# Lighting Design Process For Energy Efficient Lighting & current technology Trends with lighting measurement protocols as also basic on-site measurement equipment

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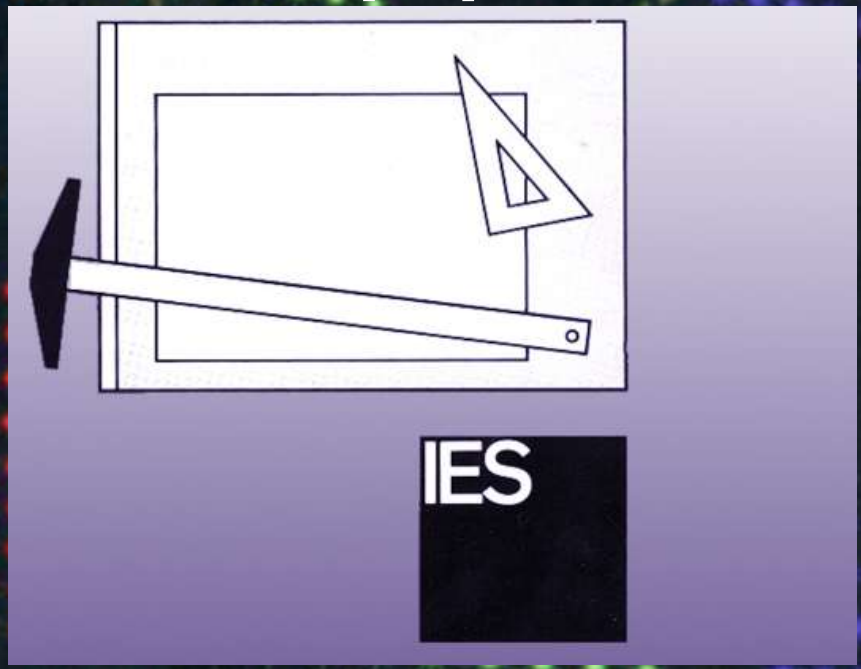
*July 27, 2010*

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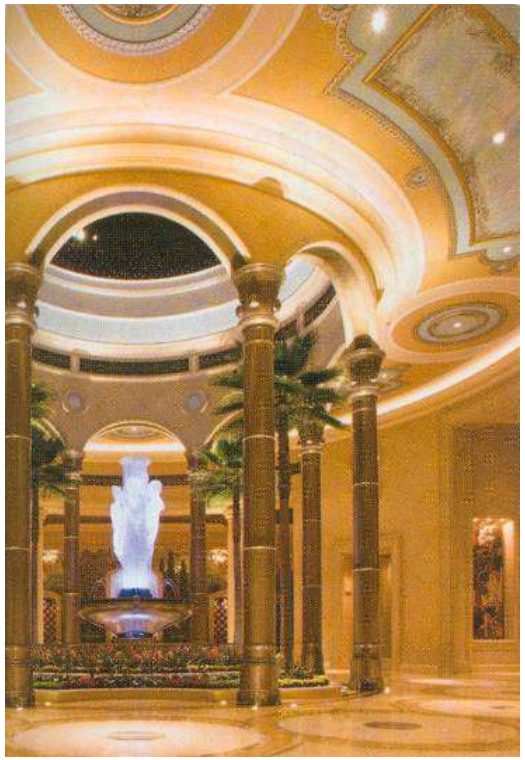
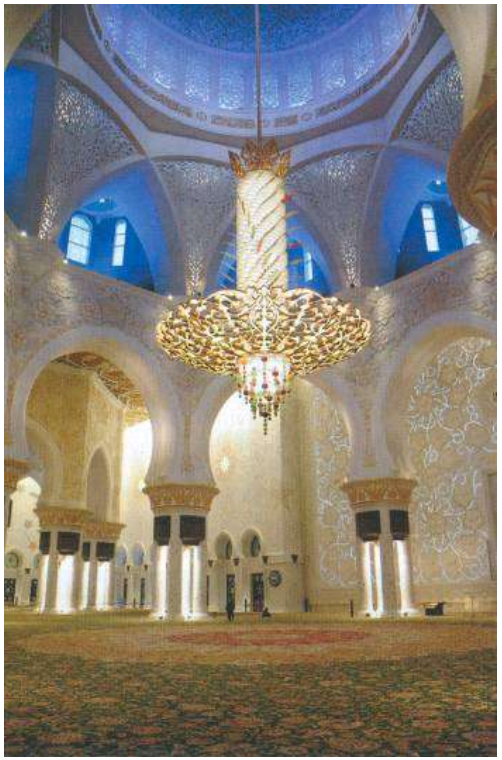
# Lighting Design – The Process

- Creative & Technical Process
- Objective – To develop cost effective and energy efficient lighting solutions
- To be safe, productive and visually appealing
- Keep in mind the built environment
- Correct quantity as well as quality of light to be delivered to the work surface
- Creative and unpredictable linear process
- Involves art and science of illumination
- Begins with a Design Concept selected from a number of options
- As it proceeds, it is filled with cross checking and doubling back






*Results of Projects Involving Lighting Design - I*

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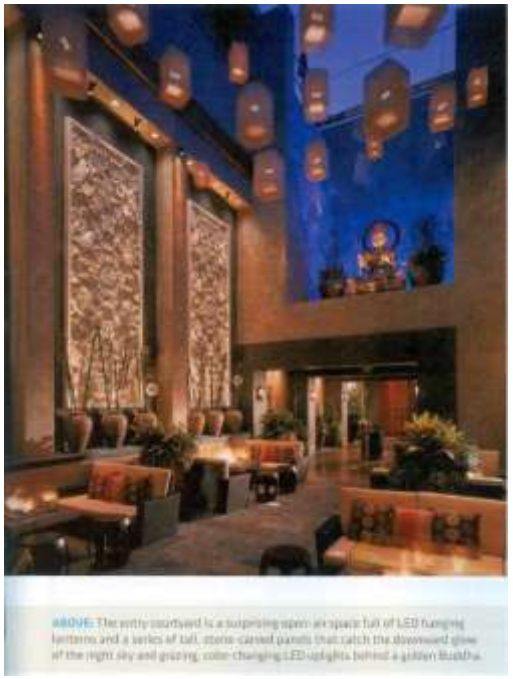

OPULENT. A double-height mural of the Buddha looks over the main seating area, facing the adjacent Santa Monica Boulevard. Unobtrusive LEDs helped augment the restaurant's atmospher without detracting from its elegant decor.

*Results of Projects Involving Lighting Design - II*

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*Results of Projects Involving Lighting Design - III*

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*Results of Projects Involving Lighting Design - IV*

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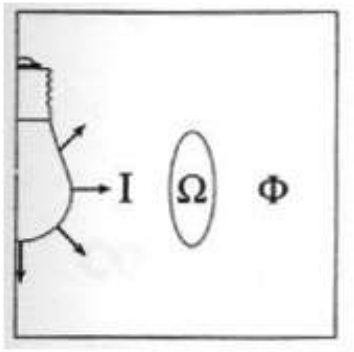
# *Glossary of some of the most important lighting terms*

## Luminous flux Φ

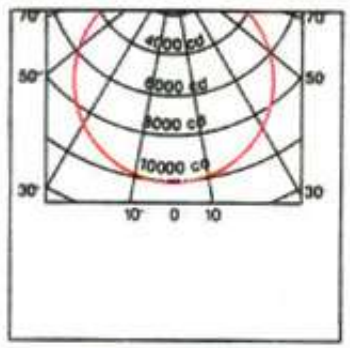
Unit of measurement:
lumen [lm]
All the radiated power emitted by a light source and perceived by the eye is called luminous flux Φ.




*Luminous intensity 1 is a measure of the luminous flux Φ emitted in solid angle Ω.*

## Luminous Intensity I

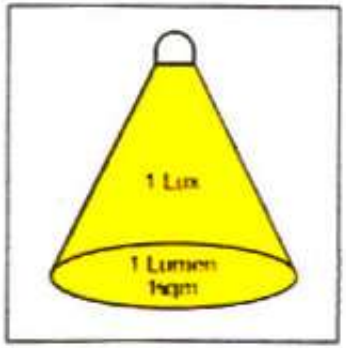
Unit of measurement :
candela {cd}
Generally speaking, a light source emits its luminous flux Φ in different directions and at different intensities. The visible radiant intensity in a particular direction is called luminous intensity I.




*Polar diagram*

## Illuminance E

Unit of measurement: lux [lx]. Illuminance E is the ratio between the luminous flux and the area to be illuminated. An illuminance of 1 lx occurs when a luminous flux of 1lm is evenly distributed over an area of 1 squre metre.




*Illuminance E*

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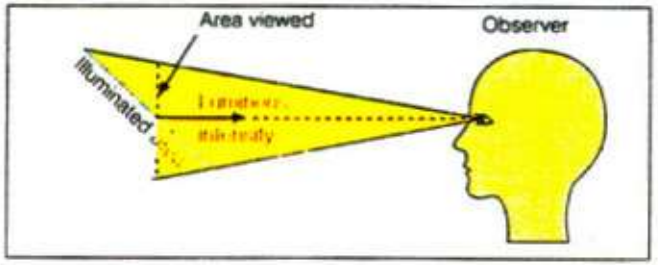
## Luminance L

Unit of measurement : candelas per square metre [cd/m] The luminance L of a light source or an how great an impression of brightness is created in the brain.




*Luminance L*

| The most important photometric formula | | |
|---|---|---|
| Luminous intensity [cd] | I | $\frac{\text{Luminous flux in solid angle}}{\text{Solid angle } \Omega \text{ [sr]}}$ |
| Illuminance [lx] | E | $\frac{\text{Luminous flux falling on area [lm]}}{\text{Illuminated area [m}^2\text{]}}$ |
| Luminance [cd/m²] | L | $\frac{\text{Luminous intensity}}{\text{Viewed Luminous area [m}^2\text{]}}$ |
| Luminous efficacy [lm/w] | h | $\frac{\text{Generated luminous flux [lm]}}{\text{Electrical power consumed [w]}}$ |

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# *Glossary of some of the most important lighting terms*

• The correlated color temperature **(CCT)** is a specification of the color appearance of the light emitted by a lamp, relating its color to the color of light from a reference source when heated to a particular temperature, measured in degrees Kelvin (K). The CCT rating for a lamp is a general "warmth" or "coolness" measure of its appearance.
• However, opposite to the temperature scale, lamps with a CCT rating below 3200 K are usually considered "warm" sources, while those with a CCT above 4000 K are usually considered "cool" in appearance.

• **CRI** is measure of the degree of color shift objects undergo when illuminated by the light source as compared with the color of those same objects when illuminated by a reference source, of comparable colour temperature.
• Light sources differ in their ability to render the color of objects "correctly." The color rendering capability of a lamp is expressed by the Color Rendering Index (CRI).

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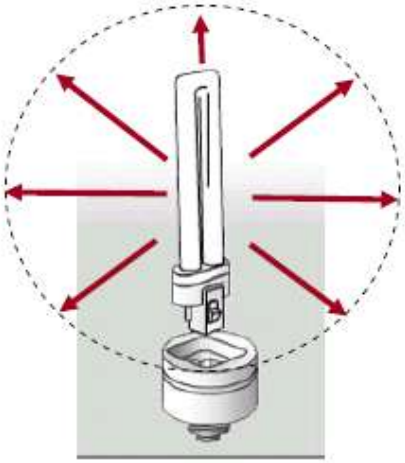
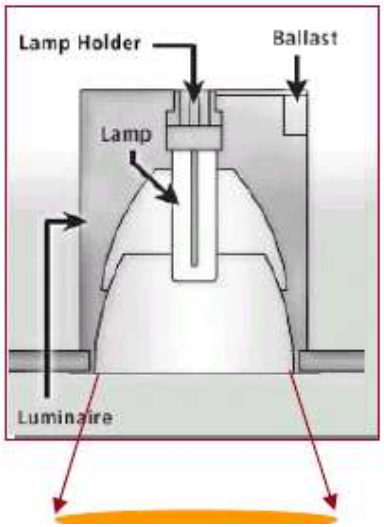
# *Different Forms Of Luminous Efficacy*

- **Light source (lamp) efficacy:** Total lumens out of the light source divided by the total input power to the light source
- **Light source + ballast efficacy:** Total lumens out of the light source divided by the total input power to the ballast
- **Luminaire efficacy:** Total lumens exiting the luminaire divided by the total input power



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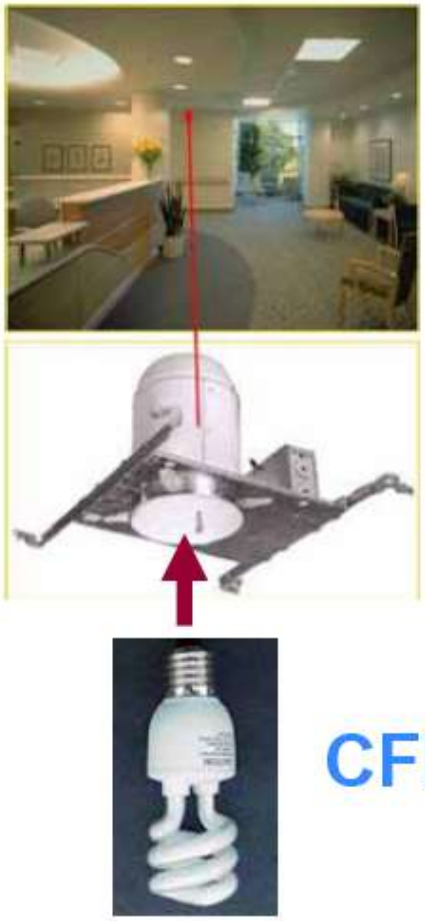
# Luminaire Efficacy

- In this example, the total luminaire efficiency is 33% to 54%.
- A 60 lm/W CFL would yield:
  - 19 to 32 lm/W final system efficacy in these luminaires
  - IR Halogen PAR lamp would be a better choice than combinations A to J

CFL

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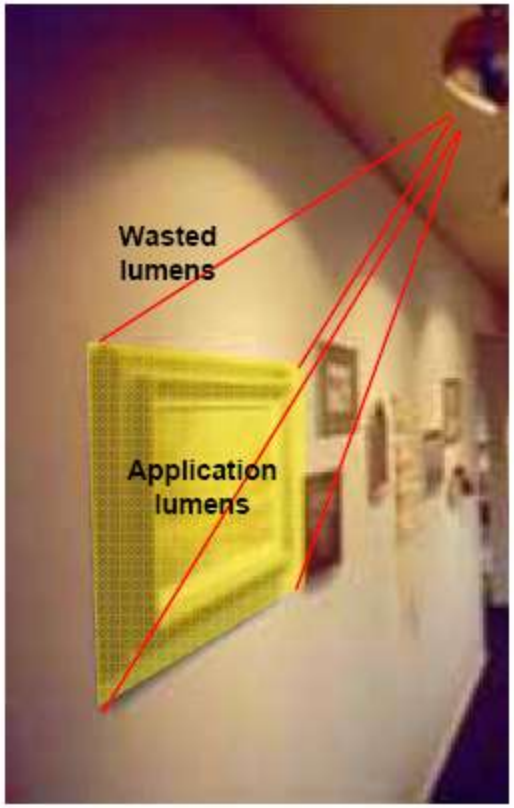
# *Application Efficacy*

## Lighting Objective – Illuminating the picture on the wall

- **Application lumens:** Total lumens reaching a picture area
- **Wasted lumens:** Lumens beyond the area of the picture

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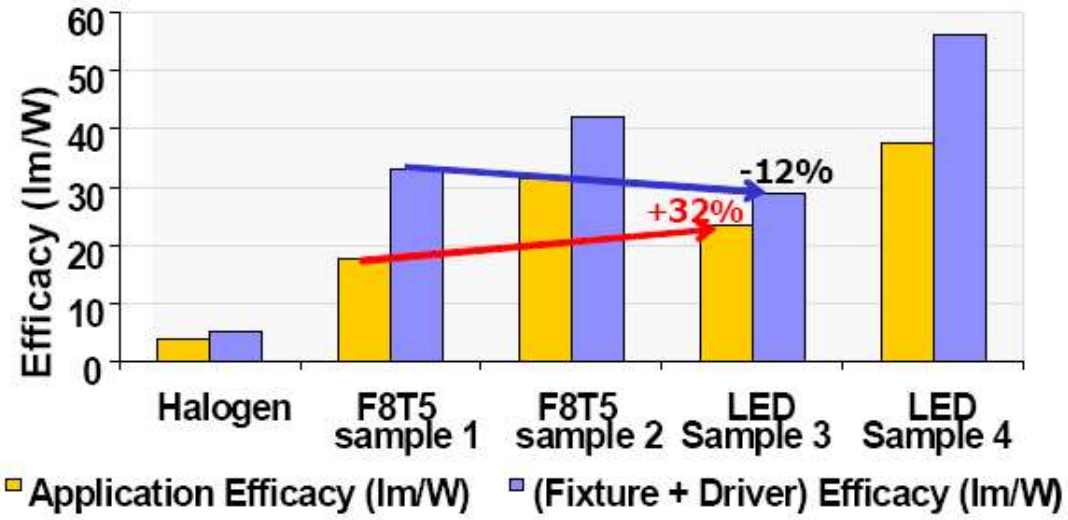
# Application Efficacy

- In this example, compared to sample 1, sample 3 is designed better to direct the exiting lumens to the area where it is needed.

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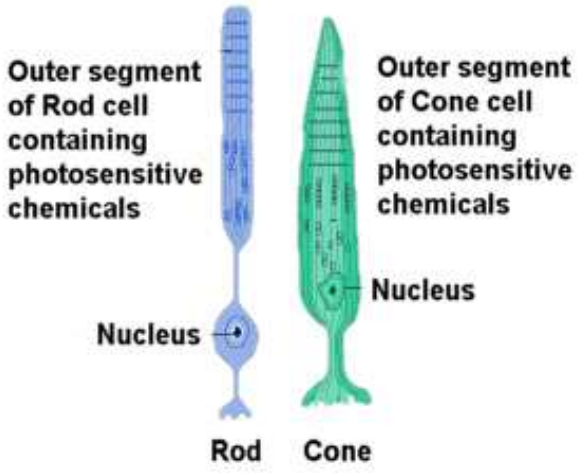
# The Human Eye and Light

- New research shows how our eyes respond to light
- Light arrives at our eye from all portions of illuminated space
- The 'Retina' is a light sensitive membrane at the back of the eye
  - contains millions of tiny light receptors
  - these receptors convert light to electrified signals sent to vision centers of the brain
- Retina contains 2 types of light receptors – Rods and Cones
  - Named after their geometric shapes
  - The central part of the Retina, the Fovea, contains only cones
  - The rest of the retina has both rods and cones
  - The ratio of rods: cones::10:1

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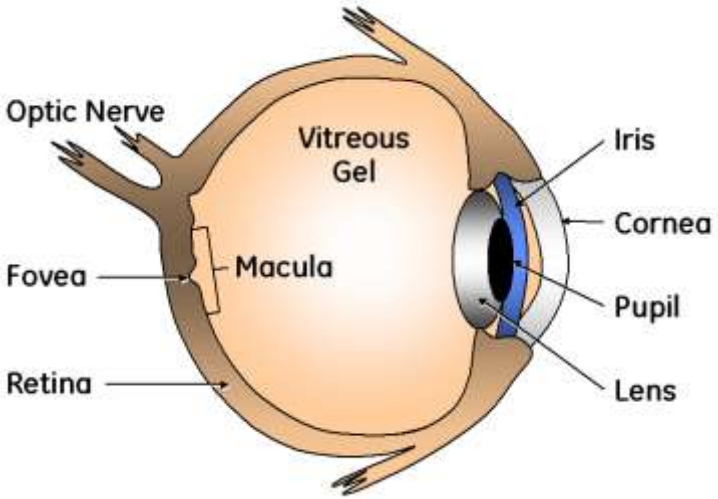
# Human Eye – Cross Section

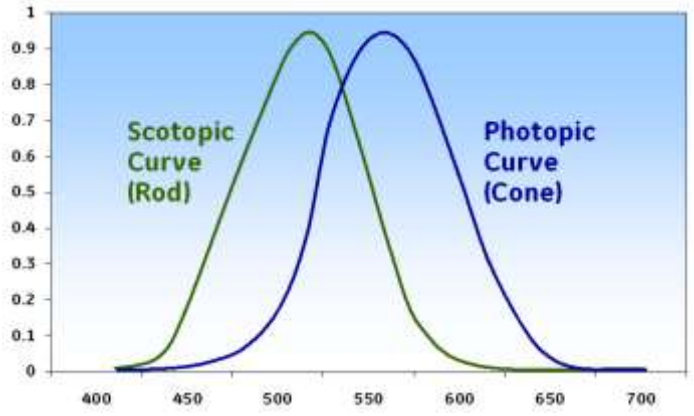



- Cones have peak response in the yellow green region – around 555 nm
- Rods have peak response in the bluish green region – around 505 nm

- Since both rods and cones have different sensitivities to colors they are represented by 2 different sensitivity curves
  - Photopic curves (representing cones)
  - Scotopic curves (representing rods)

# Scotopic and Photopic Vision

- Earlier, it was thought that cones are responsible for daytime vision and rods for night vision
- So, light meters that measure lighting levels such as lumens, lux, etc. are weighted to the cone activated part, neglecting the rod activated vision
- Study conducted by the DoE in USA shows that both rods and cones share the responsibility for vision and rods do play a part in typical workplace lighting conditions
- Need to modify lighting measurements to include rod sensitivity
- DoE study suggests multiplying Photopic Lumen rating, P, by $(S/P)^n$, where S is scotopic lumens
- Dr. Berman, who conducted the study proposes we should use n=0.78 for reading tasks and n = 1 for computer tasks
- In case we want to merely predict human response to perceived brightness of a space, we should use n = 0.58

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# *Photopic & Scotopic Vision*

**Scotopic vision: Seeing is believing.**

Human vision is enabled by three primary modes:

- Photopic vision: Vision under well-lit conditions, which provides for color perception, and which functions primarily due to cone cells in the eye.
- Mesopic vision: A combination of photopic vision and scotopic vision in low lighting, which functions due to a combination of rod and cone cells in the eye.
- Scotopic vision: Monochromatic vision in very low light, which functions primarily due to rod cells in the eye.

Although all three modes of vision help us see under different conditions, nighttime vision is generally dominated by scotopic mechanisms (for very dark conditions with no ambient light) or mesopic mechanisms (for semi-dark conditions, such as a full moon and heavily lit commercial roadways). Unfortunately, virtually all photometric tests used to determine light output from street lighting sources are based on photopic vision, which is not representative of the human response to light under low light (nighttime) conditions. Photopic measurements favor “warmer” light, such as the orange light produced by common HID street light sources, including high pressure sodium lamps. Scotopic and mesopic measurements are more representative of a broader spectrum of light, including the “cooler” light generated by most LEDs used in street lighting applications. Because of these differences, many leading scientists and lighting experts believe that photopic measurements should be used for daytime and indoor lighting measurements, and scotopic or mesopic measurements should be used to evaluate nighttime lighting measurements.

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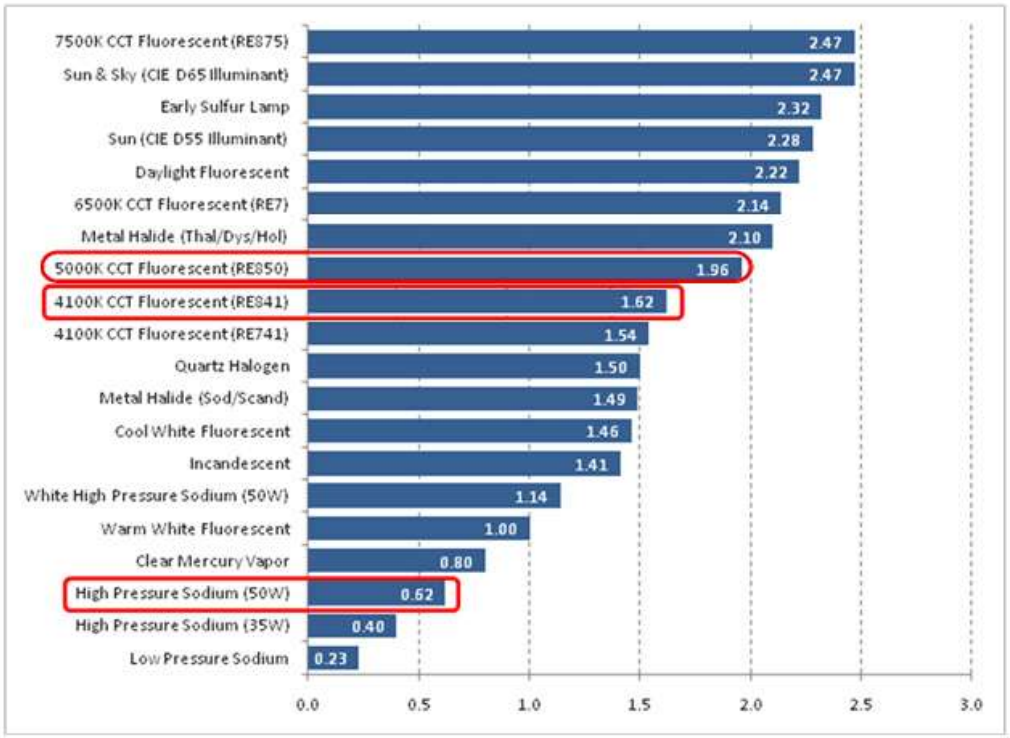
The Illuminating Engineering Society of North America (IESNA)—which currently uses photopic measurement criteria for evaluating street lights—is currently reviewing the photopic versus scotopic/mesopic measurement issue, and revised street light standards are expected to be issued from the IESNA in the near future. In the meantime, many LED users are evaluating light output based using both photopic and scotopic measurements. Since most photometry is based on photopic measurements, a scientific conversion factor is used to create scotopic measurements from photopic measurement data. These conversions are described in groundbreaking research on this topic conducted by Dr. Sam Berman and Don Jewett.

To convert from photopic to scotopic measurements, simply multiply the photopic measurement for the light source in question by the appropriate factor in the table below:




*Source: Berman, S.M., (1995), The Reengineering of Lighting Photometry, Lawrence Berkeley National Laboratory.*

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# *Low Frequency Electrodeless Induction Lamp*

Induction lighting is one of the best kept secrets in energy-efficient lighting. Simply stated, induction lighting is essentially a fluorescent light without electrodes or filaments, the items that frequently cause other bulbs to burn out quickly. Thus, many induction lighting units have an extremely long life of up to 100,000 hours. To put this in perspective, an induction lighting system lasting 100,000 hours will last more than 11 years in continuous 24/7 operation, and 25 years if operated 10 hours a day.
The technology, however, is far from new. Nikola Tesla demonstrated induction lighting in the late 1890s around the same time that his rival, Thomas Edison, was working to improve the incandescent light bulb. In the early 1990s, several major lighting manufacturers introduced induction lighting into the marketplace.

Despite its high initial cost, induction lighting has many superior characteristics, including the following:

- Virtually maintenance-free operation
- High efficacy—in many cases, 70-85 lumens per watt
- Long life
- Excellent color rendering index (CRI)—80+ and in some cases 90+
- Choice of warm white to cool white (2,700–6,500 K) color temperature
- Instant start and restrike operation
- No flickering, strobing, or noise
- Low-temperature operation
- Dimmable capability with some units
- High power factor: 0.98
- Low THDF with EMC controlled.

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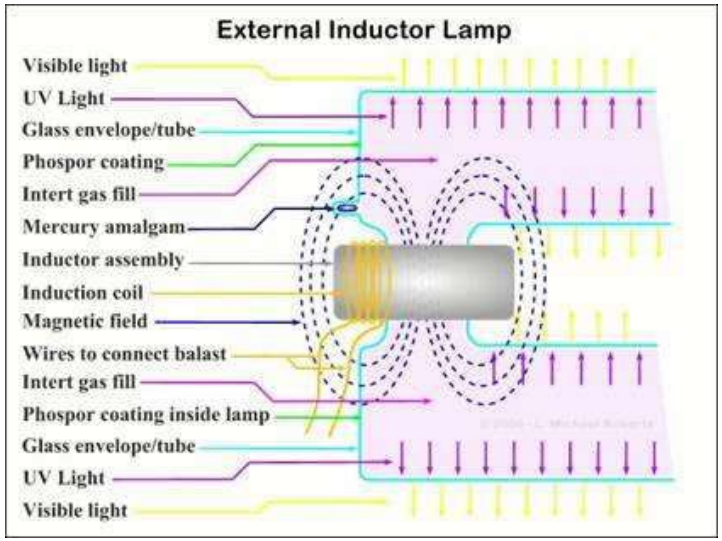
# Construction of External Induction Lamp

Magnetic induction lamps are basically fluorescent lamps with electromagnets wrapped around a part of the tube, or inserted inside the lamp. In external inductor lamps, high frequency energy, from the electronic ballast, is sent through wires, which are wrapped in a coil around the ferrite inductor, creating a powerful magnet.




The induction coil produces a very strong magnetic field which travels through the glass and excites the mercury atoms in the interior which are provided by a pellet of amalgam (a solid form of mercury). The mercury atoms emit UV light and, just as in a fluorescent tube, the UV light is up-converted to visible light by the phosphor coating on the inside of the tube. The system can be considered as a type of transformer where the inductor is the primary coil while the mercury atoms within the envelope/tube form a single-turn secondary coil.

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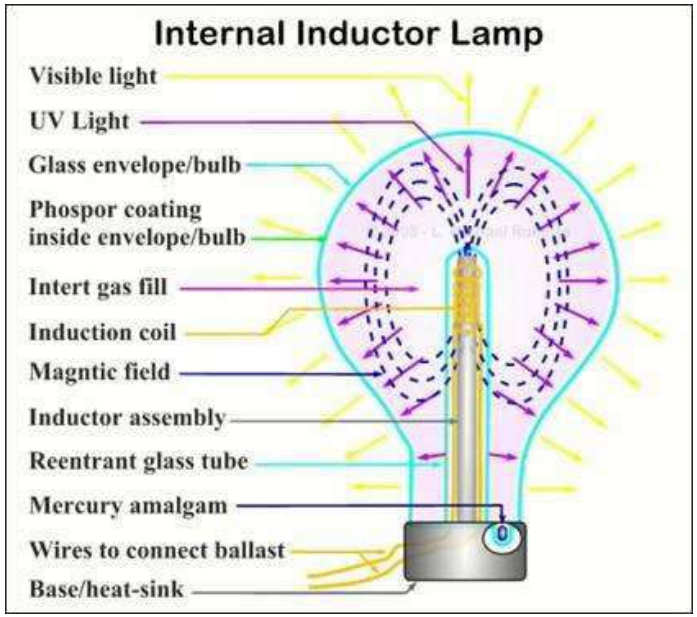
# *Construction of Integerated or Internal ELM Induction Lamp*

In a variation of this technology, a light bulb shaped glass lamp, which has a test-tube like reentrant central cavity, is coated with phosphors on the interior, filled with inert gas and a pellet of mercury amalgam. The induction coil is wound around a ferrite shaft which is inserted into the central test-tube like cavity. The inductor is excited by high frequency energy provided by an external electronic ballast causing a magnetic field to penetrate the glass and excite the mercury atoms, which emit UV light, that is converted to visible light by the phosphor coating.

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# External vs. Internal ELM Induction Lamp

The external inductor lamps have the advantage that the heat generated by the induction coil assemblies is external to the tube and can be easily dissipated by convention into the air, or conduction into the fixture. The external inductor design lends itself to higher power output lamps which can be rectangular or donut shaped. In the internal inductor lamps, the heat generated by the induction coil is emitted inside the lamp body and must cool by conduction to a heat-sink at the lamp base, and by radiation through the glass walls. The internal inductor lamps tend to have a shorter lifespan than the external inductor types due to higher internal operating temperatures. The internal inductor type looks more like a conventional light bulb than the external inductor type lamps which may be more appealing in some applications.

As with conventional fluorescent lamps, varying the composition of the phosphors coated onto the inside of induction lamps, allows for models with different colour temperatures. The most common colour temperatures of induction lamps are 3500K, 4100K, 5000K and 6500K.

Induction lamps require a correctly matched electronic ballast for proper operation. The ballast takes the incoming mains AC voltage [or DC voltage in the case of 12V and 24V ballasts] and rectifies it to DC. Solid state circuitry then converts this DC current to a very high frequency which is around 250 KHz.

This high frequency is fed to the coil wrapped around the ferrite core of the external or internal inductor. The high frequency creates a strong magnet field in the inductor which couples the energy through the glass walls of the lamp and into the mercury atoms inside the tube.

The ballasts contain control circuitry which regulates the frequency and current to the induction coil to insure stable operation of the lamp. In addition, the ballasts have a circuit which produces a large “start pulse” to initially ionize the mercury atoms and thereby start the lamp. The induction lamps do not start at 100% output - they start at between 75% and 80% output. It takes between 60 and 120 seconds for the mercury bearing amalgam in the lamp to heat up and release enough mercury atoms for the lamps to reach 100% light output.

The close regulation of the lamp by the ballast, and the use of microprocessor controlled circuits allows the ballasts to operate at around 98% efficiency. Only around 2% of the energy is wasted in the induction lamp ballast compared to the 10-15% wasted in traditional “core and coil” type designs used with most high output commercial and industrial lighting.

## Long Lifespan

Experience with using induction lighting at the U.S. Department of Energy's Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, has demonstrated the long life in actual usage. WIPP's first induction lighting system was installed in 1998, replacing high-pressure sodium (HPS) lights. More than 10 years later, all but three of the original 36 induction units are still operating after more than 88,000 hours of continuous, 24/7 operation. Additional systems were installed in 2002 and succeeding years, both indoors and outside, with excellent results.

Although they may last 100,000 hours, after 60,000 to 100,000 hours of operation the initial lumen output of many of the induction lighting systems drops to 70%—the point where relamping is often recommended.

## Applications with High Potential for Induction Lighting

- In hard-to-reach locations that make maintenance costs high, such as street lighting and tunnels, or in high ceilings where there is continuous operation, such as hotel rotundas
- Cold environments, such as supermarket walk-in coolers and freezers
- Where high-quality lighting is required or highly desirable
- Where reliability is highly valued
- Where high lumen output is required
- In areas that require lamps to reach full illumination immediately.

# *Types of Electrodeless Magnetic Induction Lamps*

- **External**
- **Internal or Integrated**

## Shapes of Electrodless Magnetic Induction Lamps

External : Rectangular & Circular

Internal : Round Spherical or tubular

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## Technical Data for external EM Induction Lamps

| Wattage | Luminous Flux | Efficacy | Color Temperature | CRI | Life (Hrs.) |
|---|---|---|---|---|---|
| 40 | 3200 | 70~75 | 3000/5000 | 80 | 100000 |
| 60 | 4800 | 75~80 | 3000/5000 | 80 | 100000 |
| 80 | 6500 | 75~80 | 3000/5000 | 80 | 100000 |
| 120 | 9600 | 75~80 | 3000/5000 | 80 | 100000 |
| 150 | 12000 | 80~85 | 3000/5000 | 80 | 100000 |
| 200 | 16500 | 80~85 | 3000/5000 | 80 | 100000 |
| 250 | 20500 | 80~85 | 3000/5000 | 80 | 100000 |
| 400 | 24500 | 80~85 | 3000/5000 | 80 | 100000 |

## Technical Data for Tubular/Spherical Self-Ballasted EM Induction Lamps

| Wattage | Luminous Flux | Efficacy | Color Temperature | CRI | Life (Hrs.) |
|---|---|---|---|---|---|
| 40 | 3000 | 70~75 | 3000/5000 | 75~80 | 60000 |
| 60 | 4500 | 70~75 | 3000/5000 | 75~80 | 60000 |

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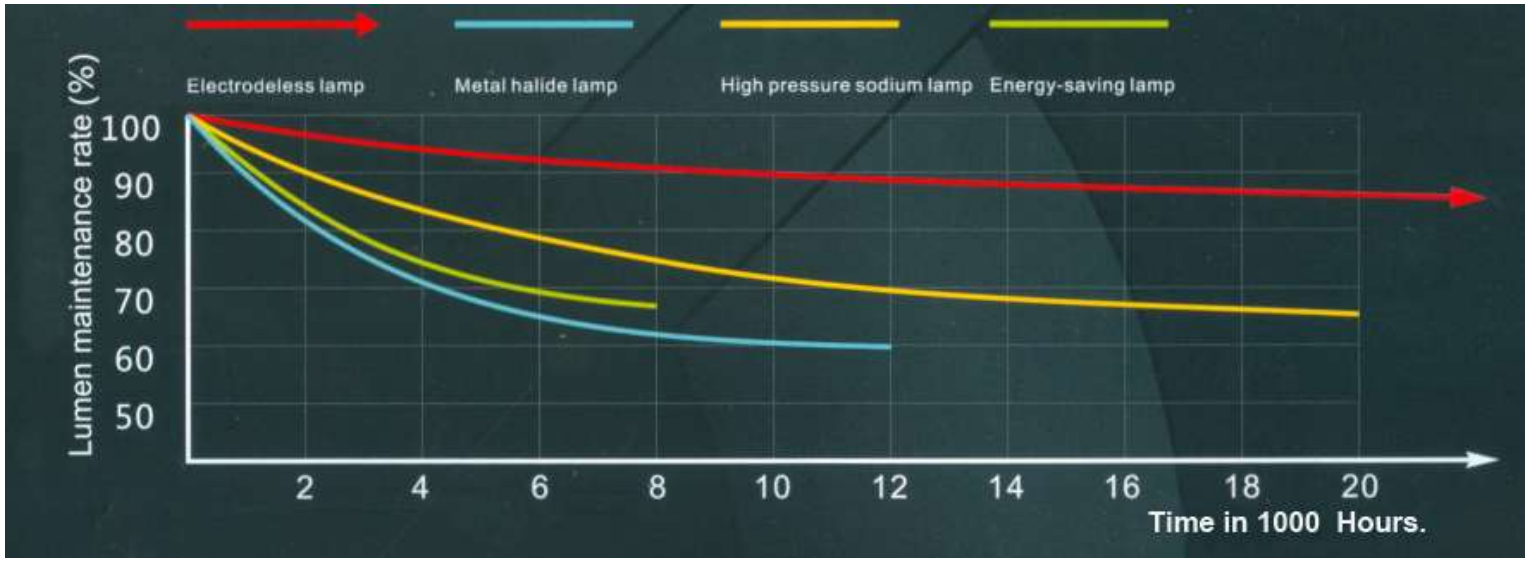
# *Lumen Maintenance Curves of Different Light Sources*




Electrodeless Magnetic Induction Lamps can be produced in 3K, 4K, 5K and 6K Color temperatures with CRI>80 they can vividly reproduce colors and do not emit any heat.

The lamp's amalgam fill technology and the heat conduction rod in the center create stable light output over a wide range of ambient temperatures, maintaining at least 85% of nominal lumens from -30$^{o}$F-130$^{o}$F (for an enclosed fixture with heatsink). Induction lamps can start at temperature as low as-40$^{o}$F. It is an instant start lamp.

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# *Some Images Of ELM Induction Lamp Installations*

**Underground Tunnel Lighting**

**Sports Stadium Lighting**

**Advertising Billboard Lighting**


**Mountain Tunnel Lighting**

**Outdoor Garden Pathway Lighting**

**Toll Booth Lighting**

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# *Some Images Of ELM Induction Lamp Fixtures*

**Industrial/ Factory Lighting**

**Toll Plaza/ Petrol Pump Lighting**

**Indoor Office Lighting**

**Pathway/ Courtyard Lighting**

**Flood Lighting**

**General Area Floodlighting**

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# *Some Images Of ELM Induction Lamp Fixtures*

**Underground Tunnel  Lighting**

**Street Lighting**

**Industrial/ Factory Lighting**

**Industrial/ Factory Lighting**

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# *Cost Benefit Analysis of 250W SON E Lamp Street Light System vs. 100W EM Induction Lamp CCT 6500K*

| SON E 250W Lamp System | 100W EM Induction Lamp |
|---|---|
| Lamp Power = 250W | System Power = 100W |
| EM Ballast Watt Loss = 40W | Power Factor = 0.98 |
| Total Typical System Power = 290W | System VA = 102 |
| Power Factor With Power Factor Correction Capacitor = 0.8 | System Lumens = 8200 |
| Total System VA = 290/0.9 = 362.5 | S/P Ratio for 6500 CCT = 2.14 |
| Lamp Lumens = 25000 | Effective Lumens = 17548 |
| S/P Ratio = 0.62 | Effective System Luminous Efficacy = 17548 / 102 = 172 lumens/VA |
| Effective Lumens = 15500 | |
| Effective System Luminous Efficacy = 15500/362.5 = 42.75 lm/VA | |

- *Therefore, 100W EM Induction Lamp system is roughly 4 times as effective per VA of energy consumed compared to a SON E 250W HPSV system commonly used in India*
- *Taking electricity cost as Rs. 4.5 per kVAhr for industrial applications, HPSV based system generates only 9.5 lumens per VA per Re. as compared to EM Induction Lamp which generates 38 lumens per VA per Re.*

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# *Running Cost Comparison and some other benefits of EM Induction Lamp System*

- *Total running cost @ 10 hours daily use amortized for 2 years*
  - *Cost of lamp and fixture Rs. 6000*
  - *Cost of electricity @ Rs. 4.5 per unit = 362.5(VA)*10(hr)*2*365*4.5/1000 = Rs. 11908*
  - *Total cost for SON E HPSV 250 W system for 2 years = Rs. 6000 + Rs. 11908 = Rs. 17908*
  - *Total running cost for 100W EM Induction Lamp under similar conditions = 102(VA)*10(hr)*2*365*4.5/1000 = Rs. 3350*
- *All HID lamps need stable 220V 10% voltage conditions to operate optimally whereas EMC compatible electronics ballast of EM Induction Lamps can operate from 150-280V AC*
- *In case of mains failure, all HID lamps must cool down before they can strike again whereas due to a special solid mercury amalgam alloy, EM Induction lamps can strike immediately on restoration of power which is a big plus in strategic and hard to reach areas*
- *Lifetime of EM Induction lamps is greater than 50,000 hours including electronics ballast and fixture operates at cooler temperatures unlike LED based luminaires which are sensitive to climactic change due to thermal characteristics of LED emitters*
- *REGNANT offers 4 - 5 years warranty on its EM Induction Lamp Systems with typical payback period of 2-3 years*

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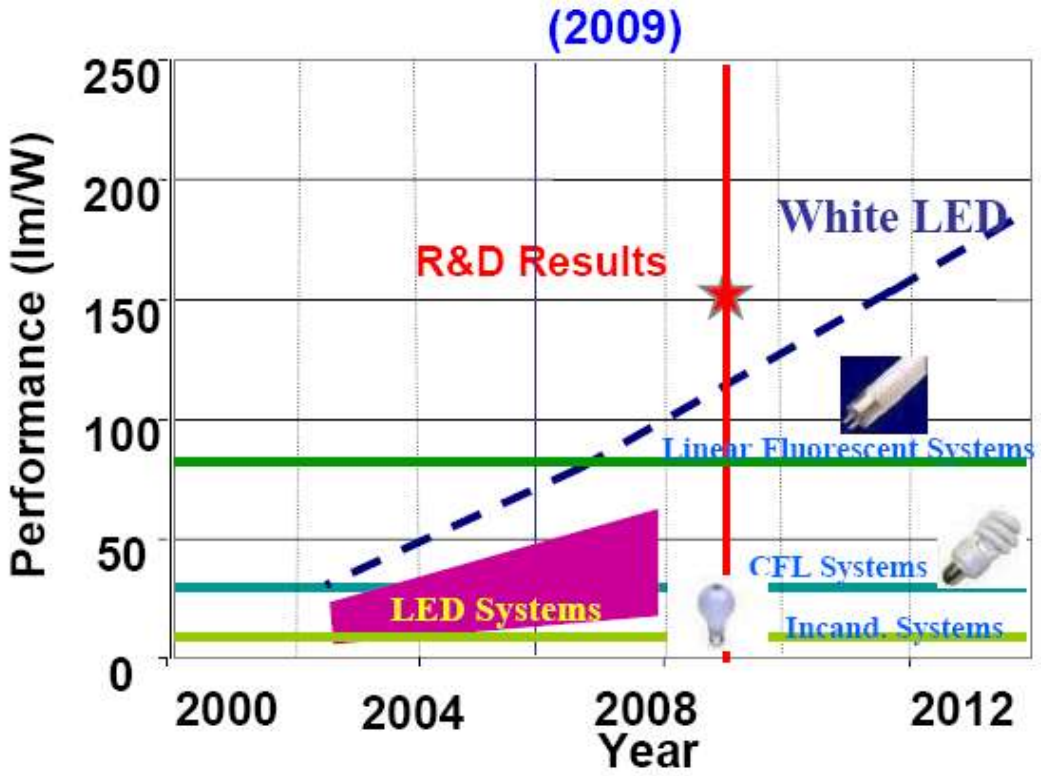
# LED Lighting System Performance

- To the end user, system performance matters …not source performance.
- At best, LEDs have 60% system efficiency.
  - Even though the best LEDs can have 100 lm/W, lighting systems will be at 60 lm/W.
  - Majority of commercial LED products have efficacies in the range of 10 to 30 lm/W.





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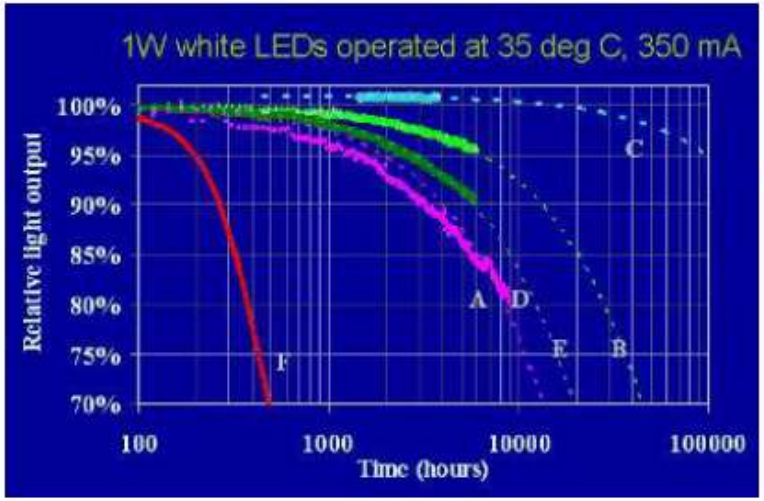
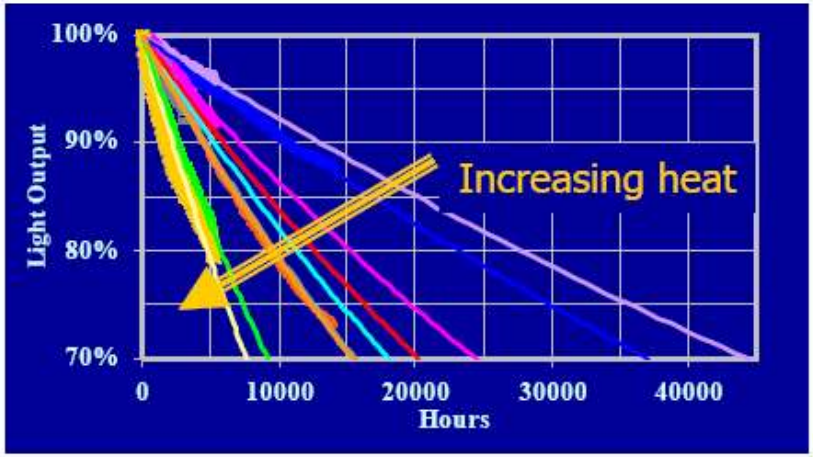
# *Reliability is still a concern*


**Buyer beware…**

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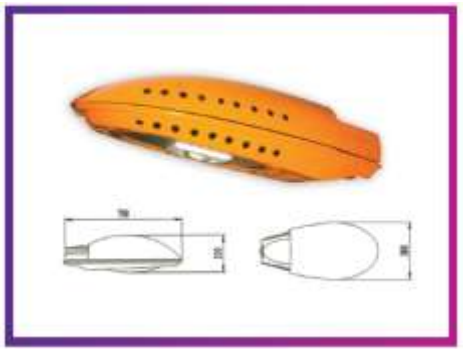
# Why Choose LED in certain Applications

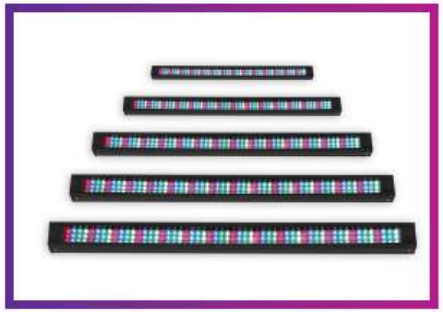
- Easy integration with electronic control gerar because it is itself a solid state p-n Junction.
- Very easy, simple and economical drive solutions when working on DC power sources.
- Easy dimming capability by changing applied current which also makes it run cooler.
- Inherently a monochromatic light source makes it an ideal choice while generating vivid colors in any lighting design.
- Using RGB or other similar chip modules, color temperatures can be changed according to mood requirement.
- Being a highly directional light source it is an ideal choice for polarised architectural accent lighting and flood lighting.
- 1 Watt and below versions are highly suitable for torchlight, automobile taillight, night lamps and other similar applications.
- Having no UV or IR radiation it is an ideal source for apparel show rooms where otherwise fabrics may fade out under other light sources.

# Regnant LED Based Products

50Watt Flood Light



High Power Street Light



LED Wall Washers

High Power Court Light

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## 1.5W LED Candle Bulb

Our low power standard E27 and slim E14 screw base lamps use only 1.5W of power, work on 240V AC and are fully dimmable making them an ideal choice for chandeliers using multiple lamps with a choice of pure white or warm white color temperatures.

## 1W and 5W Globe Lamps

Our globe type LED lamps drawing only 1W with a working voltage range of 85-260V AC, are ideal to use as night lamps and in those areas where light is required for safety. 5W model is ideal for general area soft lighting such as restaurants, bars, conference rooms, passages etc. Both of these models are available in standard E27 screw base whereas 1W model is also available in slim E14 screw base.

**Available colors:** R,G,B,Y,W or Warm white.

# Commercial Lighting Applications

- CFLs are not ideal for general ambient lighting in many commercial office lighting applications due to their limited, narrow light distribution characteristics
- T5 (16mm dia.) or T8 ( 26mm dia.) tri-band phosphors based new generations tubelights can give 78-80 lm/W system efficiency for T5 and 90lm/W system efficiency for T8 with best quality matching electronic ballasts
- Do not get misled by manufacturers' claims about T5 being more efficient than T8 because they compare tri-band T5 with electronic ballast to a conventional halophosphate 36 or 40W T8/T12 using cheap magnetic ballasts
- T5 tubes give maximum light output at 35 degree C compared to T8 optimum operating temperature of 25 degree C
- Due to thinner dia, T5 is more suited to thinner luminaires and optical directivity control is easier
- REGNANT offers both T5 and T8 based solutions using IEC standard electronics ballast

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# REGNANT IS APPOINTED SOLE AGENT FOR INVENTFINE INSTRUMENTS FOR INDIA W.E.F. MARCH 01,2010



Hangzhou Inventfine Instrument Ltd. was founded in May 2000 and is one of the pioneering R&D centres in the field of measurement instruments for lighting and power electronics, recognized by the Govt. of PRC. They are holding several patents to their credit. Their Domestic and Overseas customer base includes famous names such as GE, TOSHIBA, PHILIPS, OSRAM, OPPLE LIGHTING, NVC LIGHTING, TCL LIGHTING, YANKON LIGHTING etc. Their products are in use in USA, Brazil, Holland, Italy, Romania, Turkey, Korea, Thailand, Malaysia, Hong Kong, Taiwan, Mainland China, India, Indonesia, Iran and many other countries.

# *Regnant Current Available testing facilities*

- Complete electric & photometric testing of GLS, FTL, CFL & HID Lamps.
- All types of electronics ballast analysis.
- EMC Testing as per EN55015.
- UV & IR Radiation Measurement of all types of light sources.




**We are now investing in LED testing equipment with a goal to get NABL accredition shortly.**

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# *Regnant's Promise To the Indian Lighting Industry*

Let us join hands together to produce world class lighting products based on futuristic technologies as the worldwide demand for innovative cost effective green technology products is growing exponentially but there is a huge skilled manpower shortage in this field and little awareness in general public about career opportunities for lighting and power electronics professionals. LED based lighting products demand itself is projected to grow more than 22% every year in major developed countries.

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# Regnant's Team Mission Statement

## Where There is Vision & Passion, Things Fall in place.

**All our employees are trained to be passionate about everything they do.**

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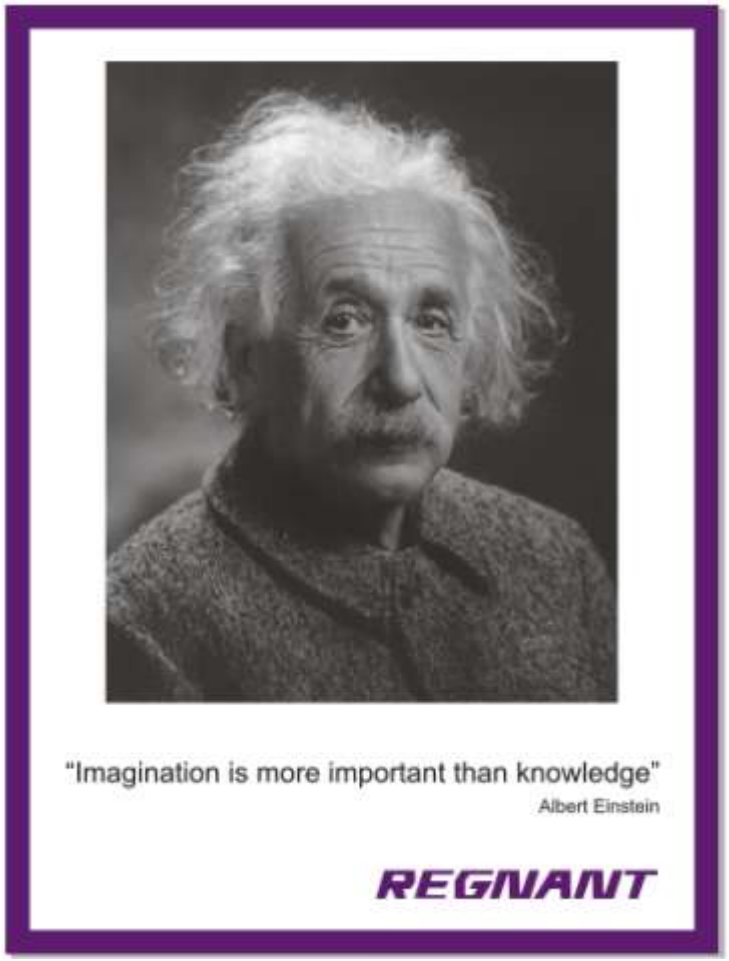
# *THE TEAM & THE DIRECTION*

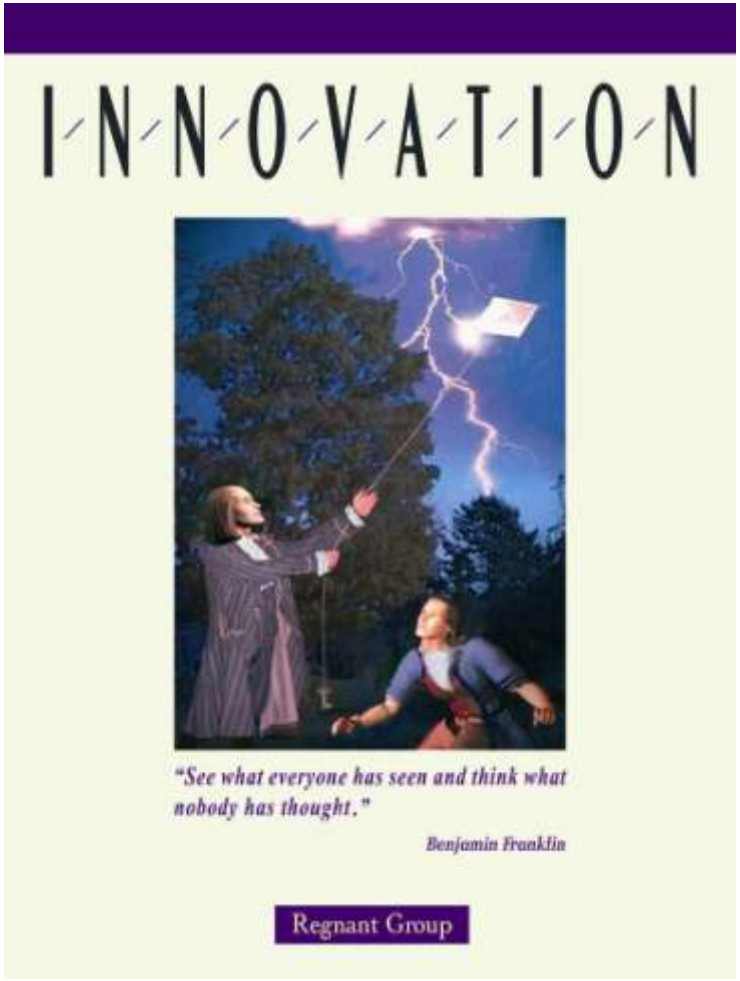
As Henry Ford notably said, “Coming together is a beginning. Keeping together is progress. Working together is success.” At Regnant, we truly believe that our team and our people are our most valuable resource and we have been assimilating the best in terms of talent and abilities from the industry since our inception.

We strive to achieve the perfect mix of novelty and experience by hiring young, ambitious professionals who are just embarking on their career paths to industry seasoned experts for our Marketing, R & D, Operations, Accounting and Manufacturing Divisions. Our senior team members who have joined hands with us after decades of experience and success in the upper echelons of management in allied industries groom our entry-level team members to be future leaders in the industry. This balance enables us to adapt quickly to the dynamic environment of the technologically intensive industries that we are part of. At the same time, it assures us of a solid foundation in the core, time-tested techniques and methods that we need to practice on a daily basis.

Essentially a team of technocrats, we have made significant investments in our research capabilities which include state of the art testing facilities and in-house Lighting and Power Electronics laboratories that have a dedicated, full-time staff. This is our initiative to ‘Breed Innovation Through Application’; a slogan that we would like to encourage not only within our organisation, but also throughout the world. We would like to invite you to join hands with us and help us spread the word.

# *My Personal Inspirations*

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**Thank You & Let Us Together Build A Sustainable Green World**