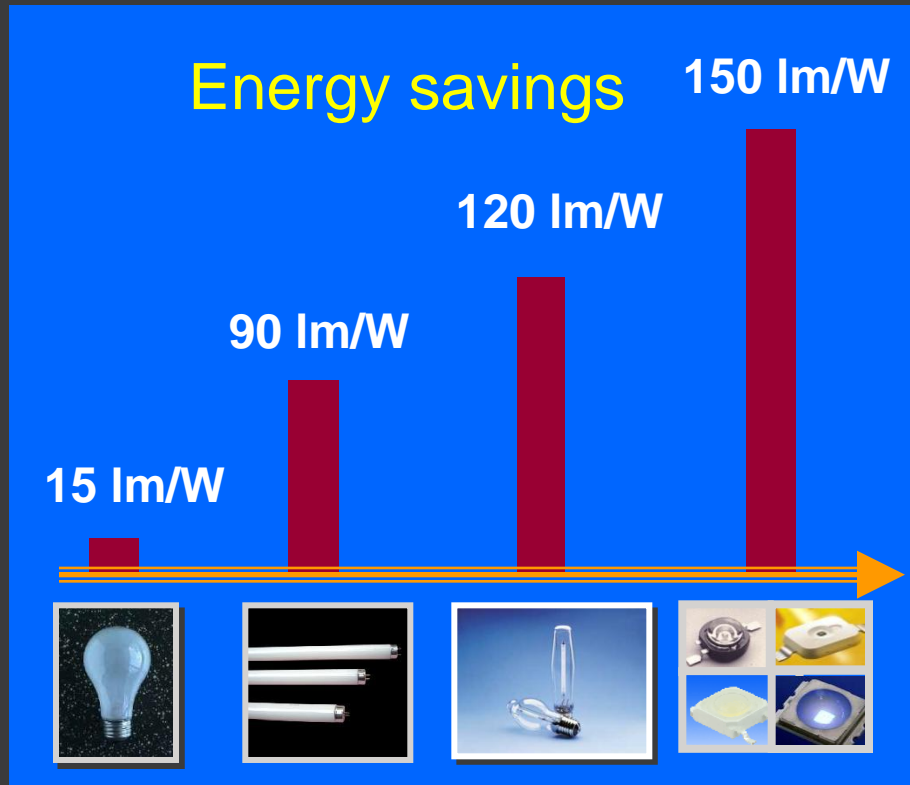
Source: E Source Lighting Atlas

Lighting Terminology

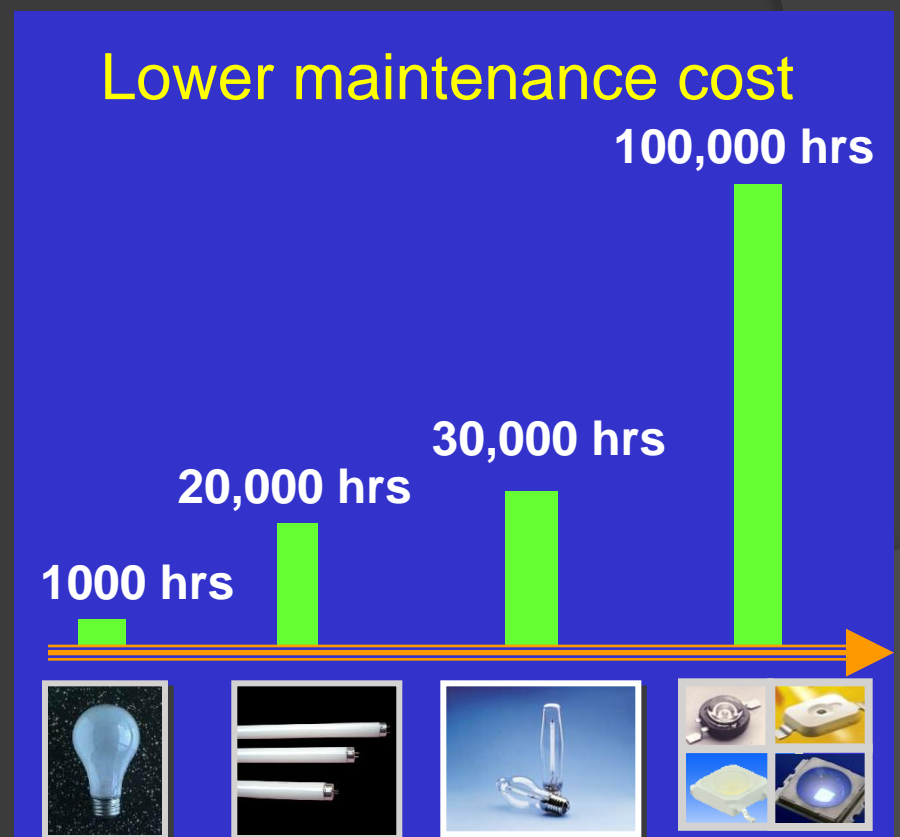


Source: *E Source Lighting Atlas*

Promise: by 2012



Source: LRC of RPI, NY



Lighting Terminology

- Colour Rendering Index (CRI)
 - Measure of the degree of the colour shift the objects undergo when illuminated by light source as compared with the color of those objects when illuminated by a **reference source**



Lighting Terminology

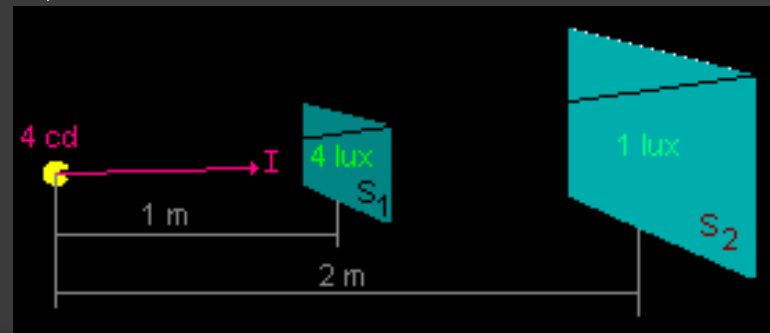
Source	CRI
Incandescent	100
Linear Fluorescent	75-85
CFL	82
Standard Metal Halide	65
Standard HP Sodium	22
Daylight	100

Source: Lighting Research Center, RPI, NY

Lighting Terminology

- Illuminance
 - Areal density of the luminous flux incident at a point on a surface
 - Calculated as amount of lumens per unit area
 - Denoted in Lux (lm/m^2) or footcandle (lm/ft^2)
 - Horizontal illuminance, vertical illuminance etc

R^2 -Law



Recommended Illuminance Levels

Standard maintained illuminance (lux)	Characteristics of activity/ interior	Representative activities/interiors
300†	Interiors occupied for longer periods, or when visual tasks are moderately easy, i.e. large details > 10 min arc and/ or high contrast.	Libraries, sports and assembly halls, teaching spaces, lecture theaters, packing
500†	Visual tasks moderately difficult, i.e. details to be seen are of moderate size (95-10 min arc) and may be of low contrast; also colour judgment may be required.	General offices, engine assembly, painting and spraying ,kitchens, laboratories, retail shops
750†	Visual tasks difficult, i.e. details to be seen are small (3-5 min arc) and of low contrast; also good colour judgment or the creation of a well lit, inviting interior may be required	Drawing offices, ceramic decoration, meat inspection, chain stores
1000†	Visual tasks very difficult, i.e. details to be seen are very small (2-3 min arc) and of low contrast; also accurate colour judgments or the creation of well lit, inviting interior may be required	General inspection, electronic assembly, gauge and tool rooms, retouching paintwork, cabinet making, supermarkets

Source: Code of Practice on EE Buildings in Sri Lanka

Lighting Technologies & Efficiency

- What does world of lighting want?
 - Acceptable return on investment (ROI)
 - Easy installation, O & M
 - Proven & tested products
 - Successful use technology is found elsewhere
 - Dissemination & communication with developers, designers & owners

Types of Lamps

- Three (3) major categories
 - Incandescent lamps.
 - Fluorescent lamps.
 - High Intensity Discharge (HID) lamps.
- An emerging fourth category
 - Light emitting diodes (LEDs).
 - White LED lamps.



Source: LRC of RPI, NY

Lighting Technologies & Efficiency

Type	Rated Power (W)	Light Output (lm)	Efficacy (lm/W)
T5	35	3600	100
T8	32	2800	85
T12	40	2650	70

Lighting Technologies & Efficiency

- Ballasts for Fluorescent
 - Device used for electric arc discharge lamps to control voltage, current & wave form
 - Operation of Fluorescent and HID lamps
 - Ballasts for fluorescent formerly magnetic, electromagnetic (operating 60 Hz) and currently electronic (20,000 -60,000 Hz)
 - **Electronic ballasts convert power to light more efficiently**

Lighting Technologies & Efficiency

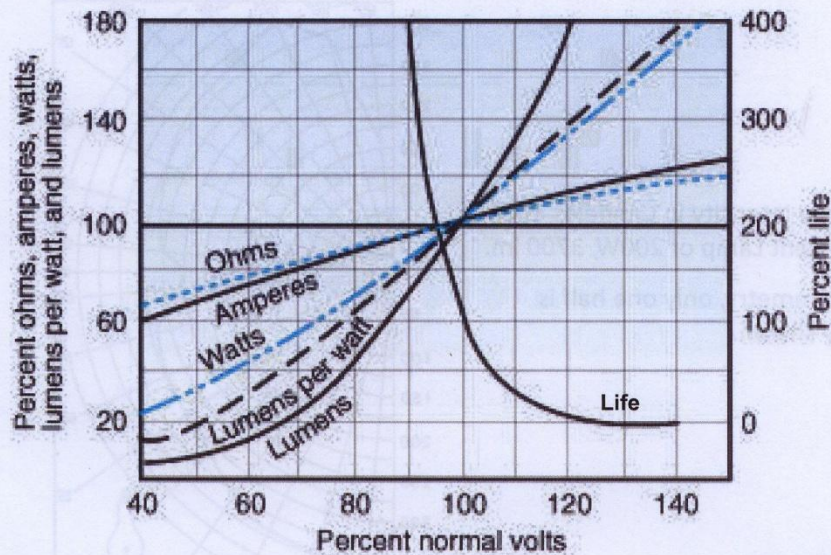
Source	Rated Life (hours)
Incandescent	1000
Halogen	2000
Fluorescent	7500-10000
Mercury Vapour	24000
Metal Halide	12000
HP Sodium	24000
LP Sodium	15000
LED	1000-100,000*

Source: E Source Lighting Atlas

Lighting Technologies & Efficiency

- Change in operating conditions

Effect of Voltage



Source: IESNA Lighting Handbook

Lighting Technologies & Efficiency

- Lighting Controls
 - Functions
 - Switching off when not needed (energy money save)
 - Adjust the quantity of light in response to the end use (energy save, change ambiance)
 - Types
 - Timer clocks (simple & cheap, manual or programmed)
 - Occupancy sensors (PIR, Ultrasonic, Dual)
 - Daylight sensing

Lighting Technologies & Efficiency

- Lighting Controls
 - Application
 - Sensor sensitivity and coverage area are issues
 - Occupancy sensors have potential for Intermittent use
 - In general around 30% of lighting energy savings possible
 - Emerging
 - Digital control, wireless control devices
 - Lighting automation through Building Automation Systems (BAS)
 - DDC (direct digital control)

Lighting Technologies & Efficiency

- Lighting Controls



Source: LRC of RPI, NY

Lighting Technologies & Efficiency

- Daylight
 - Best source of Lighting
 - Almost highest level of efficacy (100 lm/W)
 - Reference for many CRI estimation
 - Found to have favorable impact on Human health
- Use of Daylight
 - To be integrated to a maximum (attn Heat gain)
 - Consider at building design stage
 - Attention to glare issue, sky models

Lighting Technologies & Efficiency



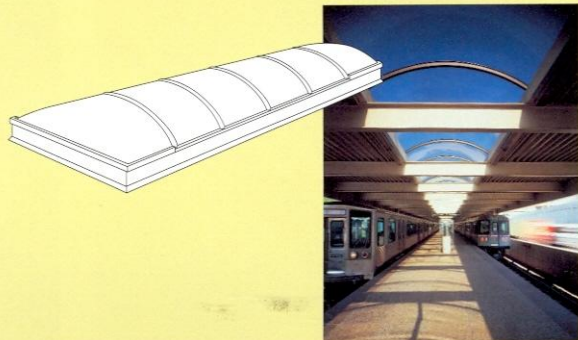
Source: Manufacturer Catalogue

Lighting Technologies & Efficiency

LOW- AND STANDARD-RISE BARREL VAULT SKYLIGHTS

Models BV, BVV, SBV

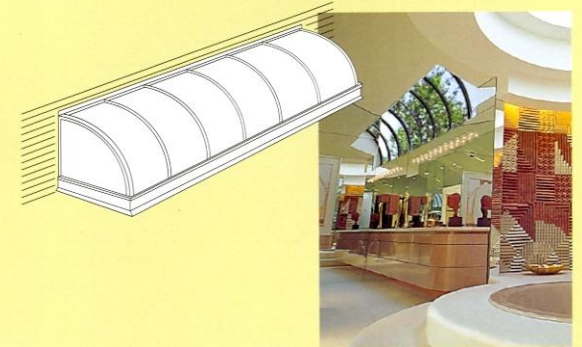
Available in widths of 36" to 120" with vertical ends, or 36" to 72" with formed ends. Structural models (SBV) available in widths from 10' to 20'. Unlimited lengths.



QUARTER-ROUND VAULTS

Models QR, SQR

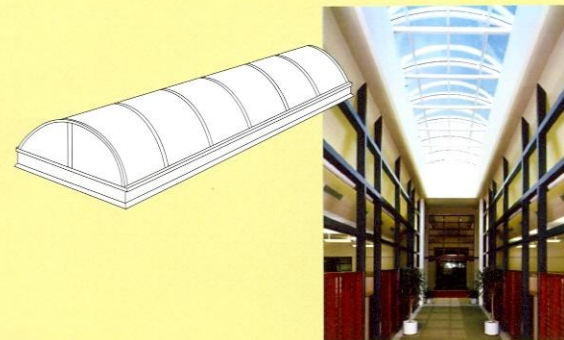
Available in 24" to 60" widths, or structural unit widths of 60" to 120". Unlimited lengths.



HALF-ROUND UNITS

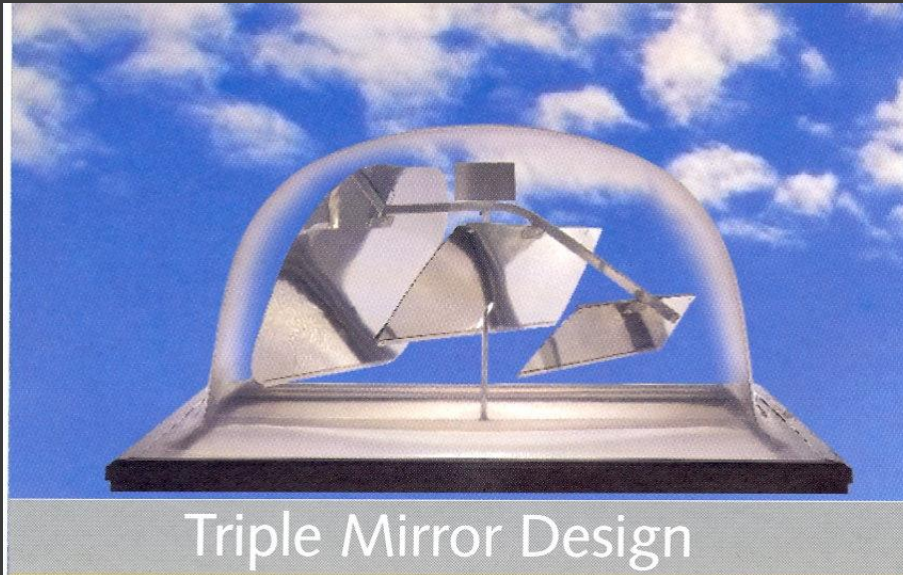
Models HR, SHR

Half-round high-rise vaults are available in widths of 48" to 120" (vertical ends only). Structural models (SHR) available in widths from 10' to 20'. Unlimited lengths.

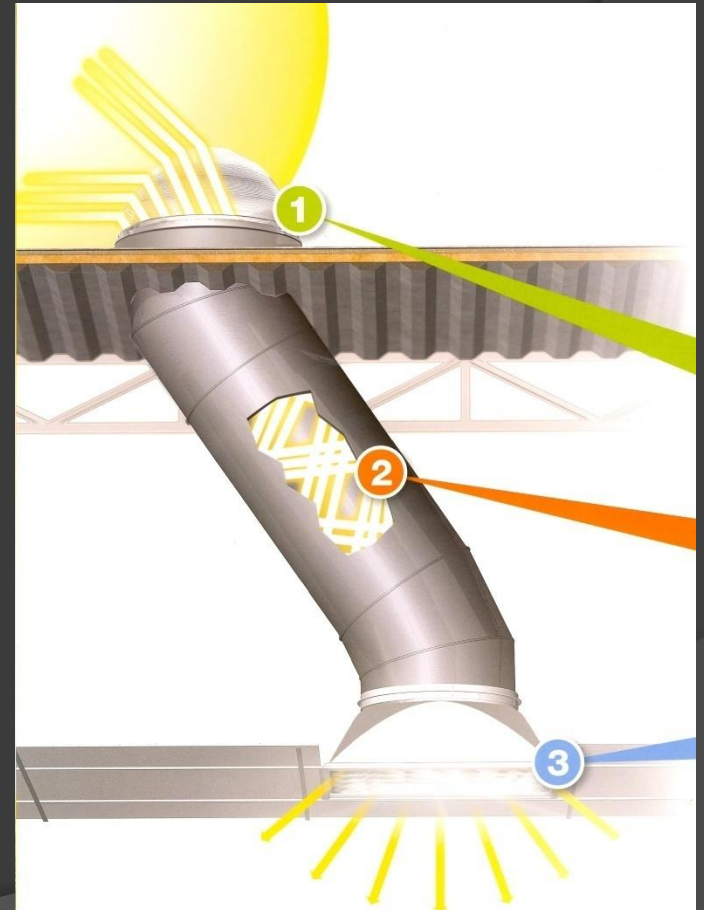


Source: *Manufacturer Catalogue*

Lighting Technologies & Efficiency



Source: Manufacturer Catalogue



Lighting Technologies & Efficiency



Source: Manufacturer Catalogue

Daylight and Health

- ⦿ Daylight can provide high light levels
- ⦿ Bright days and dark nights help to entrain the human circadian system to the 24 hour day
- ⦿ May help to keep people more alert
- ⦿ May help to prevent sleep disorders and SAD (Seasonal Affective Disorder)
- ⦿ No systematic study done to date to prove these connections

Standards & Labels

- Standards & labels
 - Minimum Efficiency Performance Standard (MEPS)
 - Labels pull the appliance performance in the market over and above MEPS
 - Identified as an economically attractive method for energy efficiency
 - Advantage for product developers
- Starting Energy Management Program
 - Strategy ???

Code of Practice

- ⦿ Energy Efficient Building in Sri Lanka – 2008.
 - Objectives.
 - Mandatory requirements.
 - Maximum allowable power for illumination.
 - Building exterior lighting power.
 - Selection of appropriate components.
 - Lighting controls.
 - Strategy for energy efficient lighting.
 - Submission procedure.

Recommended Lighting Power Density Building Interiors

Building Area Type	LPD (W/m²)	Building Area Type	LPD (W/m²)
Automotive Facility	9.7	Multifamily	7.5
Convention Center	12.9	Museum	11.8
Dining: Bar Lounge/Leisure	14.0	Office	10.8
Dining: Cafeteria/Fast Food	15.1	Parking Garage	3.2
Dining: Family	17.2	Performing Arts Theater	17.2
Dormitory/Hostel	10.8	Police/Fire Station	10.8
Gymnasium	11.8	Post Office/Town Hall	11.8
Healthcare-Clinic	10.8		14.0

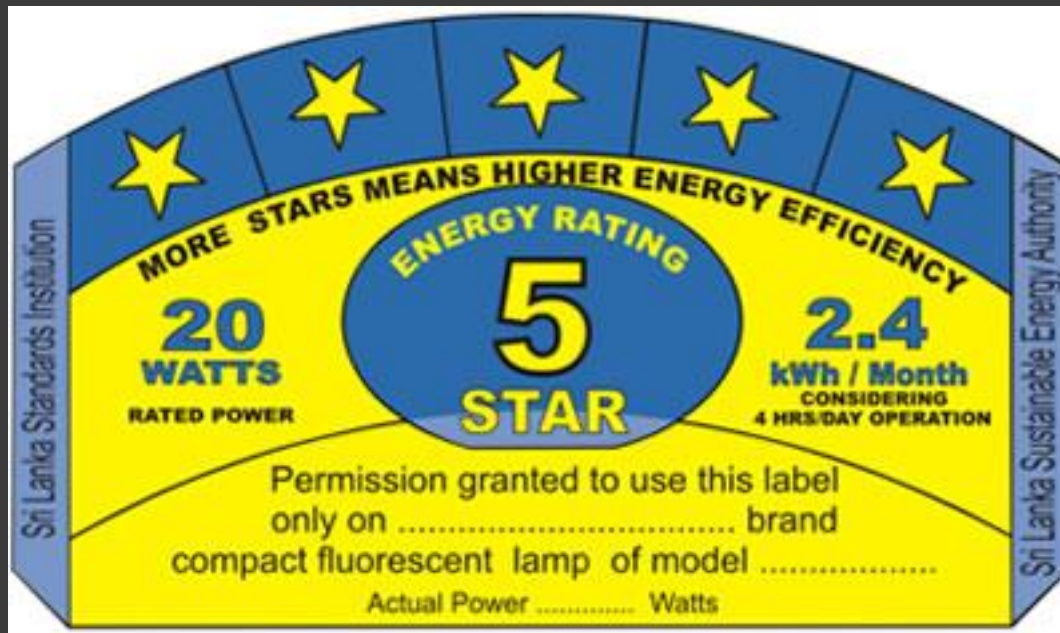
Source: Code of Practice on EE Buildings in Sri Lanka

Recommended Min Lamp Efficacy for Linear Fluorescents

Lamp Length (mm)	Lamp Power (watts)	Diameter (mm)	Minimum Lamp Efficacy (lumens/Watt)
600	18	26	55
1200	36	26	66
1500	58	26	66

Source: Code of Practice on EE Buildings in Sri Lanka

Energy Label



Source: SLSEA

Highlights...

- ◎ **Strong emphasis on Educational Lighting and Rural Lighting to eliminate Lighting Poverty**
- ◎ **Realistic economic index based on Cts/lm-hr**
 - Kerosene 15-20 Cts/lumen-hr
 - Solar PV CFL 0.10 – 0.15 Cts/lumen-hr
- ◎ **Efficiency in artificial Lighting, economic viability and affordability**
- ◎ **Exploit the potential of free, efficacious Daylight in commercial and industrial sector**
- ◎ **Exploit the potential of LED based manufacturing business creation**

END