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Conservation of Energy: a Case Study on Energy Conservation in Campus Lighting in an Institution

Biswajit Biswas[1], Sujoy Mukherjee[2] , Aritra Ghosh[3]
[12]*Department of AEIE, Murshidabad College of Engineering & Technology, India*
[3]*Department of EE, Murshidabad College of Engineering & Technology, India*

ABSTRACT : *Fossil fuel reserve in India is depleting in a rapid way with development of the country. To meet the energy crisis, end user efficiency has an important role. This paper deals with the energy conservation in lighting system with the replacement of illumination scheme as there is an increasing demand of energy in all sectors in India. A number of commonly used lighting source and their comparison in terms of luminous efficacy was discussed. The campus lighting system comprising of T12 fluorescent light fixture for vigilance purpose of residential and institutional area of an existing institution can be replaced with proposed LED light fixture of equivalent output but of higher efficiency to reduce consumption of lighting energy. This improvement of end user efficiency will reduce the peak and average demand of electricity and hence reduce burden on electric network. The savings of annual energy with the proposed scheme is around 65% compared to the existing expense which is a significant achievement through energy conservation technique. Payback period of installation of proposed illumination scheme is slightly over three years. The initial investment for short term assessment is little higher but, in long term assessment the initial investment for the proposed scheme is will reduced by 50% as the operating life span of the proposed scheme is around five times the existing scheme.*

Keywords: *Energy conservation, End User, LEDs, Luminous Efficacy, Payback Period*

I. INTRODUCTION

India has over 17 percent of the world's population and hence a significant consumer of energy resources. India consumes its maximum energy in Residential, commercial and agricultural purposes in comparison to China, Japan, Russia, EU-27 and US [1]. It is found that the share of energy consumption in India and China has also been on the raise due to sharp urbanization, population explosion, and intensive growth of IT and related business [2]. Development of the society highly depends on availability of energy. Hence meeting energy demand for the nation is an important task for sustainable development of the country. In all five year planning in India, energy sector has received significant priority. It is found that requirement of electricity during year 2010-11 was 861,591 million units and availability was 788,355 million units, i.e. a shortage of 73,236 million units (8.5%). In the year 2011-12, the requirement was 933,741 million units and the availability was 837,374 million units, again resulting in shortage of 96,367 million units (10.3%) [3]. It is seen that there exist a considerable gap demand and supply of power. It is very much essential to minimize the gap between generation and demand. From 1991 to 2007 a number of reforms have been introduced by the government to improve the power system in India. It in turn revolutionized the growth in power capacity, reliability in supply, growth in the revenue collection [4].

The conservation of energy is an important means to reduce peak and average demand of energy. It is observed that investment in energy efficiency and energy conservation is highly cost effective [5]. End user efficiency can considerably be improved by Energy conservation technology. It is possible to save energy with the implementation of energy conservation technology which means increasing generation of energy with available source [6]. The improvement of end user efficiency is a part of demand side management which reduces the amount of energy consumption by the end users. It in turn reduces the burden from the existing power supply system which also reduces in unit cost of the energy [7] [8].

In domestic, commercial and industrial sector, lighting system consumes significant amount of energy. It consumes 50% of total energy consumption in commercial buildings and 10% in industries. A number of places are found having inefficient lighting design for a particular task [9]. In all the sectors both indoor and outdoor lighting efficiency can be improved with higher efficient lighting sources which will help to reduce the gap between demand and supply.

II. SECTOR WISE ENERGY DEMAND IN INDIA

India is the one of the most populated country in the world and one of the most growing countries in the world. In order to have sustainable growth rate, energy in the usable form plays an important role. From the time of independence, India has raised the power generation capacity from 1362 MW to many folds at present [10]. In every five year planning, energy got significant importance. But the gap between generation and the demand is increasing day by day. The fossil fuel reserve in India is not very vast and may be depleted totally by the middle of the century which indicates an alarm situation of near future. Energy consumption pattern of different sectors in India in the year 2007 are given in the table I. Hence to keep up the growth rate of every sector, meeting required energy demand is essential.

Table I: Sector wise energy consumption

Areas	***Consumption (Year-2007)***
Domestic	21%
Commercial	18.0%
Industrial	32%
Transportation	29%

III. ENERGY CONSERVATION AT THE END USER

It is seen that there always exist a gap between generation of energy and energy demand of energy. It is quite impossible to bridge this gap by increasing the generation capacity as it is a very capital intensive process. At the same time most of the fossil fuel reserve will be depleted by next few decades. From the survey conducted by ministry of power in 1992 it is found that the improvement in efficiency of end users is essential. End user sector is a major area of conservation of energy to bridge the short fall between generation and demand [10]. In all the areas, conservation of energy is possible. Through demand side management it is possible to maximizing the end use efficiency [11]. Around 15,000 MW of energy can be saved through end-use energy efficiency [10]. One of the most significant areas of energy conservation is lighting energy. Lighting load shares a significant portion in all sectors namely domestic, commercial, industrial etc. It is found that in most of the cases indoor lighting get priority as far as energy efficiency is concern but campus lighting in commercial, domestic building get less importance. There is huge possibility to conserve energy if the inefficient light fittings are replaced by efficient one. Basically it is a demand side management which helps to reduce load on the electrical network. Consumption of energy can be reduced by conservation of energy.

IV. LIGHTING SOURCES AND THEIR EFFICIENCY

In all sectors there are some commonly used light fittings such as incandescent light, fluorescent light, sodium vapour, mercury vapour, metal halide etc. for particular application. Luminous efficacy i.e. lumen per watt for these light sources are different. Among these a number of areas found with incandescent light as a source of lighting which very inefficient from the point of view of energy efficiency. It is obvious that higher efficiency of lighting source will definitely reduce the energy consumption. Luminous efficacy of different light sources is listed in table II.

Table II: luminous efficacy of different light sources

Light source	***Luminous efficacy (lumen/watt)***
Incandescent light	18-20
Fluorescent light	60-70
Sodium Vapour	40-120
Mercury Vapour	50-60
Metal Halide	80-125
CFLs	50-80
LEDs	20-60

It is seen that the luminous efficacy of the LED and CFL are at per but LED is much energy efficient due to low power consumption at the driving circuit and negligible loss of power in terms of heat generation. Hence LED for lighting purpose is a good alternative of commonly used light sources. More over research is going on to develop more efficient LEDs. It is true that the initial cost of LEDs is high but its life span is extremely high compared to other light sources. So LEDs can be good alternative to replace the existing less efficient lighting source in all sectors of application.

V. A CASE STUDY OF REPLACING EXISTING LIGHTING SYSTEM (T12 FLUORESCENT) BY LED LIGHT IN THE CAMPUS OF AN INSTITUTIONAL AREA

A survey was conducted to an Engineering College and its residential complex and found that 40 number of fluorescent lamp (T12) fixture is connected to the entire campus for vigilance purpose. It is observed that all the lights remain in operation for around 12 hours at the night (6 p.m. to 6 am) for every day. The duration of operation may slightly vary depending on the seasonal change of day length. It is also observed that the lights remain in operation throughout the year irrespective of holydays and vacation as it operates for vigilance purpose of the campus. All of the lights fixtures are having electromagnetic ballast which consumes around 12 to 14 watt of additional power while in operation. So the power consumption of a single fluorescent light fixture considering minimum ballast loss is 40+12=52 watts. The light output of the fluorescent light fixtures is around 2400 lumen. Hence a significant amount of energy can be saved with improvement of end user i.e. replacing the existing light fittings with high efficient light fittings. For this purpose high efficient LED street light fixture of SHAH ELECTRONICS model no. SESTL-LED-1811was proposed. It consumes 18 watt with luminous efficacy of around 120-140 lm/w. This LED Street light provides average luminous output of around 2340 lumen and dedicated for outdoor application. The comparative study between existing lighting fittings and proposed light fittings will provide very close output with much less energy consumption. Taking 12 hours of operation in a day, total energy consumption of a single existing light i.e. fluorescent light in a day is given by:
52*12 watts-hour = 624 watt-hour.
So, annual energy consumption of a single existing light is given by:
624*365 watt-hour =227760 watt-hour or 227.76 units.
Hence annual energy consumption of total existing light i.e. 40 fluorescent light is given by:
40*227.76 unit = 9110.4 units.
Annual energy cost for campus lighting with existing light fixture is given by:
5*9110.4 = Rs. 45,552/- (Considering unit cost as Rs. 5/-)

If all existing light fittings are replaced by proposed 18 watt LED Street light which gives output of around 2340 lumen which is very close to the light output of existing fluorescent light fixture. Taking same hours of operation i.e. 12 hours day, energy consumption in a day of a LED Street light fixture is given by:

18*12 = 216 watt-hour

So, annual energy consumption of a single LED Street light fixture is given by:

216*365 = 78840 watt-hour or 78.84 units

Hence annual energy consumption of total LED Street light fixture i.e. 40 is given by:

40*78.84 = 3153.6 units

Annual energy cost for campus lighting with LED Street light fixture is given by:

5*3153.6 = Rs. 15,768/- (Considering unit cost as Rs. 5/-)

Hence annual energy savings is (9110.4 – 3153.6) = 5956.8 units.

Percentage savings in annual energy consumption is 65.38%.

Annual savings in energy cost is (45552 - 15768) = Rs. 29,784/-

Now the cost of proposed LED light fittings is Rs. 2500/- per unit.

Cost of installation of proposed LED light fittings is = 2500*40 = Rs. 100,000/-

Payback period = 100000/29784 = 3.35 years = 3 years 4 months.

It is fact that the initial investment and payback period of the proposed lighting system is high. But the savings in long term is of very significance. Minimum life span of a LED is 50000 hours whereas the life span of fluorescent light is around 10000 hours. Taking 12 hours of operation LED light fixture will last for 2 years and 3 months. For the same hours of operation per day, LED light fixture will last around 11 years. So the onetime investment in LED light is bound for around 11 years whereas the investment of fluorescent light fitting is bound only around 2 years 3 months. Hence for the period of 11 years the existing fittings needs to replace five times.

Now the cost of one light fitting of with T12 fluorescent light fixture for outdoor use is around Rs. 1,000/-. Hence total investment in 40 number is 1000*40 = Rs. 40,000/-. For the period of 11 years, the investment for light fitting of with T12 fluorescent light fixture is five times i.e. 5*40000 = Rs. 200,000/- whereas the investment for LED light fixture is Rs.100,000 only. In long term assessment the initial investment in LED light fixture is 50% less than that of fitting of with T12 fluorescent light fixture. Moreover annual savings in energy cost is around 65%. This savings through end user efficiency is of very significant for conservation of energy.

VI. Conclusion

It is found that the improvement of end user efficiency with proposed higher efficient LED light fixture provide significant result for campus lighting system. It is also found that the initial investment is high and the payback period is slightly above 3 years. It is also found that in spite of higher initial investment, the operating life of the LED system is reasonably high which results 50% savings on initial investment on long term basis as compared to existing fluorescent lamp (T12) fixture. It is also found that around 65% of annual energy consumption can be reduced with the proposed scheme.

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