Vision of future energy: Studying alternate sources of energy & its implication on human health & environment in a tertiary care hospital in India.

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Abstract- In recent years, there has been resurgence of going green, saving the planet and engaging in a sustainable lifestyle. There is a continuous need to find new and innovative ways of saving energy and to get the maximum performance with the available budget. Enormous energy savings are possible by using energy efficient equipments, effective controls, and careful designs. This study is aimed to replace conventional tube lights with energy efficient Light Emitting Diodes (LEDs) in one of the multispecialty hospitals of North India. LEDs will be run on energy produced by solar panels. These panels will be installed in open parking area of the hospital. To calculate the energy usage, the tube lights installed in different blocks were studied with respect to number, wattage, illumination and energy consumption. Return on Investment (ROI) and carbon footprint reduction were calculated. In total, there were 13,090 tube lights in the hospital having annual load of INR 1,34,64,238/-. By replacing tube lights with LEDs, there will be an annual saving of INR 1,23,80,070/-, with INR 1,30,90,000/- of initial investment. LEDs consume 628 KW/day and 210 solar panels need to be installed to power them. The ROI of this solar system operated LED is around 16 months and a significant (91.8%) carbon foot prints reduction. Thus, LEDs operated on renewable solar energy emerges as one of the best energy efficient source with lower environmental impacts, well being and increased occupant comfort.

Keywords- Energy efficiency, Solar panels, Return on Investment, Carbon footprint, LEDs, Tube lights, Environment.

1 INTRODUCTION

In an era of even more constrained resources, there is a continuous need to find new and innovative ways of saving energy and to get the maximum performance with the available budget. Enormous energy savings are possible by using energy efficient equipments, effective controls, and careful designs. The ultimate goal of efficient energy use is to reduce the amount of energy required to provide the services. Energy efficiency has proved to be a cost-effective strategy for building economies without necessarily increasing energy consumption. This energy efficient usage is also seen as a key solution to the problem of emissions.

With the depletion of non-conventional energy sources, there is a need for never ending conventional energy sources. In recent years, there has been resurgence of going green, saving the planet and engaging in a sustainable lifestyle. It is well known fact that out of the conventional resources, water, air and solar energy are the most exploited resources. Unlike majority of the other energy sources, solar energy is clean, inexhaustible, reduces the amount of greenhouse gases in the air thereby, controlling pollution and it is worth believable that humans have been utilizing the power of the sun since ancient times. A solar electric system is one of the renewable electricity generating technology suitable for cities and nations and it operate for 40 years to 50 years with little maintenance [1] and benefits of using the solar energy can be seen on the local, national and global levels. Solar systems can be designed to power the houses exclusively, or in many situations, they can be wired into local electrical utility provider, so that the excess energy generated is purchased by the utility, reducing the energy bill.

The basic building block of a solar electric system is the photovoltaic (PV) material; made out of specially treated silica semiconductor material. These cells generate electricity whenever photons (sunlight) strike the PV material and move loosely-held electrons. A solar electric module (also known as a 'panel') is made up of many PV cells that are wired together in a series to achieve the desired voltage. A solar electric system, which is tied to the electric provider's distribution grid consists of solar electric modules connected to an inverter and inverter changes the direct-current (DC) of electricity created by the solar electric modules to alternating current (AC). The AC is compatible with the electric provider's grid, and is able to power devices such as lights, appliances, computers and printers. While excess power produced by the solar electric system, can be put back onto the electric grid.

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Overall, considering the concerns about rising electricity cost, increased concern for climate change and need to find alternative energy solutions, and with the considerable government support, solar PV technology is increasingly seen as viable option for our current and future energy supply. This solar radiation is referred as global solar radiation and consists of direct and diffuse solar radiation reaching at a point on earth. The amount of solar energy falling on 1 m^2 area in India is about 4 – 7 units and as India is located near the equatorial belt, it has abundant sunshine. Also in Indian location, there are about 250 to 300 clear sunny days, thus providing reliable source of energy throughout the year. With these figures, annual solar radiation falling on 1 m^2 area in a year is between 1600 and 2200 kWh that translates to about 6000 million GWh for India, which is an immense potential that can be conserved and utilized. .

Electric lighting is a major energy consumer and it has been estimated that electricity for lighting consumes almost 20% of the output of the world's power stations. Also, adequate use of energy efficient lighting is one of the best and most cost effective ways of reducing energy consumption. The intelligent use of electric lighting reduces heat gain, thus saving air-conditioning energy and improving thermal comfort. Similarly, the design affects visual performance and visual comfort by maintaining adequate and appropriate illumination while controlling reflection and glare. So, by installing new lighting technologies, organizations can reduce the amount of electricity consumed and energy costs associated with lighting. There are several types of energy efficient and affordable lighting technologies available. For example, installation of fluorescent lights reduces the amount of energy required to attain the same level of illumination compared to traditional incandescent light bulbs [1]. Compact Fluorescent Lamps (CFL) uses a different, more advanced technology and consumes about two-third less energy than standard incandescent bulbs, giving the same amount of light, and can last 6 to 10 times longer. Now, the next generation lighting "Light Emitting Diodes" (LEDs) are extremely energy efficient [2],[3]. Earlier, LEDs were limited to single bulb use in applications (instrument panels, electronics, pen lights), but now a days, LEDs are made using many bulbs per cluster and encased in diffuser lenses which spreads light in wider beams.

LED is a semiconductor diode, which differ from traditional light sources in a way they produce light [4]. A LED is small in size (less than 1 mm), and integrated optical components may be used to shape its radiation pattern. The efficacy of LED is compatible with the present light source but the efficiency of LED lighting is very high. LEDs have many advantages over other light sources viz. lower energy consumption, longer life, improved physical robustness, smaller size, and faster switching. Also, LEDs have advantage over fluorescent lamps that they do not contain mercury [5]. On the contrary, the greatest barrier in switching to LED technology from conventional lighting is undoubtedly the initial cost. But analysis reveals that this high initial cost can be recovered in many ways, once the investment is made.

The aim of the paper is to explore the potential course of action for lowering total cost of ownership (TCO) and implementation of LED light technology in one of the premier multi specialty tertiary level healthcare organization of India. The present study was planned with the objective to calculate the energy saving with financial gains on replacement of tube lights by LED lights in the hospitals and the required power will be obtained from the equal load of solar system installed in the hospital premises. Return on investment (ROI) and carbon emissions with solar system operated LEDs will also be compared with that of other light sources.

2 METHOD

It is a descriptive study conducted in one of the multispecialty tertiary level Hospital of North India, which has five blocks viz. A, B, C, D and E. The former three blocks in-houses patient care wards, D block is an Administrative block and Block- E has all non- clinical departments. Each floor has four wards built in a modular style, having 4 cabins (6 to 8 beds in each cabin), a nursing station and ancillary rooms' vis-a-vis store, laboratories, procedure room, waiting rooms, etc. Each cabin has been installed with double set tube rods (2x40 Watt) while ancillary rooms with single rods (lx40W) or (1x20W) depending on the area and requirement. The tube lights are of standard make.

Tube lights are used maximum in evening and night hours between 7:00 P.M. till 7:00 A.M. (timing may vary with season change). It was planned to replace these tube lights with LED consoles. To calculate the energy usage, fluorescent tubes/ tube lights installed in different blocks were surveyed with respect to features viz. number, wattage, illumination and energy consumption. The energy loss due to use of chokes was also taken into account. The Administrative Block and Block- E were excluded from the study.

In the second part of the study, it was decided that electrical energy requirement of these LED consoles will be fulfilled by energy generated from solar installations or in other words, required number of solar panels will be installed, so that LED consoles light energy requirement can be fulfilled. The electrical energy generated from these panels will be first fed to main grid and then the same can be used for lighting the hospital premises. As installation of solar panels will require larger area, due consideration will be given to reduce the wastage of space. Thus, it was decided to install the required number of panels in open parking area and the same will be used as shaded roof for parking vehicles (Fig. 1 &2).

These solar plates are of monocrystalline cell type and will be installed at such angle, latitude, STC and Iridium, so that maximum energy can be generated. In India, panels that are tilted at 15° or more can generate maximum energy. These panels can convert the solar rays directly to electricity with the movements of photons. Then, the inverter converts the DC power collected from the solar panels into usable AC power. The AC power is directly fed to the utility grid and can be consumed for lighting purpose or other electrical appliances.

The major advantage of these solar panels is that it does not require any spares and has no maintenance cost. These panels should be cleaned with warm water, so that it works on designed efficiency. Further, the trees should not overshadow solar panels giving the additional benefit of being cleaned by rainfall to ensure optimal performance. Debris is less likely to accumulate as the panels will be roof mounted. If dust, debris, snow or bird droppings are a problem, the panels should be cleaned with warm water. The life of panels is expected to be 25 years or more, but the inverter may require replacement over a period of time.

The energy consumption along with the financial expenditure on conventional tube lights was calculated and compared with respect to energy savings, if these were to be replaced with LEDs and to be lit with solar power. Also, the ROI was calculated to assess after how many months the expenses spent on these installation can be recovered.

3 RESULTS

In total, there were 13,090 (10,900 tube lights of 40W and 2190 tube lights of 20W) conventional tube lights in Block A, B and C of the Hospital (Table 1). After testing, it was observed that chokes of 40 watt tube lights consumes 14 watts of power, while 20 watt tube light chokes consumes 7 watts (approx.).

Calculations:

3.1 Total number of tube lights installed = 10,900 (40W) & 2190 (20W).
Power consumed with 40 W tube lights =10,900 X 40 =4, 36,000 Watts, or 436 kW
Power consumed with 20 W tube lights =2,190 X 20 =43800 Watts, or 43.8 kW
Total Power consumed by 40W & 20W tube lights = 479.8 kW
The tube lights (on an average) working for 12 hours a day.
The financial burden per day = 479.8 x 12 x 4.73 = INR 27,233/- @ INR 4.73 per unit (1)

3.2 Power loss with tube lights chokes;
PLoss = 10,900 X 14 = 1, 52, 600 W & 2,190 X 8 = 17, 520 W
Total P Loss with chokes = 1, 70, 120 W
The tube lights (on an average) working for 12 hours a day.
Total Energy consumption per day = 2041 kWh
Financial Loss per day = 2041 X 4.73 = INR 9655/- @ INR 4.73 per unit. (2)

3.3 Total Expenditure per day = 27,233+9655 = INR 36,888/- per day
In one year = INR 1, 34, 64,120/- (3)

3.4 If tube lights were replaced with LED lighting system:
Two LED systems of around 1.4 - 2 W each will produce a required illumination that is produced by one tube light.
Total power consumed by two LED systems = 4 W
LED working for 12 hrs./ day = 0.048 kWh
Total energy consumed / day = 0.048 X 13,090 = 628 kWh
Financial burden per day 628 X 4.73 = INR 2,970
Financial burden per year 2,970 X 365 = INR 10, 84, 050

Financial saving per year INR 1, 23, 80, 070
Cost of ONE LED console system INR 500/-
Total LED system required 13,090 x 2 = 26,180 (@ 2 LED console per tube light)
Total cost of LED systems 26,180 x 500 = 1, 30, 90,000/-
Tube lights (40 w & 20w) to be replaced
13,090, with equal number of LED consoles
Energy consumption = 13090 x 4w (LED console wattage) = 52360 w, or 52.36 kW
Energy consumed per day (assuming 12 hours usage) =52.36 x 12 = 628 kWh
One solar panel at 15o angle and at temperature of 25o C produces= 250W
Number of panels required for producing 52360 W = 52360/250 = 210 panels (4)

3.5 Area required for installation:
Size of one solar panel = 1560 x 1190 mm
Area of one solar panel = 1.8 sq.m.
Area required for installing 210 panels = 210 X 1.8 = 378 sq.m.
As it is planned that open parking space will be used for solar system installation and the same will used for parking of vehicles. (5)

3.6 Return on investment (ROI):
Costing of installation = INR 125/W (as per the records of CREST (Chandigarh Renewal Energy, Science & Technology Promotion Society) rate is INR 110-125)
Cost for 52,360 W = 52360 x125 = INR 65, 45, 000
Installation cost of one panel 65, 45, 000/ 250 = INR 26,180
Installation cost of 210 panels INR 54, 97, 800 (6)

3.7 Pay Back period:
From above comparison, it was analyzed that by replacing the present system of conventional tube lights with LEDs, significant energy saving is possible. LEDs usually last for 50,000 to 70,000 hours (Table 1). Assuming life of LEDs to be 50,000 hours a system will last for at least 10 years. (7)

3.8 Carbon Foot Prints:

I. CO_2 emitted by Tube lights:
Power Consumption of 40W tubelights- 54 watts (40 watts + 14 watts PLoss) (Operated per day- 12 hours)
Power Consumption per annum- 236.52 kWh (1 kWh=619g CO_2 is released)
Lighting Carbon Emission per year/lamp (236.52 x 619g) = 1, 46,393.5 g or 146 Kg
A single 40 watts fluorescent lamp will generate 146 kilograms of CO_2 every year. Power Consumption of 20W tube lights- 27 watts (20 watts + 7 watts PLoss)
(Operated per day- 12 hours)
Power Consumption per annum- 118.26 kWh
(1 kWh=619g CO_2 is released)
Lighting Carbon Emission per year/lamp (118.26 x 619g) = 73202.94g or 73 Kg
A single 20 watts fluorescent lamp will generate 73 kilograms of CO_2 every year.
No. of 40W tube lights =10,900
Total CO_2 emissions/ year by 40 W tubelights =10,900 X 146=15,91,400 Kg
No. of 20 W tubelights =2190
Total CO_2 emissions/ year by 20 W tubelights =2190 X 73=1,59,870 Kg
Total CO_2 emissions/ Year (40W+20W) = 15,91,400 + 1,59,870 = 17, 51,270 Kgs. (1751 Tons) (8)

II. CO_2 emitted by our 4 watt LED Tube light
Power Consumption- 4 watts

Operated for 12 hours = 0.048Kwh
Per annum consumption per LED console 0.048 X 365 = 17.52 Kwh
Carbon emission/ year / LED console = 17.52 X 619 g = 10.8 Kg (Approx. 11 Kg)
Total CO2 emissions/ Year = 13,090 X 11 = 1, 43, 990 Kgs. (144 Tons) (9)

4 CONCLUSION

LED emerges energy efficient light source and one of the best options to reduce carbon footprint. There are no environmental hazards like the other light sources during its life span and even at disposal. So, enhanced automation technologies and efficient systems reduce operating costs, lower environmental impacts, increase occupant comfort and well being, thereby providing conditions for better control and management. For a tertiary care hospital like ours, this energy efficient system is must to have to reduce the enormous amount of electricity wastage abd carbon footprint can also be reduced on a large scale.

5 LIMITATIONS'/ EXCLUSION OF STUDY- The cost of the roof to be used for solar plates installations have not been taken into consideration.

6 REFERENCES

[1] Energy Star® Lighting: Provides information on energy efficient lighting and products. Retrieved from http://www.energystar.gov/index.cfm?c=lighting.pr_lighting
[2] Earth Easy: Provides general information on CFLs and LED. Retrieved from http://eartheasy.com/live_energyeff_lighting.htm
[3] US Department of Energy: Technology fact sheet on efficient lighting strategies. Retrieved from http://www.eere.energy.gov/buildings/documents/pdfs/26467.pdf
[4] Light Emitting Diode: The future of lightening IEEMA Journal, Volume XXVII No. 10 October 2007.
[5] White paper, Patrick Carner, Bringing Intelligence to LED Lighting Applications.

Figures

Figure 1: Parking area before installation of solar panels

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Figure 2: Parking area after installation of solar panel.

Tables

Table 1: Showing annual investment and saving

Lighting system	Annual Saving (INR)	Investment (INR)	Payback Period (ROI)
LED	1, 23, 80, 070	1,30,90,000	12 months
Solar panel	10,26,562	54, 97, 800	6 months
ROI	1,34, 06, 632	1,85,87,800	16 months approx.