A novel approach for an energy efficient lighting system and reducing the power consumption

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ABSTRACT

Lighting is an essential service in industrial, commercial, governmental and residential sectors. All the sectors require lighting systems either in day time or in night time. During night period the consumption of electricity by lighting systems approaches to their peak load value. By using appropriate and intelligent methods of electricity consumption and management in lighting systems we can reduce the consumption and electricity bill. In this paper cost effective and green techniques are described with their performance comparison with conventional lighting systems. As the lighting load requires detailed analysis and proper management without making any hindrance in human comfort, work or in output quality linked with it. As we light up any lighting system it produces heat and that causes another issue of unwanted space heating and lowers our comfort level. Since we focused on lighting system management and load mitigation these demerits gives more opportunity to increase the lighting efficiency at low cost of implementation.

Keywords: Energy conservation, Efficient lighting system, Performance comparison, Usage of skylight.

1. INTRODUCTION

Any sectorial superstructure has different level of lighting need at different areas which bank on type of work, usage and its resourcefulness with considering its personal and public comfort. For example: Bright level of light is required in a study room and official cabins, Low level of light intensity is suitable for restaurants and pubs, Much Brighter light is required for street light and glow sign boards, Normal light intensity is suitable in normal environment of room or workstation. The lighting quality also influences visual comfort and health of possessor. The proper lighting quality also increases the concentration and work productivity. As the requirement of level of intensity of lighting is variable thus we have more options to choose among the odds.

2. ENERGY CONSERVATION OPPORTUNITIES IN LIGHTING SYSTEMS

A. Terminology and definitions

S.No.	Terminology	Symbol	Definition	Unit
1	Luminous flux / Luminous power	lm	A measure of the total "amount" of visible light emitted by a source	lm
2	Lux	lx	Illuminance and luminous emittance, measuring luminous flux per unit area.	lm/m²
3	Luminous Efficacy	η	It is the ratio of luminous flux to power.	lm/W
4	Colour Rendering Index	CRI	A quantitative measure of the ability of a light source to reveal the colours of various objects faithfully in comparison with an ideal or natural light source.	-
5	Light Reflectance Value	LRV	A measure of visible and usable light that is reflected from a surface when illuminated by a light source.	-

The proper design of electrical lighting enhances the visual performance and comfort by maintaining adequate and appropriate illumination while controlling the reflection and glare.

Whenever any lighting source is compared the output parameter is lumens not watt. Since watt refers to the amount of electrical energy consumed, not the amount of light and lumens refers to amount of output light intensity.

B. The effects of poor lighting system

Poor lighting system can cause several problems like low productivity, high human error rates and inability to match or select correct colors, eyestrain and headache, a reduction in mental alertness, and low employee morale.

3. STEPS THAT CAN BE ADOPTED TO IMPROVE LIGHTING EFFICIENCY

A. Audit of lighting and energy requirement

By auditing of lighting and energy requirement we can easily determine the net requirement and optimal values according to data that can be installed in the sector.

B. Installation of Infrared sensors or photo sensors for switching of light

Lighting systems must be turned off when they are not in use. To avoid the over consumption when lighting system is not in use we can use automatic infrared sensors. The infrared sensors determine the occupancy with in a limited volume of space and switch on or off the lighting fixtures automatically. By using this intelligent method we can reduce the wastage of energy that is caused by carelessness of turning off lighting fixture. Photo sensors are electronic devices that monitor day light intensity, availability, controls lighting fixtures and dimmers to operate according to need. Photo sensors detect quantity of light and sends signal to main controller to adjust the lighting, these are commonly used in outdoor lighting to make their working function automatic when the availability of light is low or zero. It is very cost effective and energy saving device and by using such kind of technological advances we can reduce the energy cost by controlling the over the unnecessary hours of operation. This unit can be installed either individually or in grouped to control multiple lamps.

C. Installation of high BEE star rated fluorescent lamp and electronic ballast

Energy efficient T-5 fluorescent lamp with electronic ballast and reflector can save up to 70% of the total energy as compare to ordinary fluorescent lamp. These can also be replaced by other options of lighting systems that consumes less power and generate similar amount of illumination.

Replacing the old T-12 lamps with either T-8 or T-5, these lamps are commonly used in houses and public places so it is feasible to switch these old T-12 lamps with T-5. The figure below shows the difference between the diameters of different types of fluorescent lamp after worth the technical data is described in tabulated form to easily compare the data.

Table 1: Technical parameters of fluorescent lamp

Type of fluorescent lamp	CRI (%)	Energy Efficacy (lu/W)
T-12	62	78
T-8	85	90
T-5	85	99

Figure 1. **Differentiation of fluorescent lamp**

i. Calculations

Yearly power demand savings

PDS = N x [CPC – (PCP x BF)] x K x OH

PDS is Power Demand Savings (kW), CPC is Current Power Consumption of existing lamp and ballast (W), BF is Ballast Factor, PCP = Power Consumption of Proposed lamp and ballast (W), k is the conversion factor 0.001 kW/W and OH is operating hours per year (hr/yr)

Implementation cost determination

IC = (PLC + EB) x N

IC is Implementation cost, PLC is Proposed Lamp Cost and EB is Electronic Ballast cost.

Total light usage savings

TS = (PDS x EC) – IC

TC is Total Savings (INR) and EC is Energy Cost (INR/kWh)

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D. Usage of skylight

In various fields of work where lighting is required can be intelligently integrated with skylight which is capable to reduce the use of electrical lighting systems in day time. Sometimes it is capable of reducing up to zero consumption of light during day hours. As the consumption of electrical lighting system is minimised the amount of heat generated by the lighting system also reduces and by this effect the cooling requirements reduces and comfort level rises up thus the electrical energy is saved and cost effective system is achieved.

To improve the skylight in day hours some strategies can be followed in your space like usage of clerestory windows, using of wide window pane, location of window must be in the direction of sunlight, elimination of prior obstacles that hinders the light, usage of high LRV paints is crucial when choosing colour for the built environment (interior and exterior), Surface reflectance also plays an important role in improving the skylight that's why this parameter is also taken in account. These savings can range from about 3 to 45 INR/sq. ft. depending upon the building type, operation, location and energy cost. This efficient method is capable of reducing 80% of day time energy consumption.

E. Using intelligent illumination techniques

We can also use general illumination, local illumination and local-general illumination technique to improve the lighting efficiency without compromising our lighting comfort. Some illustrations are shown below.

Figure 2. Illumination techniques

F. Surface Reflectance determination of objects

Determine the surface reflectance of object. By such means we can easily determine the placement of lighting system in 3D space and their illumination parameter requirement according to use. A pictorial representation is given to describe the surface reflectance to get an idea of their value.

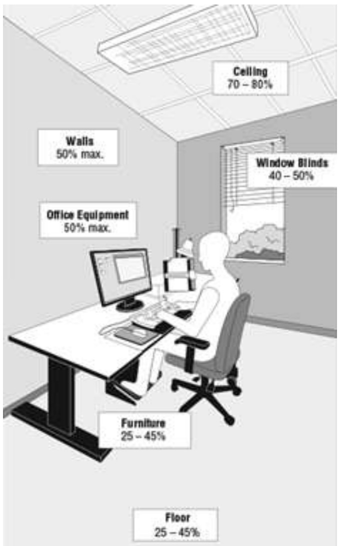

Figure 3. Surface reflactance

Table 1: Technical and cost approximation parameters of lamps

Type of lamp	Image	Energy Efficacy lu/W (Avg.)	CRI (%)	Approx. Life (hours)
Incandescent lamps		15	85	1000
Fluorescent lamps		50	70	5000
Compact fluorescent lamps		60	85	8000-10,000
High pressure mercury (HPM)		50	50	5000
Halogen lamps		20	80	2000-4000
High pressure sodium (HPS)		90	35	6000-12,000
Low pressure sodium (HPS)		150	20	6000-12,000
Light emitting diode (LED)		200	80	50,000-70,000

In above table cost comparison is done by taking the data of several lamps of approximately 800 lu. for over twenty years with taking account of bulb cost.

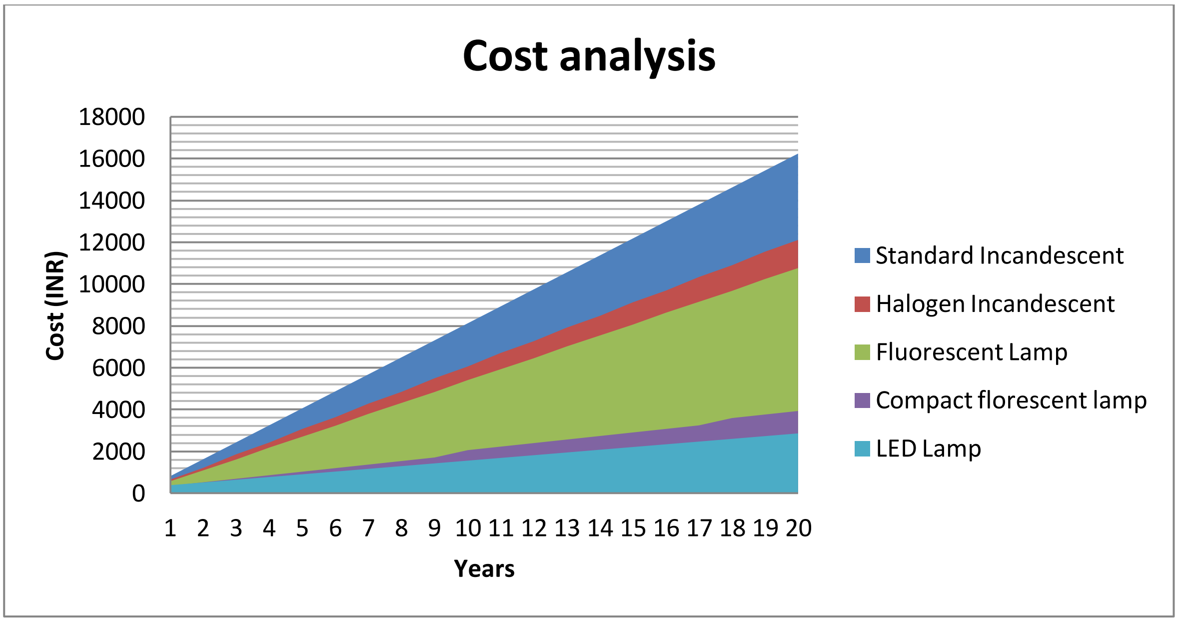

Figure 4. **Cost analysis over 20 years of running**

*Energy Cost = 5.95 INR/kWh

In above figure cost comparison is done by taking consideration of first installation cost, running time cost and replacement cost after the life completion of lamp. A cumulative data is managed in which the overall cost is estimated having a constant energy cost 5.95 INR/kWh for whole analysis. This figure also helps user to choose an energy efficient and cost effective lighting system.

4. CONCLUSION

By adopting these measures we conclude that we can reduce electricity consumption, save money and reduce the carbon dioxide emission at a large extent to build green and clean environment for our forthcoming generation. The cost comparison graph concludes that the LED lamps are most efficient as compare to other lighting sources, LED lamps are 5.68 times cost effective than standard incandescent lamp and have a greater life among all with low maintenance cost. Usage of T-5 lamp is the best option for linear light requirement in case of T-12 because T-5 lamps can save up to 70% of energy related to T-12 fluorescent lamp. By using infrared sensors or photo sensors we can easily manage the usage of electricity more efficiently and hassle-free. Promoting the energy audit to know the actual potential of energy saving is also a good option to implement energy efficient lighting system. Usage of electronic ballast with high BF is suggested in case of fluorescent lamp to reduce energy consumption. Promoting usage of skylight is also a major point to be considered in buildings to reduce their day time consumption up to 80% by using energy efficient measure of skylight consumption. Intelligent illumination techniques are also a good method that can be used mostly in commercial offices where various illumination techniques can be used to get required effect to conserve electricity.

REFERENCES

[1]. http://www.ceilume.com/lrv-and-lighting.cfm
[2]. http://www.ormalight.com/nl/actueel/light-sources-and-their-colour-rendition
[3]. http://creativelightingconcepts.com.au/led/
[4]. "The Ergonomics of Light" by Bradford J. Powell, Buildings.com, October, 2002, retrieved November 3, 2007
[5]. Illuminating Engineering Society of North America. RIESNA Lighting Handbook. (9th ed.). Illuminating Engineering Society of North America. ISBN 0-87995-150-8.
[6]. Energy Conservation Building Code Tip Sheet Building Lighting Design Version 1.0 (Reprinted)— June, 2009
[7]. http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing/programs/ph/phecc/strat_list
[8]. International Journal of Enhanced Research in Science Technology & Engineering, ISSN: 2319-7463 Vol. 3 Issue 10, October-2014, pp: (47-49), Impact Factor: 1.252
[9]. IJIRST –International Journal for Innovative Research in Science & Technology| Volume 1 | Issue 10 | March 2015 ISSN (online): 2349-6010
[10]. http://www.beeindia.in/energy_managers_auditors/documents/guide_books/1Ch3.pdf
[11]. http://www.beeindia.in/energy_managers_auditors/documents/ea_em/TR-EnergyAudits.pdf
[12]. Durmus Kaya (2003) Energy Conservation Opportunities in Lighting Systems, Energy Engineering, 100:4, 37-57
[13]. Wong-kcompt J.B., Turner W.C., Hong S, and King W.R., New Lighting Options for State Buildings, Energy Engineering, Vol. 87, No:1, pp: 46-56, 1990.
[14]. Skylights Guidelines, Heschong Mahone Group, 1998.