ENERGY CONSERVATION IN STREET LIGHTING

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ABSTRACT

Energy Conservation is the most important aspect for sustainable development. Green cities shall be designed with one of the main object to reduce the consumption of energy. Street lighting is one of the major constituents of energy consumption in cities and due to ever increasing energy costs, the governing bodies of megacities / cities/ villages/ townships etc. need to divert their major revenue to meet out with this energy demand of the city. Attempts shall therefore be made to reduce the energy requirement of street lighting by proper re-designing of existing infrastructure, by tapping the potential of existing physical resources & adoption of modern technology for effective energy reduction with consideration of minimum damage to the ecology.

In this paper generally adopted methodologies are considered and attempt of establishing correlation of theoretical methods and actual practice is made.

1. INTRODUCTION

India has been a leader in historic and pre-historic era having an entire advanced culture developed in Mohenjodaro and Harrappa along the banks of the rivers.

The precision in which the roads and drainage lines were laid in various settlement that have been recently discovered and unearthed, has proved to the world that the concept of Geometry and the use of right angles was mastered by the pre-historic Indians. The way in which gradients have been used as effective tools of town planning, show us that the knowledge on the subject of **Green City** was complete and way ahead of their times. The most important aspect for sustainable development green cities should mainly designed with following objectives of reducing the consumption of energy by tapping the potential of existing physical resources & adoption of modern technology for effective energy reduction with consideration of minimum damage to the ecology.

In the annals of early times, street lighting is almost invariably ascribed to an effort to combat robberies and other crimes. Before streets were lighted by regulation, cities and towns were patrolled by watchmen carrying lanterns or torches. Citizens who ventured forth after dark did so at considerable risk, even though they were accompanied by a 'link-boy', or torch bearer, hired as a measure of safety and protection. One of the earliest instances of a modern city to provide street lighting was in 1558, in Paris. At the time, the city was infested with robbers, as a result of which an ordinance was passed requiring all citizens to keep lights burning in windows that fronted the streets. Because the houses were close together, there was a semblance of street lighting. Records indicate that the robbers were thwarted to an appreciable degree.

Economic considerations likewise place a limit on the total amount of light - that is, foot-candles - which can be provided in modern practice. With street lighting, one is concerned with low levels of one foot-candle, plus or minus. Relatively high lighting levels in downtown business streets may be in the order of three to five foot-candles. Exceptionally high-level installations of 15 to 20 foot-candles are usually beyond the means of the average city or town government to provide as a public service; such installations are usually made possible by special contributions from the local merchants.

Theoretical methods of street lighting design are usually performed for ideal conditions to determine the illumination and luminance but other design limitations should be considered in the real world. Also the visibility level is calculated by using background and target luminance under ideal conditions. In reality, there are many factors, which are very difficult to predict and include in lighting design equation. Human eye is also a complex device due to which it is difficult to accurately design an outdoor illumination system just simply based on numerous theoretical assumptions. This calculation method needs to include some correction constant for parameters such as pavement is not level, maintenance for cleaning, aging lamps lamp reflector and refractor is not centered, lamp is off center and tilted, pole is not vertical to the pavement, voltage fluctuation, photo detectors response, ambient temperature factors, reliability of illuminators, roads crowned, and super elevation.

Roadway lighting brackets are designed to meet certain conditions. Their strength must be sufficient to withstand wind loads to be encountered and support the weight of the luminaries to be used. The length is determined by the distance the luminary is located from the pole and the rise sufficient to give proper elevation above the road. Welded pole plates and tie rods are frequently used to strengthen the bracket and minimize vibration.

Straight and right angle bend-type brackets are in lengths to 8 feet, and are constructed of galvanized steel or aluminum. They are designed for use on metal, concrete, and wood pole mountings. Braces attached to both sides of the pole or to center only, support the brackets from below or above the design, needed for strength and rigidity.

The straight bracket is more applicable to conditions where there is no interference with other circuits.

Upsweep brackets are pleasing in appearance, and provide increased mounting height from shorter poles while 4- to 12-foot overhang can be obtained. There is the advantage of keeping pole space available for other than roadway lighting equipment; thus, code standard mounting heights can be maintained even though only lower space is available on the pole. Upsweep brackets are used on wood for space need, and often on non-wood poles to give added height without pole replacement to provide for larger sources.

Engineers tend to focus on the technology and as such, tend to ignore the salient features of the environment in which the technology under design must operate. Roadway light is a good example of this mentality. First, engineers and scientist must remember that light is the fastest thing on earth. As a result, it is virtually impossible to predict the actual levels of lighting in a specific area under design. Assume that ambient light is ignored in the design any light that is added to the area under design will merely increase the level of illumination and make the area brighter than it was designed to be. Ignoring the ambient light is would constitute a conservative and hence desirable design methodology. This seems logical, but it ignores one of the fundamental concepts of visibility and its effect on traffic safety.

Designing without considering energy costs is like to farming without considering water supply. The issue of using the earth's finite supply of stored energy has been raised above simple economic to become a moral issue. It is almost criminal to waste our energy resources selfishly. We have the means to devise greater efficiencies; we should not wait until the market forces us to practice what we are capable of accomplishing. Energy costs represent a major portion of a civic body's operating costs. Lighting in turn accounts for a significant portion of the energy used.

1.1 ROADWAY LIGHTING DESIGN :

The basic goal of roadway lighting is to provide patterns and level of horizontal pavement luminance and of horizontal and vertical illumination of objects. A driver's eye discerns an object on or near the roadway due to contrast between the brightness of the object and the brightness of the background or pavement, or by means of surface detail, glint, or shadows. The illumination concept, which is almost universally used, is based on the premise that, by providing a given level of illumination and uniformity of distribution, satisfactory visibility can be achieved. The luminance concept is based on the premise that visibility is related to the luminance of the pavement and the objects on the pavement. Estimation of the reflectivity of varying pavement surfaces and objects within the driver's vision are difficult. Although other design concepts are under review, such as small Target Visibility etc.

2. DESIGN PROCESS :

By definition, lighting design according to the illumination method relies on the amount of light flux reaching the pavement and the uniformity of the light on the pavement surface.

The steps in the design process are as follows:

A. Determination of the foot-candle value by assessing the facility to be lighted.

B. Selecting the type of light sources (Type I-V).

C. Selecting light sources size and mounting height.

D. Selecting luminary type.

E. Determining luminary spacing and location.

F. Checking for design adequacy.

These steps are arranged in the order in which they are usually encountered in the design process. However, as mentioned earlier, the local utility companies for jurisdictional review complete most roadways lighting designs. Due to this fact, the following section will focus on checking for design adequacy.

DESIGN CRITERIA :-

A. Calculation - The calculation of the average horizontal illumination produced by a lighting system is essentially an iterative design process. The most frequent calculation used to determine average illumination levels is shown below:

Formula Computation

Average Maintained LL x CU x MF

Level of Illumination = S x W

WHERE:

LL = Initial Lamp Lumens

CU = Coefficient of Utilization

MF = Maintenance Factor (LLD x LDD)

LLD = Lamp Lumen Depreciation

LDD = Luminary Dirt Depreciation

S = Luminary Spacing

W = Roadway width

This formula can be used in both the English, metric or SI system of measures.

B. Determining the level of illumination (foot-candle value).

TABLE-A RECOMMENDED ILLUMINANCE VALUES AND UNIFORMITY RATIOS

Road Classification	(1) Area Classification	(2) Average Illuminance Foot-candles	Lux	Uniformity Ratio (Aver. / Min.)
Arterial (Minor & Major)	Commercial	1.1	12	3 to 1
	Intermediate	0.8	9	
	Residential	0.6	6	
Collector (Minor & Major)	Commercial	1.7	8	4 to 1
	Intermediate	0.6	6	
	Residential	0.4	4	
Local	Commercial	0.4	4	6 to 1
	Intermediate	0.3	3	
	Residential	0.2	2	
Sidewalks (Roadside)	Commercial	0.2	3	3 to 1
	Intermediate	0.6	6	4 to 1
	Residential	0.2	2	6 to 1
Pedestrian Ways (3) & Bicycle Lane		1.4	15	3 to 1

(1) Area Classification

(a) Commercial -That portion of a municipality in a business development where ordinarily there are large numbers of pedestrians and a heavy demand for parking space during periods of peak traffic or a sustained high pedestrian volume and a continuously heavy demand for off-street parking space during business hours. This definition applies to densely developed business areas outside of, as well as those that are within, the central part of a municipality

(b) Intermediate - That portion of a municipality which is outside of town area but generally within the zone of influence of a business or industrial devetopment, often characterized by a moderately heavy ntghtlime pedestrian traffic and a somewhat tower parking turnover than is found in a commercial area. This definition includes densely developed apartment areas, hospitals, public libraries, and neighborhood recreational centers.

(c) Residential - A residential development, or a mixture of residential and commercial establishments, characterized by few pedestrians and a low parking demand or turnover at night. This definition includes areas with single family homes, ownhouses, and/or small apartments. Regional parks, cemeteries, and vacant lands are also included.

(2) For PCC Roadway. For ACC roads multiply values by 1.43.

(2) This assumes a separate facility. Facilities adjacent to a vehicular roadway should use the illuminance levels for that roadway.

C. Classification of Luminary Light Distributions

(1) Luminaries - A luminary is composed of a light source, a reflector, and usually a glass or plastic lens or refractor. It is the function of the reflector and refractor to gather the light from the source, direct it toward the roadway, and shape it into a desired pattern on the roadway. Proper distribution of the light flux from the luminaries is one of the essential factors in good roadway lighting. All luminaries light distributions are classified according to their vertical and lateral distribution patterns and the light control in the upper portion of the beam. Glare shields may be added to reduce objectionable light emissions toward adjacent buildings or areas.

(2) Performance - The ultimate performance of a lighting system is dependent upon the control of luminous flux from the light source. Manufacturers provide to the designer photometric data for various lamp luminaries combinations that can be used in determining the amount and direction of luminous flux. For standardization purposes, IES has classified light distributions on the basis of the following:

(a) Vertical light distribution

(b) Lateral light distribution

(c) Control of light distribution above maximum candlepower

The classification of light distributions is made on a plan view of a roadway, which has superimposed on it a series of lines parallel with the roadway and another series transverse to the roadway. These lines, which are spaced in multiples and fractions of the mounting height, are referred to as Longitudinal Roadway Lines (LRL), and Transverse

Roadway Lines (TRL), as shown in Fig.A

FIG.-A PLAN REVIEW OF ROADWAY COVERAGE FOR DIFFERENT TYPES OF LUMINAIRES

D. Selection of Mounting Height

The distance the lamp is mounted above the roadway will affect the illumination intensity, uniformity of brightness, area covered and relative glare of the unit. Higher mounted units will provide greater coverage, more uniformity, and reduction of glare, but a lower illumination level. It is necessary to weigh the effects of larger lamps against a greater number of smaller units at lower mounting heights with maximum glare potential.

The height of luminaries above the roadway surface varies from 15 feet to more than 100 feet. Conventional roadway lighting utilized mounting height of 25 to 50 feet. The lower mounting heights require the use of cutoff or semi-cutoff luminary distribution to minimize glare. Figure B shows minimum mounting heights for various max. Candlepower levels and vertical light distributions. Figure C shows suggested minimum mounting height for various light source sizes.

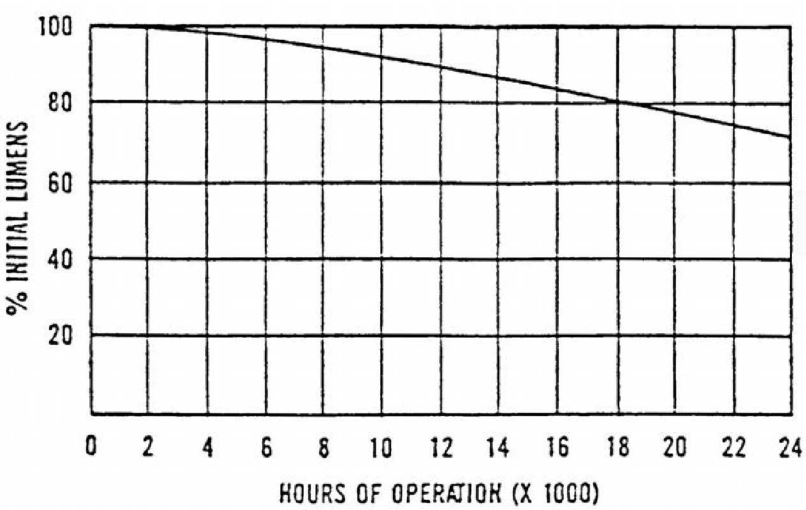
FIG–B MINIMUM LUMINAIRE MOUNTING HEIGHTS FOR VARIOUS MAXIMUM

CANDLEPOWER LEVELS AND VERTICAL LIGHT DISTRIBUTIONS

FIG.-C SUGGESTED MINIMUM MOUNTING HEIGHTS FOR VARIOUS LIGHT SOURCE SIZES

E. Light System Depreciation

TYPICAL LAMP LUMEN MAINTENANCE CURVE



The primary factors of lighting system depreciation are lamp lumen depreciation (LLD) and luminary dirt depreciation (LDD). A typical range for LLD is from 0.9 to 0.78. A typical range for LDD is 0.95 to 0.78. The product of these two factors is referred to as the Maintenance Factor (MF). Figures D and E show lamp lumen and dirt depreciation curves.

SELECT THE APPROPRIATE CURVE IN ACCORDANCE WITH THE TYPE OF AMBIENT AS DESCRIBED BY THE FOLLOWING EXAMPLES:

VERY CLEAN - No nearby smoke or dust generating activities and a low ambient contaminant level. Light traffic. Generally limited to residential or rural areas. The ambient particulate level is no more than 150 micrograms per cubic meter.

CLEAN - NO NEARBY SMOKE OR DUST GENERATING ACTIVITIES. MODERATE TO HEAVY TRAFFIC. THE AMBIENT PARTICULATE LEVEL IS NO MORE

than 300 micrograms per cubic meter.

MODERATE - Moderate smoke or dust generating activities nearby. The ambient particulate level is no more than 600 micrograms per cubic meter.

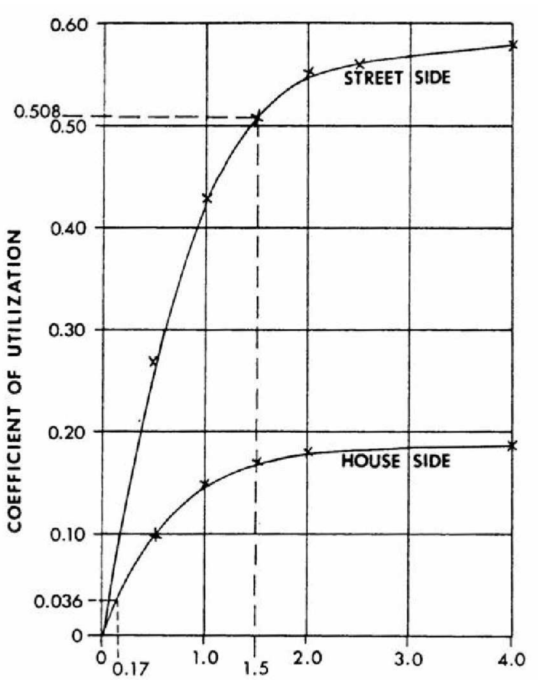
DIRTY - Smoke or dust plumes generated by nearby activities may occasionally envelope the luminaries.

VERY DIRTY - As above but the luminaries are commonly enveloped by smoke or dust plumes.

F. Coefficient of Utilization (CU) - Measured as the percent of total lamp lumens, which are actually delivered to the roadway, surface. Utilization differs with each luminary type, and depends upon mounting height, road width, and overhang. See Figure F

FIGURE F . EXAMPLE OF COEFFICIENT OF UTILIZATION CURVES FOR LUMINAIRE PROVIDING TYPE III - M LIGHT DISTRIBUTION.

TYPE I, II, III, IV, & V TO BE OBTAINED FROM MANUFACTURER'S PERFORMANCE DATA



G. Luminary Spacing - Luminary spacing is often determined by location of utility poles, driveways, property lines, block lengths, or terrain features. It is generally more economical to use lamps with high lumen output, at more reasonable spacing and mounting heights, than to use lamps with lower lumen output at more frequent intervals with lower mounting heights. In designing a lighting system, maximizing spacing of luminaries consistent with good illumination design should be emphasized. From the standpoint of economy and safety, the minimum number of luminaries and luminary supports should be used while satisfying the illumination quantity and quality criteria.

H. Final Review -

Having determined roadway illumination and uniformity ratios, the design can be compared to the local jurisdictions light level policy or other criteria such as those in Table A.

3. TIPS FOR STREET LIGHTING DESIGN :-

* Grade Intersections - It is recommended that the illumination level for an intersection at grade be the sum of the levels for the intersecting roadways. Luminaries should be located so that both vehicles and pedestrians in and near the intersection area are illuminated.

* Curves and Grades - Large radius curves and gentle sloping grades may be treated in the same manner as straight, level sections. Sharper curves and steeper grades require closer luminaries spacing in order to provide uniform pavement brightness. Curbs and guardrails should be illuminated.

· Underpasses - A short underpass may be illuminated satisfactorily by standard luminaries if those on either side of the underpass are positioned so that their pavement illumination overlaps underneath the structure. Longer underpasses require special pole or soffit-mounted lighting fixtures for nighttime and possible daytime use.

* Converging Traffic Lanes - Good direct lighting should be provided on the vehicles entering the main traffics lanes.

* Diverging Traffic Lanes - Curbs, abutments, guardrails, and vehicles in the divergence area should be illuminated. Lighting should also be provided in the deceleration zone.

* Overhead Traffic Signs - Illumination of overhead signs is essential because they will receive little light from vehicle headlights and because other highway lighting, if present in the vicinity is not designed to illuminate the vertical surface of such signs. California practice is to provide an average illumination of 30 fc (3 lux) on the surface of the sign, with the sign message having a reflectance of 70% when clean, and the background having a reflectance of less than 10%.

* Railroad Crossings - Grade crossings of streets and railroads should be illuminated to indicate the presence of a train or railroad car within the crossing at night. Luminaries should be placed on both sides so that the train can be seen both by silhouette and by surface detail.

*Alleys - Streetlights are usually not installed in alleys unless special circumstances exist. These circumstances are not standard and will vary between governing authorities.

* Parking Lots - Parking lots that are used after dark are then lighted to enable drivers to observe pavement markings and see pedestrians, and to deter thefts. Average illumination levels of 0.5-1.0 fc (0.05-0.10 lux) are recommended, but higher levels are sometimes used for public relations values. The illumination level should be greater than that of surrounding streets.

*Low Level Lighting - Low level lighting, which is sometimes referred to as streetscape lighting or ornament lighting, is becoming increasingly popular in downtown historical districts, plan unit developments, parking lots, and separate pedestrian pathways. This type of lighting ranges from lighted bollards (posts) to antique reproduction lighting. Low level lighting should not become a source of unwanted light and glare. Therefore, the distribution must provide precise control of light with good uniformity and no objectionable glare. As an example, parking lot lighting should contain a concealed light source with a cut-off provided to prevent glare as spill over onto adjacent buildings. The Project Engineer or Architect should consult with the Jurisdiction before proceeding with low level lighting. The interchangeability of luminaries and various available posts allows the designer to tailor the amount of light required to meet civic or pedestrian needs. The result is an aesthetic pleasing light sources that conveys a flavor of a specific time period or locale.

4. MAINTENANCE OF STREET LIGHTING:

A street lighting system may be maintained in perfect working order mechanically and electrically, yet it may deliver to the surface of the street a third, or even less, of the illumination for which the system was designed. In a typical case, depreciation of light due to dirt and dust alone was 43 percent; depreciation due to aging of lamps was 23 percent. In some cases, additional loss of light can be attributed to operating lamps at less than their rated current or voltage.

One utility reports a case where an enclosed 4,000-lumen light had not been washed for over two years; foot candles on the pavement averaged 0.4 before washing, and 2.8 - or seven times greater - after washing! In another case, the same utility reports that where luminaries were washed regularly, every six months average foot candles before washing were 2.5, and after washing, 3.5. By a regular six months' washing schedule, illumination depreciation, due to dirt alone, was reduced to 28 percent.

A systematic maintenance program, based upon appropriate studies of the particular system, will reduce operational and maintenance costs. Street lighting has been termed the show window of the electric utility, and those systems which are properly operated and maintained will forestall criticism, promote good customer relations, and aid in community development. Due to the increased acceptance of street lighting, and since the utility is staffed to maintain its electrical supply facilities on a 24-hour basis, the utility is in a position to adequately maintain street lighting in an efficient and safe manner. Special mobile washing equipment has been designed for street lighting maintenance, which can be rented or purchased outright. Some utilities may prefer to employ equipment of their own design or specification. One particular form of truck of special design is equipped with a unique elevated platform that adjusts from the floor of the truck to the working level, and can be extended in either direction by power at the working position. The truck contains washing tanks, heated drying racks, and ample space for lamps, glassware, and other hardware. An efficient arrangement eliminates wasted motion as much as possible, and has facilitated the cleaning of approximately 60 lights per day per man.

Steel posts and brackets should be painted as frequently as required by local conditions. Some utilities may prefer to establish a regular schedule for all such equipment on the system. Dividing a large system into geographical areas and establishing a sequence cycle by area is a most satisfactory method of preparing a schedule. Climatic conditions in a given area will determine the number of months during the year when painting is satisfactory. All rust and scaling paint should be removed and, after priming, a durable, high-grade, exterior paint applied.

Other types of posts such aluminum, concrete, and wood (when fully pressure-impregnated) require very little maintenance.

How do street lighting options compare?

The most cost effective lighting solution is the technology that utilizes Bright Light Solar specialist electronics. This converts the dc power from the battery store to high voltage to drive the lamps. To optimise the lamps for most cost effectiveness it is possible to programme the lights to operate only at the times they are needed. This means the lamps can be programmed to run for 5 or 6 hours after dark then switch off until they're needed again a couple of hours before dawn. By doing this we can reduce the size of the solar panels and offer a lower cost solution.

Type of Problem with the Street Light

* Burn-out
* Cycles (turns on and off repeatedly)
* Light burns 24 hours a day
* Broken glassware
* Water or debris in glassware
* Pole is bent
* Pole needs painting
* Support arm is bent or broken
* Multiple lights are out

5. STREET LIGHTING OF NEXT DECADE:

It is evident that Solar charged LED lighting system is going to dominate the street lighting of green cities in next decade. It will be consisting of following main components.

Panels : High efficiency, poly-crystalline panels will be used in all the Green Street Lighting systems. Sizes can vary depending on the location and the light fitting used. The size and number of the panels are chosen in order that the amount of energy generated in normal applications over the full year is balanced to the energy used in powering the light.. This means that the system generates more power in the summer(when demands on the grid are the highest) and less power is generated in the winter when the surplus energy is "borrowed" back from the grid. This helps balance the energy demands of the power supply and can help reduce peak loads. This can be a significant effect as most energy is generated from the solar panels on bright sunny days which happens to occur when the grid is under it's highest loading from air-conditioning loads.

In some applications where very high light levels are required, the energy generated may not be sufficient to fully balance energy use. In these cases of complimentary supply, the benefits of load matching are still achieved and the net energy drain reduced.

ELECTRONICS :

The electronic system consists of a full sine wave grid interactive 240VAC inverter for connection in grid interactive solar systems. This inverter is controlled by a monitoring system that both monitors the energy balance of the system, switches on and off the light system and monitors total system operation.

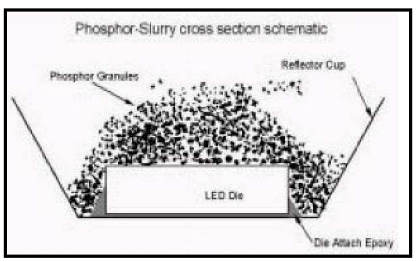
LIGHT FITTING :

A wide range of light fittings can be used to match existing systems or allow standardization with other systems mainly consisting of LED (Light Emitting Diodes).

6. LED's:

LED's are special diodes that emit light when connected in a circuit. They were frequently used as "pilot" lights in electronic appliances to indicate whether the circuit is closed or not. A a clear (or often colored) epoxy case enclosed the heart The two wires extending below the LED epoxy enclosure, or the "bulb" indicate how the LED should be connected into a circuit.

6.1 CONSTRUCTION DETAILS OF LED'S:



First generation white pc-LEDs are made by depositing in measured quantities of a slurry mixture of phosphor and epoxy within a containment cup surrounding the pump die during the encapsulation step .Several factors inhibit process uniformity, including the difficulty of measuring precise small quantities of a viscous fluid, slurry settling both before and after dispensing, distribution of the mixture within the cup, and phosphor powder grain size variations.

· **What Causes the LED to Emit Light and What Determines the Color of the Light?**

When sufficient voltage is applied to the chip across the leads of the LED, electrons can move easily in only one direction across the *junction* between the *p* and *n* regions. In the *p region* there are many more positive than negative charges. In the *n region* the electrons are more numerous than the positive electric charges. When a voltage is applied and the current starts to flow, electrons in the *n region* have sufficient energy to move across the junction into the *p region*. Once in the *p region* the electrons are immediately attracted to the positive charges due to the mutual Coulomb forces of attraction between opposite electric charges. When an electron moves sufficiently close to a positive charge in the *p region*, the two charges "re-combine". Each time an electron *recombines* with a positive charge, electric potential energy is converted into electromagnetic energy. For each recombination of a negative and a positive charge, a quantum of electromagnetic energy is emitted in the form of a photon of light with a frequency characteristic of the semi-conductor material (usually a combination of the chemical elements gallium, arsenic and phosphorus). Only photons in a very narrow frequency range can be emitted by any material. LED's that emit different colors are made of different semi-conductor materials, and require different energies to light them.

6.2 ADVANTAGES OF LED:

• **Reduced Maintenance Costs**

Since LED based light sources last at least 10 times longer than a normal light source, there is no need to replace the light source, reducing or even eliminating ongoing maintenance costs and periodic replacing expenses. The long life of a LED also allows for trouble free designs.

• **More Energy Efficient**

LED light source are more efficient than incandescent and most halogen light sources. When viewing LED lighting as an alternative, it is important to consider the total system level benefits. For example, due to the decrease in energy used for the lighting of a building, air handling costs drop, generating both additional initial and ongoing investment savings. Additional benefits such as the directionality of light for general lighting and vivid true colors without the need for filters in signaling applications add to the energy efficiency on a system level.

• **Design Flexibility and Unobtrusive Hidden Light**

LEDs are typically much smaller than conventional light sources, allowing for dramatically different lighting designs capitalizing on the unobtrusiveness of the source. Light emitting diodes provide the lighting designer with additional options and choices compared to conventional technologies.

• **Vivid Saturated Colors—Without Filters**

Light Emitting Diodes require no filters to create colored light, resulting in deeper saturated colors without wasted light. deep reds, greens, blues and other colors can be produced in monochromatic form directly form the solid state element. There is no need for expensive filters, and there is no wasted energy.

• **Directed Light for Increased System Efficiency**

The light emitted from an LED is directional. Typical conventional sources such as incandescent, halogen, or fluorescent lights are omni-directional, emitting light in all directions. A side benefit from the directionality of light emitted from the LED solution is the reduction of light pollution.

• **Instant On, Full Color, 100% Light**

Light emitting diodes have turn on times measured in microseconds. The instant on feature of LEDs provides additional reaction time in safety critical applications. There is no flickering or warm up period as the source reaches ignition temperature in an LED lighting system and the emitted wave length is reached instantaneously.

• No Mercury in the Light Source

Unlike most fluorescent sources, LEDs contains no Mercury. LED is Solid State technology made in Silicon Valley using similar technologies that are used in the latest microprocessors. As it is a solid state device, it has no moving parts, no fragile glass environments, no mercury, no toxic gasses, and no filament. Eliminating Mercury from your lighting system will enable you to meet new and future increasingly stringent environmental regulations.

• No Heat or UV in the Light Beam

Conventional light sources (as well as some LEDs) contain invisible radiation as well as the visible component of light in the beam. This radiation can be very short wavelength blue, known as ultraviolet light, or long wavelength red, known as infrared, which causes heat. Ultraviolet light can, and will, damage materials, cause color changes and eventually breakdown many materials. Museums and other applications where ultraviolet light is a liability use expensive low flexibility light pipes to filter out this harmful component of the generated light. Frequently the light sources used for these light pipes is a very bright, hot, incandescent or halogen sources, generating most of their light as heat. Infrared light can damage displayed objects, increases air conditioning costs, decreases environmental comfort, and when reflected off reading surfaces increases eyestrain.

• Cold Start Capable

Many light sources in use today are not well suited to cold environments. The cold start ability allows for instant on/off control without specially designed circuitry, simplifying your system design while lowering the cost of the electronic driver.

• Low Voltage DC Operation

Unlike conventional light sources, light emitting diodes are current driven low voltage devices. This enables never before solutions that meet regulatory requirements without expensive safety interactions. Due to the low voltages required, disposable and rechargeable battery operation or alternative energy sources (such as solar or wind) can be easily used to power the light source

• How Much Energy Does an LED Emit?

The electric energy is proportional to the voltage needed to cause electrons to flow across the p-n junction. The different colored LED's emit predominantly light of a single color. The energy (E) of the light emitted by an LED is related to the electric charge (q) of an electron and the voltage (V) required to light the LED by the expression: $E = qV$ Joules. This expression simply says that the voltage is proportional to the electric energy, and is a general statement which applies to any circuit, as well as to LED's. The constant q is the electric charge of a single electron, -1.6×10^{-19} *Coulomb*.

• Finding the Energy from the Voltage

Suppose you measured the voltage across the leads of an LED, and you wished to find the corresponding energy required to light the LED. Let us say that you have a red LED, and the voltage measured between the leads of is 1.71 Volts. So the Energy required to light the LED is $E = qV$ or $E = -1.6 \times 10^{-19}$ (1.71) Joule, since a Coulomb-Volt is a Joule. Multiplication of these numbers then gives $E = 2.74 \times 10^{-19}$ Joule.

7. MEASUREMENT OF ILLUMINANCE:

Illumination (Unit – Lux, Symbol - E)

The luminous flux reaching the working plane per unit of area is called the illumination. For the magnitude of illumination it does not matter the direction form which the luminous flux reaches the plane. The illumination is a scalar quantity. The illumination on a plane due to one light source and due to another source on the same plane can therefore be added to arrive at a total value.

If the luminous flux is not uniformly distributed over the plane, one has to work out average illumination (Eav) on that plane. The illumination on the working plane is therefore the result of direct as well as reflected light.

The symbol of illuminationis E and unit is as follows:

In Metric System , Illumination E = Ô/A lumen/m^2 or Lux. It is Measured with help of Lux meter

8. CASE STUDY :

A data regarding type of fitting, height of fitting and Lux was collected on Shivaji University Kolhapur Campus and is analyzed in following paragraphs

SR. NO.	LOCATION ON UNIVERSITY CAMPUS	TYPE OF FITTING	HEIGHT. OF FITTING FROM G.L.	LUX MEASURED BELOW FITTING	LUX MEASURED 10 FT. AWAY FROM FITTING
1	Panch Bungalow	Fluorescent Tube	17'0"	10.0	6.0
2	Near guest house	Sodium Vapour lamp	15'0"	7.0	7.0
3	Near Girls Hostel	Sodium Vapour lamp	15'0"	10.0	7.0
4	Humanity Bldg.	Sodium Vapour lamp	15'0"	22.0	17.0
5	Library	Fluorescent Tube	8'0"	22.0	3.0
6	University Garden	Sodium Vapour lamp	30'0"	17.0	7.0
7	Main Gate	Florescent Tube	15'0"	21.0	6.0
8	Exam Bldg. Square	Florescent Tube	15'0"	9.0	4.0
9	Staff Quarters	Sodium Vapor lamp	15'0"	7.0	5.0

WATT Hr. REQUREMENT

SR. NO.	Type Of Lighting	No. Of Fitting In University Campus	Watt Require For Each Fitting	Total watt hr. (12hr/day)
1	Fluorescent Tube	117	40	56160
2	Sodium Vapor lamp	57	70	47880
3	Sodium Vapor lamp	10	150	18000
		184	**TOTAL**	**122040**

Annual electricity consumption= 122040x365
=44544.6 Kwhr. = 44544.6 Units

In Present study, a street light for University campus was fabricated using 12 super bright light emitting diodes. The street light system was provided with 6 Volt, 3.2 AH/20hr, non-Spillable Sealed rechargeable lead battery, which was connected to 10V, 8watt Solar Photovoltaic panel (Which is generally used for 8 watt CFL solar lantern). The light output measured on Lux meter is as follows.

In Present study, a street light in University campus was fabricated using 12 super bright light emitting diodes. The street light system was provided with 6 Volt, 3.2 AH/20hr, non-Spillable Sealed rechargeable lead battery, which was connected to 10V, 8watt Solar Photovoltaic panel. The light output measured on Lux meter is as follows.

SR. NO	Type Of Lighting	No. Of Fitting In University Campus	Watt Require For Each Fitting	Total watt hr. (12hr/day)
1	Fluorescent Tube	102	40	48960
2	Sodium Vapor lamp	57	70	47880
3	Sodium Vapor lamp	10	150	18000
4	LED Solar street lighting system in front of library.	15	4.0	720
		184	**TOTAL**	**115560**

9.DISCUSSION :

Option 1:

Energy saving if Fluorescent tubes are replaced by LED fittings in front of library Building.

It can be seen that on university campus in front of library building there are 15 fluorescent tubes which are at height of 8Ft. from ground level. If these tube are replaced by solar lighting system at same height and with same flux there will be saving of 6480 watt hr/day.

Option 2:

All fluorescent tubes are shifted at 8 Ft. height with making provision of antitheft accessories.

SR. NO	Type Of Lighting	No. Of Fitting In University Campus	Watt Require For Each Fitting	Total watt hr. (12hr/day)
1	LED Solar street lighting system in place of all existing fluore scent tubes.	117	4	5616
2	Sodium Vapor lamp	57	70	47880
3	Sodium Vapor lamp	10	150	18000
		184	**TOTAL**	**71496**

It can be seen that on university campus there are 117 fluorescent tubes which are at height of 15Ft. from ground level. If these tube are replaced by solar lighting system at 8 Ft. and with same flux there will be saving of 50544 watt hr/day.

- For this system of 12 super bright LED's used as street lamp at 8 Ft. height, one 10V, 8watt Solar Photovoltaic panel can daily charge this fitting of street lighting for all days a year.
- Present cost of solar panel at Rs. 220/watt, total investment required for solar panel 117No. x 8 watts x Rs. 220.00 = **Rs. 205920.00**
- Cost of production of one fitting is 3500 Rs. . So total cost of all fittings =117x3500.00 = 409500.00 Rs.
- Total cost of LED solar street lighting system = cost of panels + cost of fittings

= **Rs.615420.00**

Savings in electricity charges

- Considering 117 existing fluorescent fitting using 40watt tube giving 22 Lux output used for 12hr./day for 365 days in a year if replaced by LED Solar street lighting system. There will annual saving of =50544x365

= 1,84,48,560whr./annum

=18448.60Kwhr/.annum

= **18448.60 Units/annum**

- Saving in electricity = **26096** Units /annum
- Prevailing M.S.E.B. rate is 5.00 Rs./unit.

Years	Cost / Unit	Electricity in Rs.	Cost saved saved units	Units Rs. Produced in Plant (33% losses assumed)	CO_2 Prevented m3
0-3	5.00	26096.00	130480.00	35000.00	9800.00 (18.13T)
3-6	7.50	78288.00	717640.00	70000.00	19600.00 (32.26T)
6-9	11.25	156576.00	2479120.00	105000.00	29400.00 (54.39T)
9-12	16.90	234864.00	6448321.60	140000.00	39200.00 (72.52T)
12-15	25.35	313152.00	14386724.80	175000.00	49000.00 (90.65T)

RESULTS :

Pay Back period = 4 Year & 8 Months

$C0_2$ prevented in 15 years = 90.65 Tons

10.CONCLUSION

It is evident form above case study that the general lux level maintained on the roads irrespective of type of fitting, position of fitting used is around 20 lux. High wattage sodium vapor lamp placed at 30 feet height and 40 watt fluorescent tube placed at 8 feet height produce same illumination intensity. It can also be seen that lux level obtained under LED fitting under testing is also 20 lux.

The wattage of 30 feet high mounting consisting of sodium vapor lamp is 70 watt, the wattage of fluorescent tube is 40 watts where as wattage of LED fitting under testing is only 2 watts which will lead to substantial energy saving as well as recurring expenses of cities.

Secondly if this LED fitting is connected to solar photovoltaic panels then the question of external connecting cables will automatically become obsolete, which will help during maintenance works of water supply and sanitory lines of the cities.

It is therefore suggested that while Designing Street lighting system the present practice of lighting design need be reviewed.

The utilization Opto-electronics and solar energy Technologies need to be promoted that can help the existing street lighting systems to be used in more efficient and profitable manner to meet basic energy needs for street lighting in rural, urban-domestic, commercial, and industrial areas.

Solar energy and energy efficiency must both be an integral part of any future energy system that addresses the issues of sustainable development.

Though the per watt cost of solar panels is reducing annually, still it is prohibitive but use of LED technology can reduce the pay back period substantially and make the street lighting systems more popular without assistance from the Government.

Making use of solar energy, electronics & LED's contribute to substantial reduction in CO_2 formation assisting formation of green environment thus can contribute to bring the dream of green cities in reality.

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