

INTRODUCTION - LIGHTING SYSTEM

Lighting is an essential service in all the industries. The power consumption by the industrial lighting varies between 2 to 10% of the total power depending on the type of industry. Innovation and continuous improvement in the field of lighting, has given rise to tremendous energy saving opportunities in this area.

Lighting is an area, which provides a major scope to achieve energy efficiency at the design stage, by incorporation of modern energy efficient lamps, luminaires and gears, apart from good operational practices.

The term lighting control system refers to an intelligent networked system of devices related to lighting control. These devices may include relays, occupancy sensors, photocells, light control switches or touchscreens, and signals from other building systems (such as fire alarm or HVAC).

BASIC TERMS IN LIGHTING SYSTEM

Lamps

Lamp is equipment, which produces light. The most commonly used lamps are described briefly as follows:

Incandescent lamps :

Incandescent lamps produce light by means of a filament heated to incandescence by the flow of electric current through it. The principal parts of an incandescent lamp, also known as GLS (General Lighting Service) lamp include the filament, the bulb, the fill gas and the cap.

Reflector lamps :

Reflector lamps are basically incandescent, provided with a high quality internal mirror, which follows exactly the parabolic shape of the lamp. The reflector is resistant to corrosion, thus making the lamp maintenance free and output efficient.

BASIC TERMS IN LIGHTING SYSTEM +

Gas Discharge lamps :

The light from a gas discharge lamp is produced by the excitation of gas contained in either a tubular or elliptical outer bulb. The most commonly used discharge lamps are as follows:

- ☒ Fluorescent tube lamps (FTL)
- ☒ Compact Fluorescent Lamps (CFL)
- ☒ Mercury Vapour Lamps
- ☒ Sodium Vapour Lamps
- ☒ Metal Halide Lamps

Luminaire :

Luminaire is a device that distributes, filters or transforms the light emitted from one or more lamps. The luminaire includes, all the parts necessary for fixing and protecting the lamps, except the lamps themselves. In some cases, luminaires also include the necessary circuit auxiliaries, together with the means for connecting them to the electric supply. The basic physical principles used in optical luminaire are reflection, absorption, transmission and refraction.

BASIC TERMS IN LIGHTING SYSTEM +

Control Gear :

The gears used in the lighting equipment are as follows:

Ballast :

A current limiting device, to counter negative resistance characteristics of any discharge lamps. In case of fluorescent lamps, it aids the initial voltage build-up, required for starting.

Igniters:

These are used for starting high intensity Metal Halide and Sodium vapour lamps.

ILux (lx) :

This is the illuminance produced by a luminous flux of one lumen, uniformly distributed over a surface area of one square metre. One lux is equal to one lumen per square meter.

BASIC TERMS IN LIGHTING SYSTEM +

Illuminance :

This is the quotient of the illuminous flux incident on an element of the surface at a point of surface containing the point, by the area of that element. The lighting level produced by a lighting installation is usually qualified by the illuminance produced on a specified plane. In most cases, this plane is the major plane of the tasks in the interior and is commonly called the working plane. The illuminance provided by an installation affects both the performance of the tasks and the appearance of the space.

Luminous Efficacy (lm/W) :

This is the ratio of luminous flux emitted by a lamp to the power consumed by the lamp. It is a reflection of efficiency of energy conversion from electricity to light form.

Colour Rendering Index (RI) :

Colour Rendering Index (RI) is a measure of the degree to which the colours of surfaces illuminated by a given light source confirm to those of the same surfaces under a reference illuminant; suitable allowance having been made for the state of Chromatic adaptation.

LAMP TYPES AND THEIR FEATURES

TABLE 2.1 LUMINOUS PERFORMANCE CHARACTERISTICS OF COMMONLY USED LUMINARIES

Type of Lamp	Lumens / Watt Range	Avg.	Color Rendering Index	Typical Application	Typical Life (hours)
Incandescent	8-18	14	Excellent	Homes, restaurants, general lighting, emergency lighting	1000
Fluorescent Lamps	46-60	50	Good w.c.t. coating	Offices, shops, hospitals, homes	5000
Compact fluorescent lamps (CFL)	40-70	60	Very good	Hotels, shops, homes, offices	8000-10000
High pressure mercury (HPMV)	44-57	50	Fair	General lighting in factories, garages, car parking, flood lighting	5000
Halogen lamps	18-24	20	Excellent	Display, flood lighting, stadium exhibition grounds, concentric areas	2000-4000
High pressure sodium (HPSV) SON	67-121	90	Fair	General lighting in factories, ware houses, street lighting	6000-12000
Low pressure sodium (LPSV) SON	101-175	150	Poor	Roadways, tunnels, canals, street lighting	6000-12000

The Table 2.1 shows the various types of lamp available along with their features, performance of the tasks and the appearance of the space.



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METHODOLOGY OF LIGHTING SYSTEM ENERGY EFFICIENCY STUDY



A step-by-step approach for assessing energy efficiency of lighting system is given below:

Step-1: Inventorise the Lighting System elements, & transformers in the facility as per following typical format (Table – 2.2 and 2.3). In case of distribution boards (instead of transformers) being available, fuse ratings may be inventorised along the above pattern in place of transformer kVA.

TABLE 2.2 DEVICE RATING, POPULATION AND USE PROFILE

S. No.	Plant Location	Lighting Device & Ballast Type	Rating in Watts Lamp & Ballast	Population Numbers	No. of hours / Day

TABLE 2.3 LIGHTING TRANSFORMER / RATING AND POPULATION PROFILE:

S. No.	Plant Location	Lighting Transformer Rating (kVA)	Numbers Installed	Meter Provisions Available Volts / Amps / KW / Energy

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Step-2: With the aid of a lux meter, measure and document the lux levels at various plant locations at working level, as daytime lux and night time lux values alongside the number of lamps "ON" during measurement.

Step-3: With the aid of portable load analyzer, measure and document the voltage, current, power factor and power consumption at various input points, namely the distribution boards or the lighting voltage transformers at the same as that of the lighting level audit.

Step-4: Compare the measured lux values with standard values as reference and identify locations as under lit and over lit areas.

Step-5: Collect and Analyse the failure rates of lamps, ballasts and the actual life expectancy levels from the past data.

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Step-6: Based on careful assessment and evaluation, bring out improvement options, which could include :

- ✓ Maximise sunlight use through use of transparent roof sheets, north light roof, etc.
- ✓ Examine scope for replacements of lamps by more energy efficient lamps, with due consideration to luminaire, colour rendering index, lux level as well as expected life comparison.
- ✓ Replace conventional magnetic ballasts by more energy efficient ballasts, with due consideration to life and power factor apart from watt loss.
- ✓ Select interior colours for light reflection.
- ✓ Modify layout for optimum lighting.
- ✓ Providing individual / group controls for lighting for energy efficiency such as:
 - a. On / off type voltage regulation type (for illuminance control)
 - b. Group control switches / units
 - c. Occupancy sensors
 - d. Photocell controls
 - e. Timer operated controls
 - f. Pager operated controls
 - g. Computerized lighting control programs

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✓ Install input voltage regulators / controllers for energy efficiency as well as longer life expectancy for lamps where higher voltages, fluctuations are expected.

✓ Replace energy efficient displays like LED's in place of lamp type displays in control panels / instrumentation areas, etc.

CASE EXAMPLES

Energy Efficient Replacement Options :

The lamp efficacy is the ratio of light output in lumens to power input to lamps in watts. Over the years development in lamp technology has led to improvements in efficacy of lamps. However, the low efficacy lamps, such as incandescent bulbs, still constitute a major share of the lighting load. High efficacy gas discharge lamps suitable for different types of applications offer appreciable scope for energy conservation. Typical energy efficient replacement options, along with the per cent energy saving, are given in Table- 2.4.

TABLE 2.4 SAVINGS BY USE OF HIGH EFFICACY LAMPS

Sector	Lamp type				Power saving	
	Existing		Proposed		Watts	%
Domestic/Commercial	GLS	100 W	*CFL	25 W	75	75
Industry	GLS	13 W	*CFL	9 W	4	31
	GLS	200 W	Bimetal	160 W	40	20
	TL	40 W	TLD	36 W	4	10
	HPMV	250 W	HPSV	150 W	100	37
Industry/Commercial	HPMV	400 W	HPSV	250 W	150	35

* Wattages of CFL includes energy consumption in ballasts.

ENERGY SAVING POTENTIAL IN STREET LIGHTING

The energy saving potential, in typical cases of replacement of inefficient lamps with efficient lamps in street lighting is given in the Table 2.5

TABLE 2.5 SAVING POTENTIAL BY USE OF HIGH EFFICACY LAMPS FOR STREET LIGHTING

Existing lamp			Replaced units			Saving	
Type	W	Life	Type	W	Life	W	%
GLS	200	1000	ML	160	5000	40	7
GLS	300	1000	ML	250	5000	50	17
TL	2 X 40	5000	TL	2 X 36	5000	8	6
HPMV	125	5000	HPSV	70	12000	25	44
HPMV	250	5000	HPSV	150	12000	100	40
HPMV	400	5000	HPSV	250	12000	150	38


