THE TRANSITION TO LED ILLUMINATION: A CASE STUDY ON ENERGY CONSERVATION

NARENDRA B SONI, *Member IEEE, Certified Energy Auditor and* **P. DEVENDRA**, *MISTE*
Email:

ABSTRACT

This paper deals with the energy saving potential possible with changing in illumination schemes. The case study in an engineering institute deals with the replacement of existing conventional lighting scheme with LED lighting scheme will have huge energy saving potential, with pay back period of even less than 18 months. The LED lighting scheme provides additional advantages as cool light, decreased maintenance cost, longer life, more flexibility, easier handling With increase in energy crisis there is a need of looking for additional energy sources or reduce in energy consumption in any form without loosing comfort. It is always preferred over energy conservation over energy generation, as energy generated is many fold energy generated. Energy audition is the new trend in the present scenario. An energy auditor can play a major role in energy saving. Energy saving potential is possible at every part of life. One of the energy saving scheme in illumination is, by using natural light and/or use of LEDs. LEDs are having major advantages of longer life & almost negligible power consumption compared to any type of illuminating source(s).

Keywords: *Compact fluorescent lamp, Efficacy, Organic LED, Pay back period,*

I. INTRODUCTION

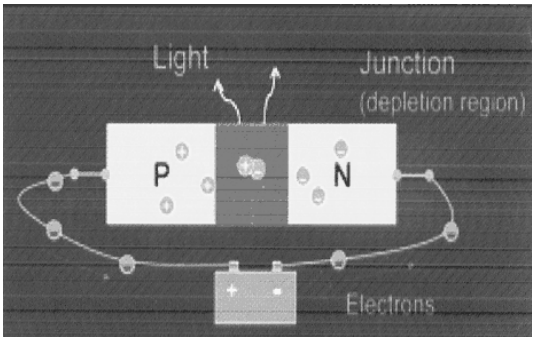
In olden age, incandescence and fluorescence lamps were the main focus in illumination technology. With development in SV, MV and metal halide (in recent), make possible to replace this old technology. But none of these technologies could improve the efficacy exceeding 200 lumens per watt and efficiency beyond 60-70%. The current technology of CFL has improved the efficiency and it has really proved standards. The obstacle in becoming popular is the initial cost and the decrease in illumination over the use. These days with support of government (in taxes) and improvement in manufacturing technology the initial cost has come to the vision of common man.

With the advent of commercial LEDs in the 1960s, however, a new kind of lighting became available. LEDs will consume less electricity than conventional lighting including CFLs and can produce less of the parasitic by-product heat. Now the LED are available with different colour improving RI and giving a better look and *cool light*. To produce a white (Solid State Light) SSL device, however, a blue LED was needed, which was later discovered through materials science and extensive research and development

In 1993, *Shuji Nakamura* of *Nichia Chemical Industries* came up with a blue LED using Gallium Nitride (GaN). With use of GaN, now it is possible to create white light by combining the light of separate LEDs (red, green and blue) or by placing a blue LED within a special package with an internal light conversion phosphor (some of the blue output becomes red and green) with the result that the LED light emission appears white to the human eye.

II. LED AS LIGHTING SOURCE

A. PRINCIPLE OF OPERATION[1]



LEDs differ from traditional light sources in the way they produce light An LED, is a semiconductor diode. It consists of a chip of semiconducting material treated to create a structure called a *pn* junction. When connected to a power source, current flows from the p-side (or anode) to the n-side (or cathode) and not in the reverse direction. The charge-carriers (electrons and electron holes) flow into the junction from electrodes. When an electron meets a hole, it falls into a lower energy level, and releases energy in the form of a photon (light). The specific wavelength or color emitted by the LED depends on the materials used to make the diode.

B. RECENT DEVELOPMENTS IN LED LIGHTING[4,5]

The efficacy of light source is measured in lumens/watt. The efficacy of LED is compatible with the present light source but the efficiency of LED lighting is very high. As in normal incandescence lamp is having efficacy of around 18 lumens/watts and LEDs are in the range of 40 Lumens/watt, but in incandescence lamps most of the power (watts) lost in heat as the efficiency of incandesce lamp is very low in the range of 10-15%. As there is no heat developed in LEDs this power towards heat will be reduced, only losses taking place will be in driver circuits which account for 10-15% losses, thus a higher efficiency in the range of 85-90 % can be obtained. That makes a potential difference in saving in energy in LED lighting. The research is going on in development of LED with high lumens/watt output. The maximum achieved efficacy is 132 lm/w , but it is yet to be commercialized. By passing a high current through a LED higher lumens/watt can be obtained with increase in power rating as well. Generally 1 w LEDs are considered high watt LED and are in use for illumination purpose.

Organic light-emitting diodes (OLED) can be a revolutionary change in display purpose. With development of OLED, it is possible to make LED displays as thin as paper. A electronic paper which can be folded & carried away. Such displays can be very useful for advertisement purpose.

C. COMPARISON OF LEDS WITH OTHER TYPE OF LIGHT SOURCES:

As discussed earlier the efficacy of LEDs is not very high, but the efficiency. Following chart shows the comparison of efficacy of various illumination schemes:

Type of Scheme	Efficacy (lm/w)
Incandescence	18-20
Fluorescent	60-70
Sodium Vapor	40-120
Mercury Vapor	50-60
Metal Halide	80-125
CFLs	50-80
LED	20-60

From above table it can be observed that the efficacy of LEDs is on par with CFLs, but as the driver losses are negligible and there no production of heat, thus giving higher efficiency.

D. ADVANTAGES OF LEDS:

1) The high efficacy of LEDs makes them useful in battery powered or energy-saving devices.

2) The correct RI makes pleasant and cool appearance.

3) LEDs can emit light of an intended color without the use of color filters that traditional lighting methods require.

4) The SSL can be designed to focus its light without use of reflector as in conventional lighting.

5) LEDs can be used for dimmer applications without change in colour, as the current

through element is lowered to dim the light; where as, conventional lamps turns yellow when used with low voltage to dim the light. In fact with fluorescent and pressured lamps dimming is not possible at all.

5) LEDs are ideal for use in high speed applications and where frequent ON-OFF is required, unlike in incandescence lamps, the maximum failure rates of lamps are during ON-OFF only.

6) LEDs, being solid state components, are mechanically more rugged compared to delicate other lamps.

7) The life span of LEDs is an extremely long compared to any other type of lamps. The life span is around 1, 00,000 hours, approximately 12 years non stop! Where as the incandescence lamps has a life span of 1000-2000 hours, maximum of 3 months…..

8) The turn on time of LED is very high compared to Pressure lamps and Fluorescent lamps.

9) LEDs do not contain mercury, as compact fluorescent lamps do.

10) LED do not produce any heat making stay comfortable, and reducing further air conditioning load.

11) Only one LED is not sufficient for illumination purpose, LEDs are used in packed form. It can be made practically possible to replace only faulty LED, reducing inventory and maintenance cost.

E. DISADVANTAGES OF LEDS:

The major disadvantage lies with LEDs, is only initial cost. As the initial cost of LEDs is very high, it is not so popular in common man. The other drawback is that of production of beam, as the efficacy is low (compared to pressure lamps) and beam can not be produced the application of LEDs in flood lighting is limited.

III. APPLICATIONS OF LED SYSTEMS:

Backup lighting: The LEDs can be used in every part of life, including applications from house hold to industries. As the power consumption is very low, the LEDs are very useful for battery operated systems like home lighting on inverters, torch lights etc. In commercial building and shops also they find applications where back up lighting (with independent power supply) is provided through out the day irrespective of power supply.

Street Light: LEDs are used in street lighting because they have extremely long life makes them more economical to operate over their span of operation and LEDs can provide a more pleasant spectrum.

The city hopes to be able to cut street lighting budget in half by switching to LED street lighting, and that accounts for just the energy savings.

Vigilance: The other application of LED lighting is in corridors, parking place and places where vigilance is required. Generally the vigilance lighting is thought the night, and just sufficient enough to illuminate, LED lightings are ideal choice and pay back period is also very less.

Rural areas: The LED lighting can be very helpful in remote rural areas, where grid has not reached. With the help of solar PV panels, batteries can be charged and if it is used through LED lighting system, a long back can be possible.

Street Reflectors[2]: LED lighting is a wondrous application for street reflectors. The self charging LED lighting scheme can be used as reflectors on road. During day time they will store energy and later same will be used for glowing during night time, as reflectors, thus avoiding accidents.

Operation Theaters: LED lighting can be life saver, when used in operation theaters. As the operation theater light need to be ON irrespective of grid power available, LED system can be used as backup lighting, operating on battery and giving backup for a long time.

Under water & mines: As the under water lighting and mined headlight. As they are light in weight & as power consumption is less, a small battery size will provide the required back up.

Organic LEDs[3]: As mentioned earlier organic LEDs will be very useful as display boards for advertisement purpose. Also they have applications in small gadgets like digital

cameras, palm tops, MP3 players etc. Also LEDs have applications in Optical communication systems, and some other modern electronic trends.

IV. A CASE STUDY OF REPLACING CONVENTIONAL LIGHTING SYSTEM (FLUORESCENT) BY LEDS AND/OR CFL:

In an Engineering college there were 113 conventional tube lights, which were ON for the purpose of vigilance through out the night. The tube lights use to ON from 8 PM to 6 PM (Timing use to vary subject to season change). The tube lights were of standard make. After testing on choke it was observed that chokes are consuming 13 watts of power (average).

Thus total power loss using tube lights P_{Loss}=113*13= 1469 watts.

The tube lights (on an average) working for 10 hours a day.

Total Energy loss per day = 14.69 kWH

Financial Loss per day = 73/- @ 5/- per unit

This amount for accounted per day only to make up the losses.

These fixtures were provided with 40 W tube lights.

Total power consumed with 40 W tube lights (for purpose of vigilance) =113*40 = 4520 W

The financial burden = 4.52 * 10 * 5 = Rs. 226/-

Total Expenditure per day (towards vigilance) = 226 + 73 = RS. 300/-

In one year = Rs. 1, 09,500/-

i) If these lights were replaced with CFLs:

Lux obtained by a fluorescent Tube = 2200

The commercially available CFL of 15 W will provide a lux of 1000, so number of CFLs required to produce required lighting = 2

Power consumed by TWO CFLs = 30 Watts (53 watts in case of Tube lights).

NOTE: Though the lux produced by CFLs is less, it is sufficient enough to produce required illumination.

Power saved = 53 – 30 = 23 Watts

Energy saved per day = 0.023 * 113 * 10 = 26 units per day

Financial saving = 26 * 5 = Rs.130/- per day.

Saving over one year = 130 * 365 = 47,450 Rs. 47,450/-

Investment (Initial cost) to replace Tubes with CFLs:

Cost of one CFL = Rs. 110/-

Cost of fitting to fix CFL = Rs. 12/-

Total of one CFL with fitting = Rs. 122/-

No. of tubes to be replaced = 113.

Equivalent number of CFLs = 226 (@ Two CFLs per tube light)

Total Initial investment = 226 * 122 = Rs. 27,572/-

Pay back period = 27572/47450 = 0.58 years

= 0.58 * 12 = 7 (Appro. seven months)

ii) If tube lights were replaced with LED lighting system:

The white color LEDs, in LED Pack form (24 LEDs per pack) manufactured by SECO Instruments Pvt Ltd are used.

Two LED systems of around 1.4 - 2 W each will produce a required illumination that produced by one tube light.

Total power consumed by two LED systems = 4 W

Power saved = 53-4 = 49 W

Energy saved per day = 0.049 * 113 * 10 = 55.37 units

Financial Saving / day = 55.37 * 5 = Rs. 277/-

Per year saving = Rs.1,01,105/-

Cost of ONE LED system = Rs. 500/-

Total LED system required = 113 * 2 = 226 (@ 2 LED system per tube light)

Total cost of LED systems

= 226 * 500 = 1, 13,000/-

Pay Back period = 1, 13,000/1, 01,105 = 1.12 Years = 14 months.

Lighting system	Annual Saving	Investment	Pay back Period
Present	Nil	Nil	Nil
CFL	47450	27,570	6 months
LED	1,01,105	1,13,000	14 Month

From above comparison it can be seen that by replacing the present system of conventional tube lights, energy saving potential is possible

with CFLs and LEDs. The CFL system is seems to be have quicker pay back period. But the above analysis can be compared depends on the life of the Lighting system as well.

CFLs are having a life span of around 5000-7000 hours. At the rate of 10 hours per day a CFL will not stand for more than two years. Thus an investment of Rs. 30,000/- is bound over two years. Whereas LED last for 75000 to 100000 hours. Taking 75000 hours life, a LED system will last for at least 10 years.

Comparing over 10 years:

CFL system:

Saving in CFL system = Rs. 4,75,000/-

Investment (5 times) = Rs. 1,32,000/-

Nett Saving = Rs. 3, 43,000/-

Saving in LED system = 10, 00,000/-

Investment (One time) = 1, 20,000/-

Nett Saving = 8, 80,000/-

It can be observed that CFL system is no way comparable with LED system, over a period of 10 years.

Note: Cost of technology is coming down and that of energy is increasing. The saving will be at higher side with increase in energy cost and investment will be at lower side with decrease in cost.

V. CONCLUSION

It has been observed that LED illumination is better than any general illumination systems (including CFLs) in terms of energy saving and cost effectiveness .The technology is being improved and full conversion will 'save'many generating stations in the world.

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AUTHORS:

Narendra B Soni,
Member IEEE, is currently working as Associate Professor in department of EEE, GMR Institute of Technology, Rajam. He has completed his M.E. from Shivaji University. Currently he is pursuing Ph.D from Osmania University. He has 11 years of experience in teaching & research. His current areas of interest are Energy conservation & Energy Auditing, Renewable Energy Sources, Electrical Machine. He is also a qualified Energy Auditor, Certified by Bureau of Energy Efficiency, Ministry of Power, GOI, New Delhi. He is member of various professional Societies.

P. Devendra,
is currently working as Associate Professor in department of EEE, GMR Institute of Technology, Rajam. He has completed M.E from Anna University; Chennai .He has around seven years of teaching experience.
His areas of current interests are Energy conservation, Energy efficient drives and Adaptive control systems.