Energy efficiency lighting

Any lighting scheme interior or exterior can be called an efficient scheme when it provides the required illuminance level for the application it has been designed while utilizing least amount of energy. Technical information for achieving efficiency in the lighting scheme for three categories which are External Lighting, Internal Lighting for Commercial Buildings, and Internal Lighting for Residential Buildings have been elaborated below-

Optimized Lighting Scheme –

What is an optimized lighting scheme?

Optimized lighting scheme comprises of two key components –

1. Effectiveness of the lighting scheme
2. Efficiency of the lighting scheme

1. Effectiveness of lighting scheme

Effective Lighting Scheme –

A lighting scheme can be called an effective one when it serves the purpose for which it is designed. The purpose of a lighting scheme is to provide visual comfort for different kind of activities in different spaces as per various standards. In India we have standard for visual comfort given in Part 8, Section-1, Table - 4 of Lighting and Ventilation of NBC (National Building Code of India) 2005 and a lighting scheme will be called effective if it conforms to NBC 2005 recommended illuminance levels for various activities and spaces.

Efficient Lighting scheme –

A lighting scheme is called efficient over the other when for the same visual comfort and usage pattern it will consume lesser amount of electrical energy. The efficiency in a lighting scheme is guided by the following three factors –

a. *Lighting Power Density*
b. *Integration of artificial lighting scheme with daylight*
c. *Lighting controls*

a. Lighting Power Density –

Lighting power density of a lighting scheme is the ratio of installed lighting power in a space (includes power of lamp, ballast, current regulators and control devices) to the floor area of that space. The ECBC (Energy Conservation Building Code of India) 2007 gives the maximum permissible lighting power values for different types of space usages and the lighting power of a designed scheme should be lower than or equal to these values.

Energy efficiency in external lighting – External lighting in and around a building is used for lighting pedestrian walks, landscaping, artifacts, parkways & parking, facade lighting, security etc. To achieve the efficiency in external lighting scheme designed for various application following can be practiced –

Use of efficient Lamps –Depending upon the kind of application, the following lamp types can be used in external lighting scheme to improve the efficiency –

High Pressure Sodium Vapour Lamps (HPSV)

High Pressure Sodium vapor lamp is a gas discharge lamp which uses sodium in an excited state to produce light. The efficacy of HPSV varies from 50 -140 lumens/watt and lamp life is around 16000 - 24000 hrs. The color rendering index of these lamps is quite low. These lamps can be primarily used for applications where lighting from a height around 5m is desired such as for the drive ways in a campus or car parking etc.

Metal Halide Lamps (MH)

Metal halide lamps are similar in construction and appearance to mercury vapor lamps. The addition of metal halide gases to mercury gas within the lamp results in higher light output, more lumens per watt (50-110 lumen/watt) and a higher color rendition index than from mercury gas alone. Metal halide lamps have shorter lifetimes (5,000–20,000 hours) compared to both mercury vapor and high-pressure sodium lamps. Metal halide lamps in external lighting are used when better color rendition is required such as facade lighting etc.

Fluorescent Lamps

Fluorescent lamp is a low–pressure mercury electric discharge lamp with a glass tube filled with a mixture of argon gas and mercury vapour at low pressure. When current flows through the ionized gas between the electrodes, it emits ultraviolet (UV) radiation from the mercury arc which is then converted to visible light by a fluorescent coating on the inside of the tube. Fluorescent lamps are usually available in various colors i.e. warm white, normal white, cool white etc. Fluorescent lamp efficacy is around 40-100 lumen/watt and the average life of the lamp varies from 10000 – 24000 hrs. The color rendering of the fluorescent lamps is very good.

Compact Fluorescent lamps (CFL)

Compact fluorescent lamps are fluorescent lamps which are small in size, come in both types ballast integrated and non-integrated. Life of CFL lamps is almost 9 to 10 times to that of an incandescent lamp. CFLs can be extensively used in landscape lighting, security lighting fixtures, bollard lighting etc.

Light emitting diode (LED) Lamps

The LEDs are semiconductor lighting sources. When a diode is forward biased (switched on), electrons are able to recombine with holes within the device, releasing energy in the form of photons. LEDs consume very less power and have a very long life (50000-70000 hrs) as they are shock and vibration proof. LEDs because of their very small size can be used for variety of lighting application in landscaping.

Table 1: Lamps and control gears used in outdoor lighting should be selected based on the minimum efficacy values given in the table below

Light Source	**Minimum allowable luminous efficacy (lm/W)**
CFLs (compact fluorescent lamps)	50
LEDs (light emitting diodes)	50
Fluorescent Lamps	75
Metal Halide Lamps	75
High Pressure Sodium Vapour Lamps	90

The exterior lighting power for the applications as mentioned in the table given below as per ECBC 2007 should be calculated and it should be in the limit of recommended values in the table –

Table 2: Exterior Lighting Power Densities

Exterior Lighting Applications	**Power Limits**
Building entrance (with canopy)	13W/m^2 (1.3W/ft^2) of canopied area
Building entrance (without canopy)	90W/lin m (30 W/lin ft) of door width
Building exit	60W/lin m (20 W/lin ft) of door width
Building Facades	2W/m^2 (0.2W/ft^2) of vertical facade area

b. Integration of daylight –

Utilization of daylight can reduce the dependency on artificial lighting during daytime and can help in saving significant amount of energy which would have been otherwise wasted to provide similar visual comforts.

c. Lighting controls –

Lighting controls in a lighting scheme are directly related to the operations. Controls like dimming, step-down, on-off, occupancy; photocells, timers etc are widely used now a day in lighting schemes.
Lighting controls in a lighting scheme should be provided as recommended in the ECBC 2007 to ensure the operations and energy consumptions are taken care of.

Controls in Day-lighted Areas

a. There should be use of appropriate controls. And it should be well integrated with internal lighting. Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Refer guidance note for the same. Is capable of reducing the light output of the luminaires in the daylighted areas by at least 50%, and
b. Controls only the luminaires located entirely within the daylighted area.

Common types of controls: Lighting controls

Each control device shall

a. Control a maximum of 250 m^2 (2,500 ft^2) for a space less than or equal to 1,000 m^2 (10,000 ft^2), and a maximum of 1,000 m^2 (10,000 ft^2) for a space greater than 1,000 m^2 (10,000 ft^2).
b. Be capable of overriding the shutoff control required in (a) for no more than 2 hours, and
c. Be readily accessible and located so the occupant can see the control.

Timers

These represent the most basic type of automation, and are very popular for outdoor applications. Timers can be simple (responding to one setting all year round) or sophisticated enough to contain several settings that go into effect over time.

Occupancy sensors

These devices – also known as 'motion detectors' – turn lights off and on in response to human presence. Once sensitivity and coverage area is established, sensors are selected from two predominant technology types.

Passive infrared sensors

These detect the motion or heat between vertical and horizontal detection zones. This technology requires a direct line of sight and is more sensitive to lateral motion, but it requires layer motion as distance from the sensor increases. The coverage pattern and field of view can also be precisely controlled. It typically finds its best application in smaller spaces with a direct line of sight, such as restrooms.

Ultrasonic sensors

These detect movement by sensing disturbances in high-frequency ultrasonic patterns. Because this technology emits ultrasonic waves that are reflected around the room surfaces, it does not require a direct line of sight. It is more sensitive to motion towards and away from the sensor and its sensitivity decreases relative to its distances from the sensor. It also does not have a definable coverage pattern or field of view. These characteristics make it suitable for use in layer-enclosed areas that may have cabinets, shelving, partitions, or other obstructions. If necessary, these technologies can also be combined into one product to improve detection and reduce the likelihood of triggering a false on or off mode.

Photocells

These measure the amount of natural light available and suitable for both indoor and outdoor applications. When available light falls below a specified level, a control unit switches the lights on (or adjusts a driver to provide more light). Photocells can be programmed so that lights do not flip on and off on partially cloudy days.

In conclusion one can say that a lighting scheme is optimized when it is effective and at the same time efficient also.

2. Efficiency of lighting scheme
How to design an optimized lighting scheme?

To design an optimized lighting scheme one should follow the following steps –

1. ***Select lamps, luminaires and control gears which are efficient –***

Efficiency of lamps - Efficiency of lamp is defined by the term efficacy which means the amount of lumen produced by the lamp per unit wattage. Higher the efficacy of the lamp better it is. Also the CRI value of the lamps selected must be in accordance with the application for which it is going to be used. For example in an office space or a display area of a commercial complex one will require lamps with CRI values which will give a very near to the realistic view but on the other hand in case of a street light the CRI will not be the guiding factor in selection of lamp.

High efficacy Lamps

Lamp efficacy, in an interior lighting scheme, plays a very crucial role. A lighting scheme which utilizes lamps with lower efficacies will result in increased number of lamps and hence increase the LPD (lighting power density) of a space. The increased LPD will not only increase the lighting power consumption but also indirectly increase the heating load on the HVAC equipment and further add to energy consumption.

The reduction in energy consumption is possible with proper choice of lighting fixtures and the lamp types. Lighting output and wattage should be seen before choosing the lights.

Given below are examples of high efficacy lamps currently available in market

T5 lamps - These are fluorescent lamps with a diameter of 16 mm, which is 40% less than the diameter of existing slim fluorescent lamps. They are designed for higher efficacy and system miniaturization. The life span of T5 lamps is also very long, around 18 000 hours as compared to 8000 hours of standard fluorescent lamps.

Bureau of energy efficiency, India in its appliance energy labelling program has rated various tubular fluorescent lamps, by different manufacturers, on the basis of the energy consumption and light output. Given below is the table listing out the BEE rated TFL lamps

Table 3: BEE (bureau of energy efficiency) rated TFL lamps

S.No	Product	Brand	Watt	Lamp Type	Star Rating
1	TFL	OSRAM	36 W	HL Tubular Fluorescent Lamp	5 Star
2	TFL	OSRAM	36 W	HL Tubular Fluorescent Lamp	5 Star
3	TFL	OSRAM	36 W	HL Tubular Fluorescent Lamp	5 Star
4	TFL	PHILIPS	36 W	Tubular Fluorescent Lamp	5 Star
5	TFL	PHILIPS	36 W	Tubular Fluorescent Lamp	5 Star

6	TFL	PHILIPS	36 W	Tubular Fluorescent Lamp	5 Star
7	TFL	WIPRO	36 W	Ultralite Tubular Fluorescent Lamp	5 Star
8	TFL	WIPRO	36 W	Ultralite Tubular Fluorescent Lamp	5 Star
9	TFL	WIPRO	36 W	Ultralite Tubular Fluorescent Lamp	5 Star
10	TFL	CROMPTON	36 W	Power-Lux Tubular Fluorescent Lamp	5 Star
11	TFL	CROMPTON	36 W	Power-Lux Tubular Fluorescent Lamp	5 Star
12	TFL	Samsung	36 W	Tubular Fluorescent Lamp	5 Star
13	TFL	SURYA	36 W	SUPER BRIGHT Tubular Fluorescent Lamp	4 Star
14	TFL	GALAXY	36 W	SUPER BRIGHT Tubular Fluorescent Lamp	4 Star
15	TFL	MYNA	36 W	high lumen Tubular Fluorescent Lamp	4 Star
16	TFL	SURYA	40 W	Tubular Fluorescent Lamp	3 Star
17	TFL	SURYA	36 W	K SLIMLITE Tubular Fluorescent Lamp	3 Star
18	TFL	GALAXY	40 W	Tubular Fluorescent Lamp	3 Star
19	TFL	GALAXY	36 W	SLIMLITE Tubular Fluorescent Lamp	3 Star
20	TFL	OSRAM	36 W	Tubular Fluorescent Lamp	3 Star
21	TFL	OSRAM	40 W	OSRAM BASIC PLUS TFL	3 Star
22	TFL	OSRAM	40 W	Tubular Fluorescent Lamp	3 Star
23	TFL	PHILIPS	40 W	Tubular Fluorescent Lamp	3 Star
24	TFL	PHILIPS	36 W	Tubular Fluorescent Lamp	3 Star
25	TFL	WIPRO	40 W	PREMIUM Tubular Fluorescent Lamp	3 Star
26	TFL	WIPRO	36 W	SAFELITE Tubular Fluorescent Lamp	3 Star
27	TFL	WIPRO	40 W	Tubular Fluorescent Lamp	3 Star
28	TFL	ANCHOR	40 W	Tubular Fluorescent Lamp	3 Star
29	TFL	ANCHOR	36 W	Tubular Fluorescent Lamp	3 Star
30	TFL	CROMPTON	36 W	Super Saver Tubular Fluorescent Lamp	3 Star
31	TFL	CROMPTON	40 W	Brightlux Tubular Fluorescent Lamp	3 Star
32	TFL	CROMPTON	40 W	Tubular Fluorescent Lamp	3 Star
33	TFL	BAJAJ	40 W	Cool Day Light Tubular Fluorescent Lamp	3 Star
34	TFL	BAJAJ	36 W	Tubular Fluorescent Lamp	3 Star
35	TFL	HIND	40 W	Cool Day Light Tubular Fluorescent Lamp	3 Star
36	TFL	HIND	36 W	Cool Day Light Tubular Fluorescent Lamp	3 Star
37	TFL	MYNA	40 W	Tubular Fluorescent Lamp	3 Star
38	TFL	MYNA	36 W	Tubular Fluorescent Lamp	3 Star
39	TFL	GE	36 W	GE SLENDER TFL	3 Star
40	TFL	GE	40 W	GE Standard TFL	3 Star
41	TFL	CEMA	36 W	CEMA Energy Saver	3 Star
42	TFL	CEMA	40 W	CEMA TC 3	3 Star
43	TFL	Samsung	40 W	Tubular Fluorescent Lamp	3 Star
44	TFL	ONIDA	36 W	Tubular Fluorescent Lamp	3 Star
45	TFL	ONIDA	40 W	Tubular Fluorescent Lamp	3 Star
46	TFL	ECOLITE	40 W	Tubular Fluorescent Lamp	3 Star
47	TFL	ECOLITE	36 W	Tubular Fluorescent Lamp	3 Star
48	TFL	JINDAL	40 W	Cool Day Light Tubular Fluorescent Lamp	3 Star
49	TFL	PHILIPS	40 W	Tubular Fluorescent Lamp	2 Star

Compact Fluorescent lamps - CFLs (Compact fluorescent lamps) produce light in the same manner as linear fluorescent lamp. Their tube diameter is usually 5/8 inch (T5) or smaller. CFL power is 5-55W. Typical CFLs have been presented in figure

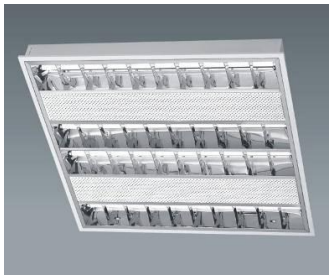
Light emitting diodes

LEDs are small in size but can be grouped together for higher intensity. The efficacy of a typical residential application LED is approximately 20 lumens per watt though 100 lumens per watt have been created in laboratory conditions. LEDs are better at placing lighting in a single direction than incandescent or fluorescent bulbs. LED strip lights can be installed under counters, in hallways, and in staircases; concentrated arrays can be used for room lighting. Waterproof, outdoor fixtures are also available. Some manufacturers consider applications such as gardens, walkways, and decorative fixtures outside garage doors to be the most cost-efficient.

LED lights are more rugged and damage-resistant than compact fluorescents and incandescent bulbs. LED lights don't flicker. They are very heat sensitive; excessive heat or inappropriate applications dramatically reduce both light output and lifetime. Uses include:

- Task and reading lamps
- Linear strip lighting (under kitchen cabinets)
- Recessed lighting/ceiling cans
- Porch/outdoor/landscaping lighting
- Art lighting
- Night lights
- Stair and walkway lighting
- Pendants and overhead
- Retrofit bulbs for lamps

LEDs last considerably longer than incandescent or fluorescent lighting. LEDs don't typically burn out like traditional lighting, but rather gradually decrease in light output.



Efficiency of Luminaires – The efficiency of a luminaire is defined by the term ‘luminaire output ratio’ or ‘the light output ratio of the fixture’ which is the ratio of the lumen output of a lamp to the lumen output of a luminaire. Higher the ratio means more amount of light produced by the lamp is coming out of the luminaire. Also the light distribution, governed by the mirror optics of a luminaire, plays an important role in selection of luminaires.

Efficient luminaire also plays an important role for energy conservation in lighting. The choice of a luminaire should be such that it is efficient not only initially but also throughout its life. Following luminaries are recommended by the NBC 2005 for different locations

- For offices semi-direct type of luminaries are recommended so that both the work plane illumination and surround luminance can be effectively enhanced.

- For corridors and staircases direct type of luminaries with wide spread of light distribution are recommended.
- In residential buildings, bare fluorescent tubes are recommended. Wherever the incandescent lamps are employed, they should be provided with white enamelled conical reflectors at an inclination of about 45°from vertical.

Efficiency of Control Gears – Control gears in the discharge lamps which are basically ballasts shall have lower losses. For example the electronic ballasts used with the 28 or 36 W fluorescent tubular lamps consumes 2-3 W of power where as for the same lamps the conventional magnetic ballasts consumes power as high as 15 W.

Ballasts- All discharge lamps, including fluorescents, require ballast for proper operation. Typical ballast losses are taken as approximately 15% of the lamp wattage. It is important to include calculation of ballast losses when comparing consumption and savings of different kinds of lamps.

New electronic or solid state ballasts, now available in market, save approximately 20—30% in energy consumption over standard ballasts. Electronic ballasts usually change the frequency of the power from the standard mains (e.g., 50 Hz in India) frequency to 20,000 Hz or higher, substantially eliminating the stroboscopic effect of flicker associated with fluorescent lighting. In addition, because more gas remains ionized in the arc stream, the lamps actually operate at about 9% higher efficiency above approximately 10 kHz. Lamp efficiency increases sharply at about 10 kHz and continues to improve until approximately 20 kHz. Because of the higher efficiency of the ballast itself and the improvement of lamp efficiency by operating at a higher frequency, electronic ballasts offer higher system efficiency.

2. Design the scheme/layout of luminaires in a manner that will provide the lighting levels as recommended by the NBC 2005 with a better uniformity over the entire working plane.
3. Where ever possible integrate the artificial lighting scheme with daylight through appropriate controls. Controls like manual switching on/off or step-dimming or automatic controls like photo-sensors can be installed in the lighting scheme to optimize the operations. Also the luminaires falling in the daylighted area should be put on a different circuit so that there is no interference of operations.
4. Controls like on/off, occupancy, timer etc should be provided to avoid wasting of energy as and when the lighting fixtures are not required to be switched on.
5. Effective maintenance of the space and luminaires – An effective maintenance plan should be in place to maintain the cleanliness of the space and luminaires which during the course of time accrete dust and dirt.

“An optimized lighting scheme will not only enhance the quality of the built environment, reduce the lighting energy consumption but will also bring down the cooling demand as well as the cooling energy of a built environment.”

MANUFACTURERS LIST

Some of the manufacturers of lighting systems are as mentioned below. The list mentioned below is not extensive and has to be checked in the market for more updates and more information.

- ASIAN ELECTRONICS
- BAJAJ ELECTRICALS
- CERCO LIGHTING
- DECON LIGHTING
- GE LIGHTING
- HALONIX LIGHTING
- HAVELLS INDIA LIMITED
- LUCIFER LIGHTS LTD.
- OSRAM INDIA PVT LTD.
- PHILIPS ELECTRONICS INDIA LIMITED
- SURYA ROSHNI
- WIPRO LIGHTING

Some of the manufacturers of daylight controls are as mentioned below. The list mentioned below is not extensive and has to be checked in the market for more updates and more information.

- ASIAN ELECTRONICS
- HONEYWELL ELECTRICAL DEVICES AND SYSTEMS INDIA LTD
- PHOENIX
- RELIANCE INDUSTRIES LTD
- GE LIGHTING
- ALIEN ENERGY LTD
- HAVELLS INDIA LIMITED
- CROMPTON GREAVES LTD
- OSRAM INDIA PVT LTD.
- PHILIPS ELECTRONICS INDIA LIMITED
- SURYA ROSHNI
- WIPRO LIGHTING
- LEGRAND LUMINAIRES PVT LTD
- MICROBIT CONTROLS
- UNILITE INDUSTRIES
- POWER ELECTONICS