Energy efficient lighting for Buildings

Green Mark Manager (GMM) Course

Facilitator: K. Seshadri (SESH)

- CEO Gritti Consulting Pte Ltd
- Chairman Luma Group Hg Pte Ltd (SEA & middle east)
- EX-VP, Philips Hg Asia Pacific

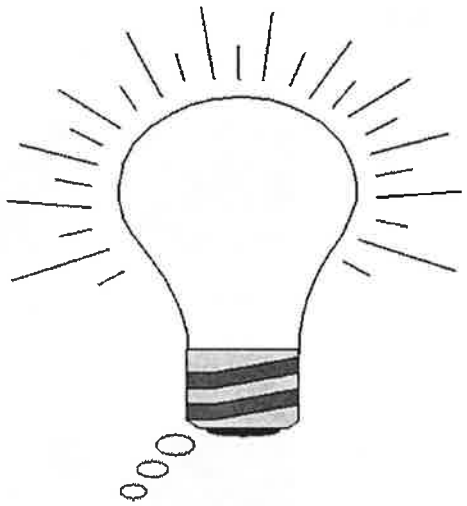
k.seshadri@gritticonsulting.org



Key Terminologies (for GMM)

- Light Output
- Light Efficacy
- Illuminance
- Colour Rendering Index
- Power Density (W / m^2)

Light output (= Luminous Flux)



Total quantity of light per second (= energy emitted in the band of 400-700 NM) by a Light source

Unit Lumens

Light output (examples)

Lamp	Power (W)	Light output (Lumens)
Incandescent Lamp	75W	900
Compact Fluorescent Lamp (CFL)	15W	900
Light Emitting Diode (at Performance level)	1-5W	40-600
Fluorescent tube Tri-Phosphor	36W	3200
Induction lamp	250W	21500
High Pressure Sodium	400W	56000

Depends on wattage and method of generating light

Luminous Efficacy (examples)

Lamp	Power (W)	Light output (Lumens)	Efficacy Lumens/Watt
Incandescent Lamp	75W	900	12
Compact Fluorescent Lamp (CFL)	15W	900	60
Light Emitting Diode (at Performance level)	1-5W	40-600	40-120
Fluorescent tube Tri-Phosphor	36W	3200	89
Induction lamp	250W	21500	85
High Pressure Sodium	400W	56000	140

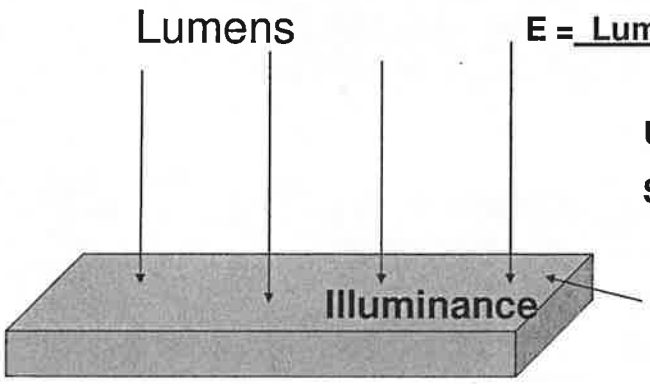
most efficient lamp.

exclude ballast loss

Why sodium lamp is not recommended since it is the most efficient ?
- colour rendering (yellowish light)
- Object under sodium light appears in diff colour (diff from original colour)

Illuminance (or Lighting level)

Luminous flux incident on a surface divided by the area of that surface : also called Lighting Level



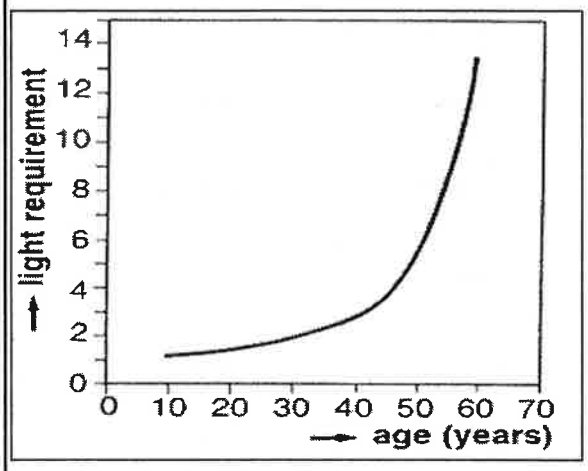
$$E = \frac{\text{Lumens x (certain Factors*)}}{\text{Area}}$$

Unit : Lux

Symbol : E

* These factors will vary with the room dimensions, type of fitting used, reflectance of walls & ceiling, height of fitting suspension etc

Age Vs Illuminance



(For a few hours of working)

12 years = 200 lux

40 years = 600 lux

60 years = 3000 lux



SS 531:2006 typical recommendations

Clause	Type of Interior	E (Lux)	Unified Glare Rating	CRI
3.1	Filing, copying	**300**	19	80
3.2	Writing, reading, Data processing	**500**	19	80
3.3	Technical drawings	**750**	16	80
3.4	CAD work stations	**500**	19	80
3.5	Conf & Meeting rooms	**500**	19	80
3.6	Reception desk	**300**	22	80
3.7	Archives	**200**	25	80

Full moon light - 0.25 lux
New moon light - 0.002 lux

Colour Rendering Index

CRI
acceptable range is 80.
excellent is 90.



Colour Temperature (example)



2000 K



3000 K



4000 K

Power density

- Calculate the load (in Watts) per luminaire.
- Multiply by all luminaires to get total load
- Calculate the area of interior in M^2
- **Power Density = Total W / M^2**

Compare it with Maximum Power density allowed as per Code of Practice SS 530

Offices	**15W / M^2**

SS 530:2006 Power densities

No	Type of usage	Maximum lighting power budget **Watts/M2**
1	Offices	15
2	Class rooms	15
3	Lecture theatres	15
4	Shops / Supermarkets / Departmental Stores (including general, accent & display lighting	25
5	Restaurants	15

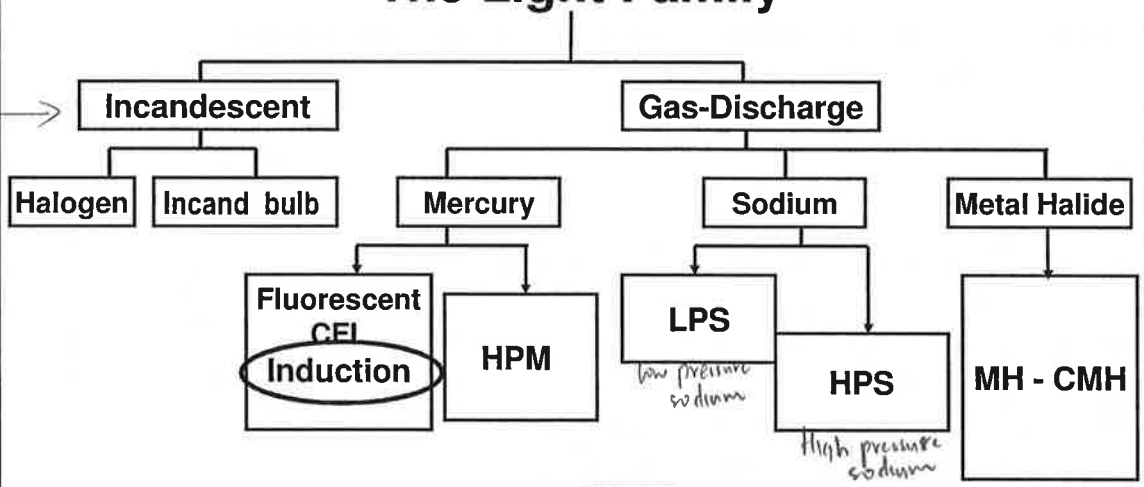
SS 530:2006 Power densities

No	Type of usage	Maximum lighting power budget **Watts/M2**
6	Lobbies / Atriums / Concourse	10
7	Stairs / Corridors	10
8	Car parks	6
9	Electronic manufacturing and fine detail / Assembly industries	20
10	Medium and heavy industries	15
11	Warehouses / Storage areas	10

Lamps-LED-Accessories-Applications & Energy efficiency

NEA is going to ban this type of lamp.

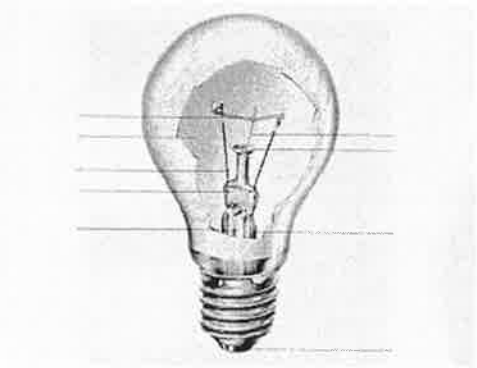
The Light Family



Ballast, Starter, Igniter | LED & LEP* | Luminaire

* Light Emitting Plasma. All 3 are Electrodeless long-life light sources

The Incandescent Lamp

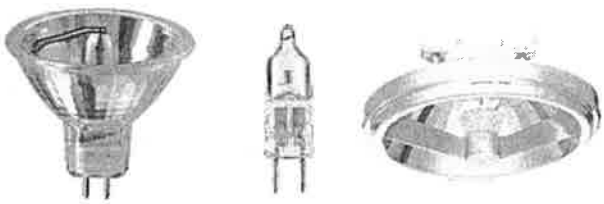


- **Glass Shell**
  - ***Clear , frosted or opal finish***
  - ***Protects the filament***
- **Fill Gas**
  - ***Reduces the evaporation rate of tungsten***
  - ***Inert (Argon and Nitrogen)***
- **Filament**
  - ***Tungsten , light emitter 2700 K***
- **Lamp Cap - *brass or aluminum***

Heat radiated: About 92%

Halogen Lamps

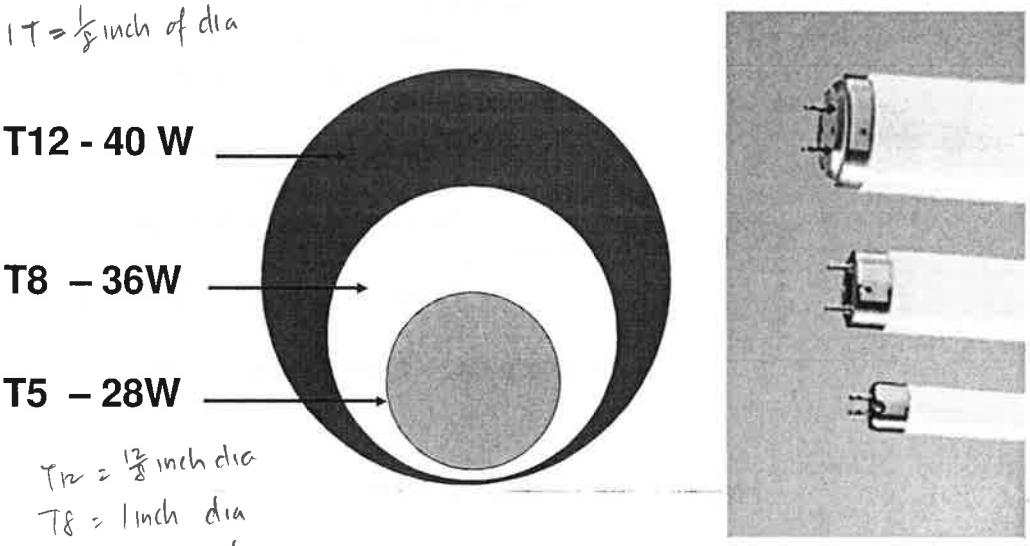
12V Halogen Dichroic lamp
Common rating : 50W
Heat radiated: About 85%



Applications: Shops, Hotels, Social areas & Car headlights

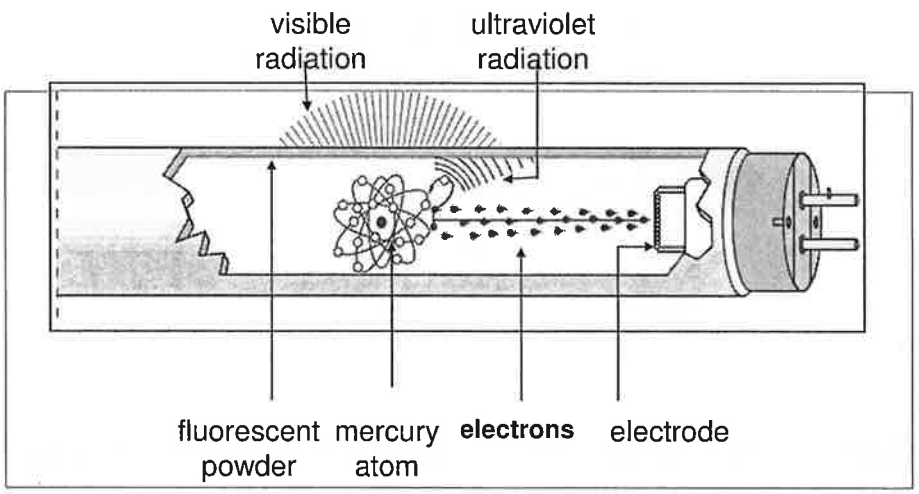
The Fluorescent lamp family

1T = 1/8 inch of dia

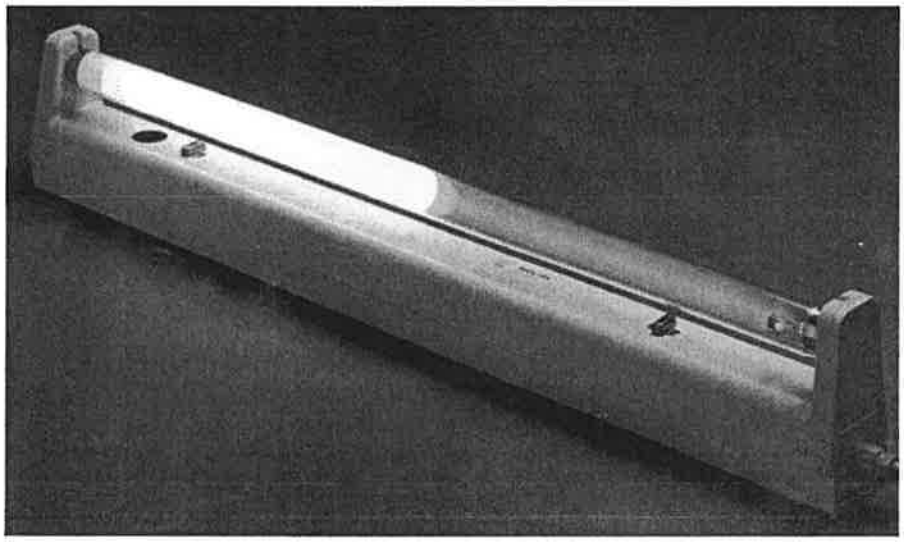


T12 = 12/8 inch dia
T8 = 1 inch dia
T5 = 5/8 inch dia

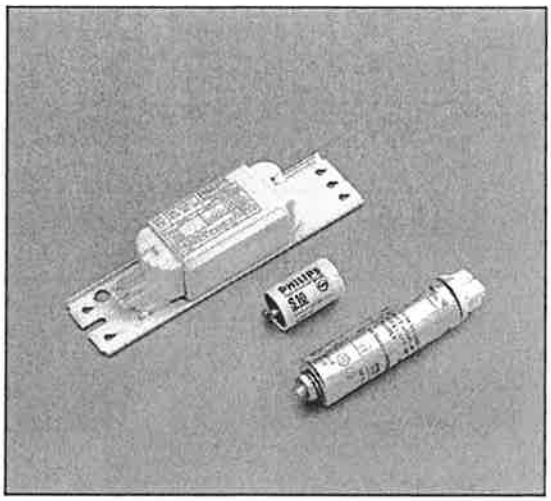
Fluorescent lamp functioning

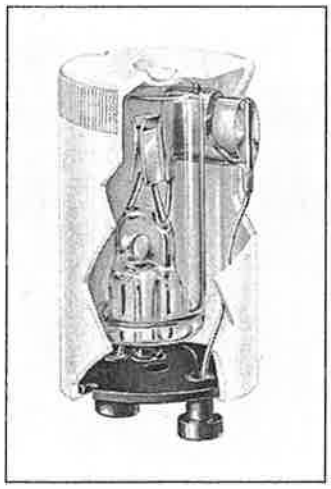


Fluorescent powder coating



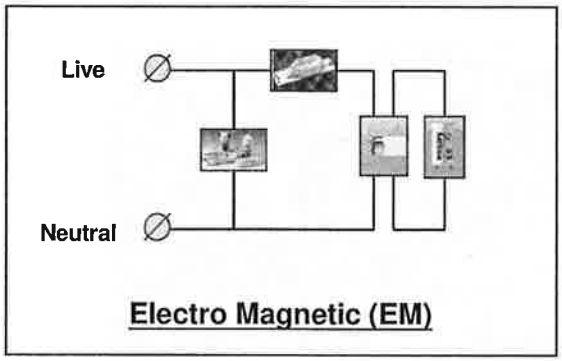
Electro Magnetic (EM) ballast components



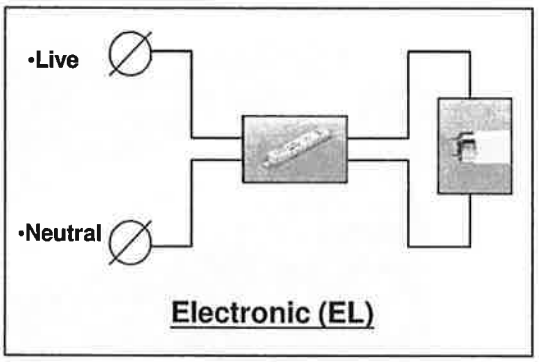


Capacitor - electrical requirement to bring up pf.
Not a requirement for lamp.

EM Vs EL ballast



Electro Magnetic (EM)



Electronic (EL)

The circuit with **(EL)** Electronic ballast is more simple and saves more Energy

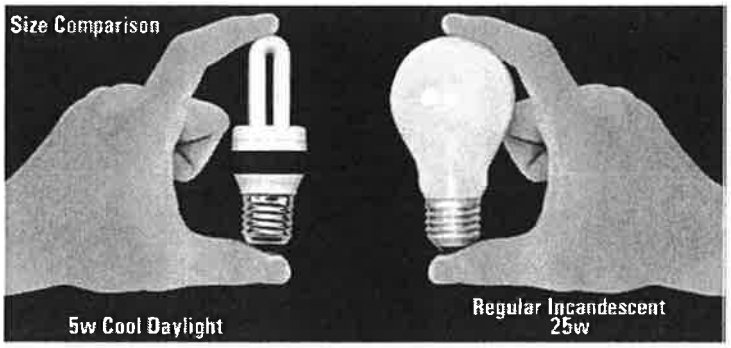
Load reduction by EL ballast

Lamp	Ballast type	Lamp power	Ballast loss	Total power
T8 36W	EM	36W	9W	45W
T8 36W	EL	**32W**	**4W**	**36W**

life span for both - 50,000 hrs.

CFL – I example

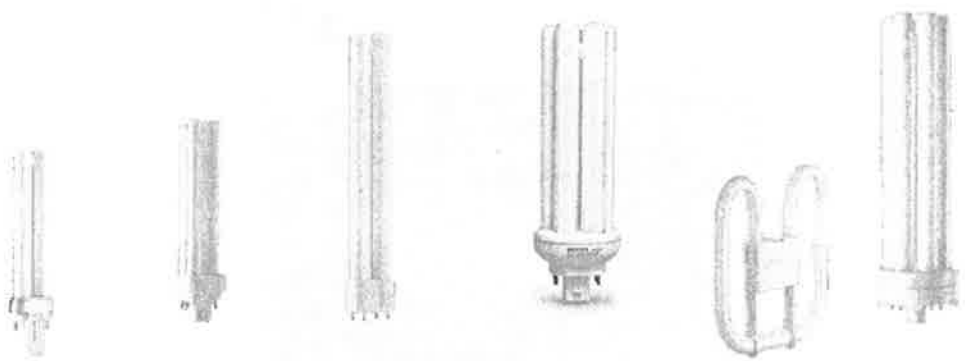
The Ballast is Integrated at the base



CFL 20W	=	**Incand 100W**
CFL 15W	=	**Incand 75W**
CFL 11W	=	**Incand 60W**

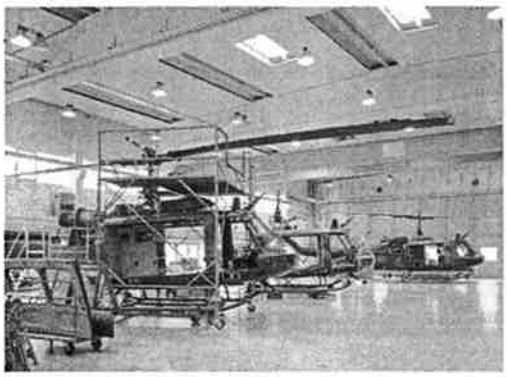
CFL – NI example

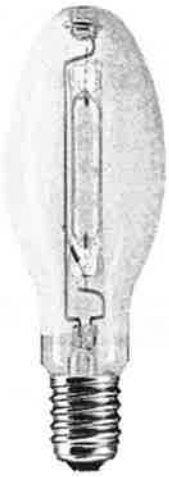
Ballast is Non-Integrated. External ballast required



High Pressure Mercury lamp

High bay 7 to 8m





High Pressure Sodium

Road Ltg.





Standard Metal Halide

sports complex





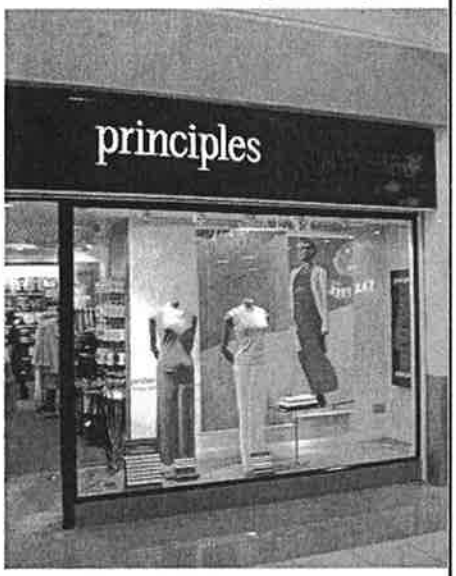
Ceramic Metal Halide (CMH)

25% of halogen electrical used · CRI = 90

- High beam intensities, high light output
- High efficiency
- Long life 20,000hrs
- Colour stability
- UV-block
- **Best Substitute for Halogen for Shops & Shopping Centres**

3000 hrs
15% light
85% heat





Electrodeless long-life lamps

1. Light Emitting Diode (**LED**)
2. Induction lamp (**IL**)
3. Light Emitting Plasma (**LEP**)

LED



Surface mount LEDs
Computers
mobile phones

BACKLIGHT





5 mm LEDs
Traffic signals
Auto indicator lights
Exit light signs

INDICATION

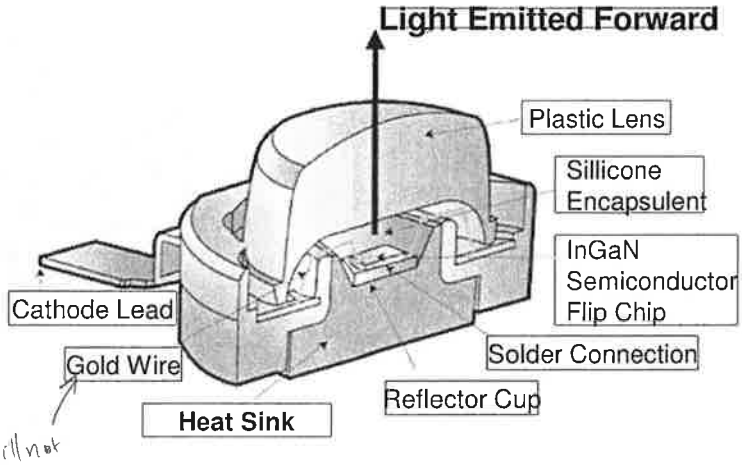
Power LEDs:
Accent Lighting
General illumination
Torch
Entertainment





ILLUMINATION

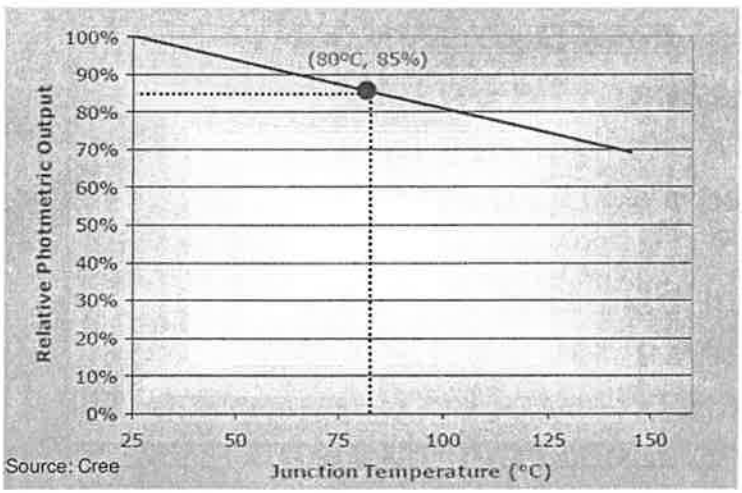
LEDs generate heat



- will not melt
- ↓ diff

Heat conducted backward

Light output depends on Junction Temperature

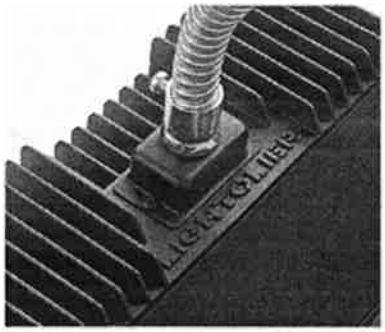


Light output goes down as junction temperature goes up
100 lumens @ 25°C Tj goes down to 85 lumens @ 80°C Tj

To request for light output during operating temp.

LED Heat sink

A heat sink is typically required to dissipate the heat produced by the LED sources
The interface between the circuit board and the heat sink is critical
A thermally conductive material is typically used between the PCB and heat sink to minimize air gaps which reduce the transfer of heat



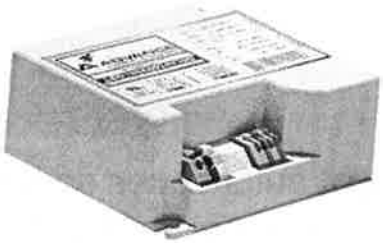


should last to do 12 years. same as incl(ED) lamp

LED Driver

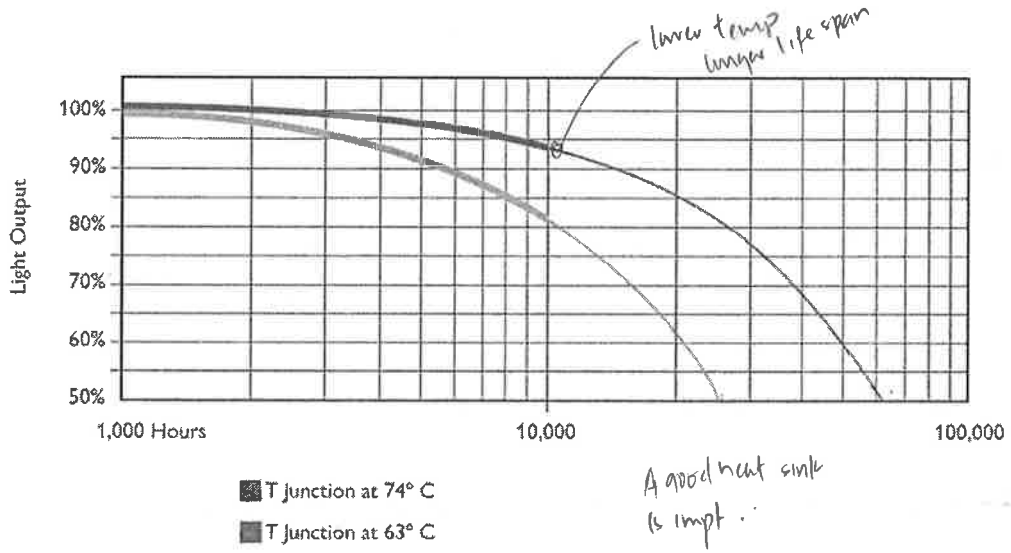
The Life of an LED system is mainly the life of its Driver !
LEDs are typically driven by a constant-current DC power source
High Power ED generally refers to a package of roughly 1.2W at a drive current of 350 mA
Drivers also contain temperature sensitive electronic components





LED life time and Tj

Higher temperature means faster lumen depreciation



Benefits of LED



Conventional Lamps		LED Benefits
Incandescent		Ultra long life
Halogen		Low power consumption Low maintenance
Fluorescent		No moving parts No UV radiation Cool beam of light
Gas-discharge (example: Sodium)		Digitally controllable Environment -friendly

Take away for LED

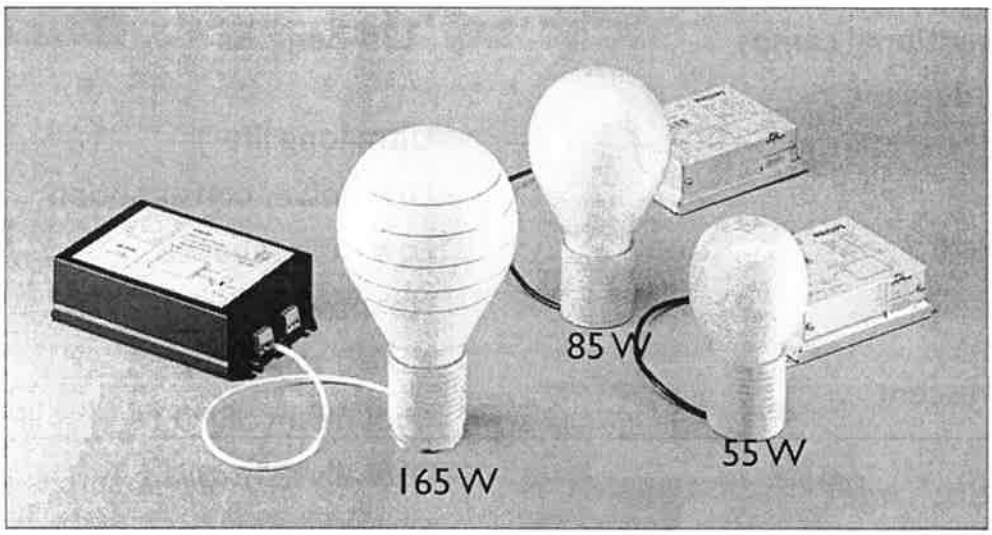
LEDs are available in a huge assortment of physical sizes, efficacy claims, and power ratings

Efficacy and output vary amongst the different color LEDs

There is no simple system to gauge relative output
Good news: Huge selection of choice in cost, output, efficacy, light quality, etc.
Bad news: Many ways to exaggerate on these claims.

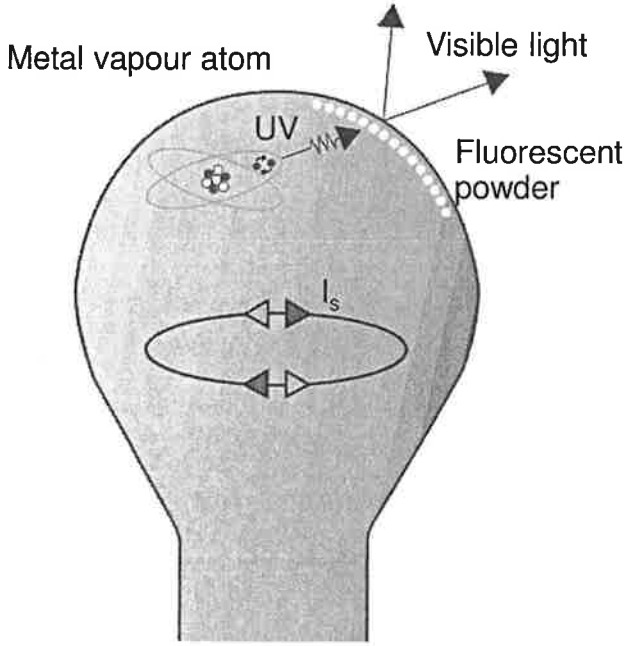
Your choice: Go with reputable, proven brands

Induction lamps

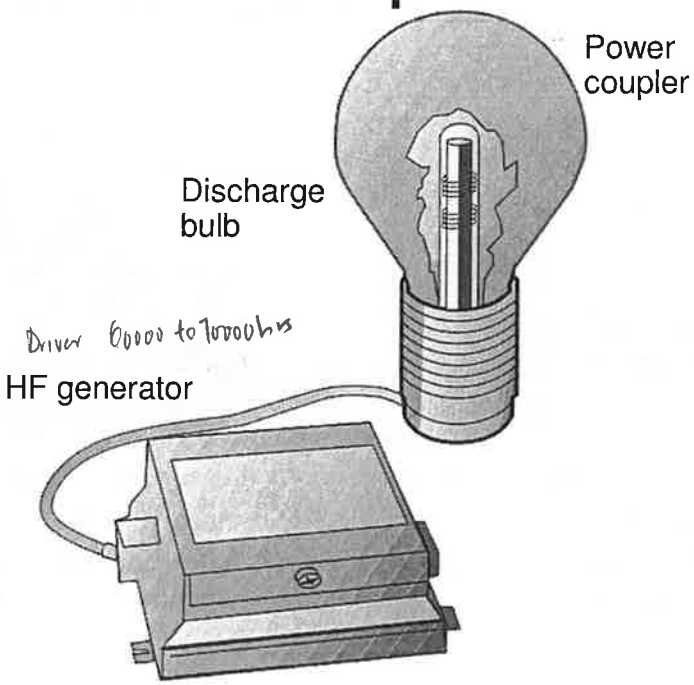


Induction lamp

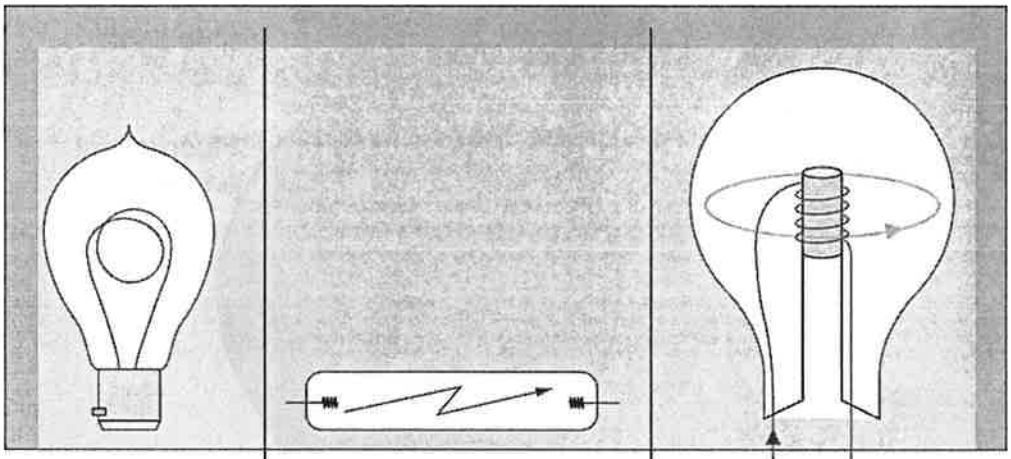
Discharge Principle



Induction lamp



Lifetime



Incandescent lamp	Conventional discharge lamp	Induction lamp
1,000 hrs	20000 hrs	80,000 hrs

Induction at Changi Airport ex-Budget Terminal



Old : 150W Metal Halide
Height : 6m
Effect : Poor Lighting distribution

New: 100W Induction
Height : 6m
Effect : Even distribution
Comments : Energy Saving of 40%

Warehouse application





Old: 400W Mercury
Height : 7m



New: 200W Induction
Height: 7m
Effect: same
Comments: Energy Saving 50%

Postal sorting bays





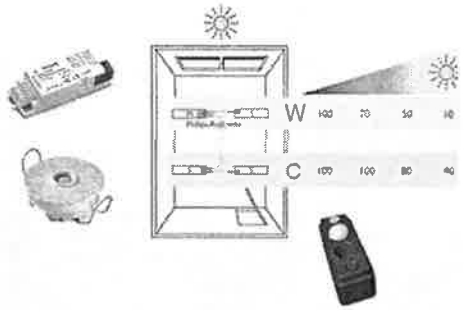


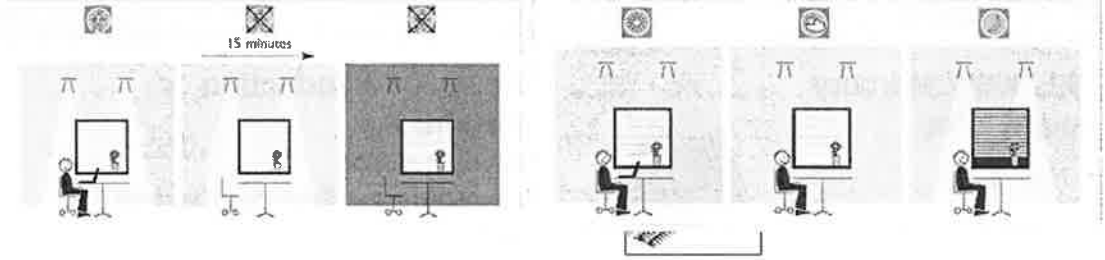
Old: 250W Metal Halide
Height : 4.5m
Effect : Nil
Comments : High maintenance cost

New: 150W Induction
Height : 4.5m
Effect : Better CRI
Comments : Energy Saving of 40%

Daylight sensing & Presence Detector

- Daylight sensing and Presence detection save energy by using daylight penetration and avoiding light when people are away
- Uses the HF REGULATOR ballast





Energy cost & lighting investment

Our eye is used to	**= 100,000 lux**
Recommended office lighting level	**= 500 lux**
The electrical load density to achieve this	**= 10W / m^2**
@ 8 m^2 per pax, the lighting load / person	**= 80W**
For 10 hrs per day, energy consumed	**= 80 x 10 WHr** **= 0.80 Kw Hr**
@S$ 0.25 / KwHr, the cost of lighting / day	**= S$ 0.20!**

How much does a cup of tea cost ?

How many cups would we drink everyday?

So, do a Life Cycle study and decide on proper lighting solution

Thank you !