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Transition from Conventional to LED lamps in India – Need and Way Forward

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***Abstract*— Over the past few years, there has been a transition from traditional sources of light such as incandescent lamps, halogen lamps and fluorescent lamps to LED lamps. Even though this transition is slow and is not yet complete, the masses are gradually shifting from traditional light sources to LEDs because of the advantages LEDs hold over traditional light sources. LED lamps have better efficacy i.e. lumen output/input power and greater lifetime as compared to traditional light sources. They also have several environmental benefits. In a country like India, savings up to Rs 40,000 crores can be made per year by replacing all household lights with LED lights.**

***Index Terms*— Cool White, Warm White, energy, environmental benefits, cost, efficacy, LED, mercury, savings.**

I. INTRODUCTION

LED stands for Light Emitting Diode. LED's are basically semiconductors emitting light when current flows through it. The semiconductor in the LED converts the electrical energy into light. The diode through which the current flows is unidirectional, thus the LED will generate light only if direct current flows from the anode to cathode. The intensity or the amount of light generated is directly proportional to the amount of current flowing through the semiconductor.

LED light sources can be classified into three broad categories, namely LED with primary optics, preassembled LED's and LED modules. In LED's with primary optics the LED components are purchased by the manufacturer who then makes the PCB and combines them. Presently SMD LD's are used, these LED's are directly soldered onto the PCB. In preassembled LED's, the manufacturer purchases preassemble PCB's. One or more LED's can be mounted on such PCB's. These PCB's are available in various shapes. Lastly the LED modules, they go a step further. The modules are basically preassembled LED's which are integrated into required thermal and electrical interfaces in its housing.

The LED lamps are basically available in two colors, warm white and cool white. As the name itself suggests, warm white lamps render yellowish light and the cool white lamps render whitish light. The difference in the color of both the lamps is due to the difference in temperatures at which these two colors are obtained. White light is generally achieved at higher temperatures as compared to the yellow light. LED lamps render white light at temperatures greater than 5000K, whereas yellow light can be achieved at much lower temperatures i.e. around 3300K. The efficacy of cool white lamps is around 95lm/watt which is higher than that of warm white lamps because the efficacy of warm white lamps is around 85lm/W. The reason behind the higher efficacy of the cool white lamp is the luminescent material which is coated on the LED die. To obtain yellow light from the LED the luminescent coating has more of the red component and the efficiency of this red component is very low, which in turn reduces the net efficacy of warm white lamp.

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II. ADVANCEMENTS IN LIGHTING

The invention of the light bulb cannot be credited to one inventor. It was a series of small inventions on the ideas of the previous inventors that have led to the lamps we are today using in our homes.

The first constant electric light source was demonstrated in the year 1835, but it was not before 1879 when Thomas Alva Edison invented the incandescent lamp which consisted of a filament that would generate light when electricity was passed through it as result of the heating up of the filament. The filament is placed inside a glass casing which contains an inert gas so as to prevent the filament from getting oxidized and burnt away. Initially the filament was made up of carbonized element which could last up to a maximum of 145 hours. With time the element of the filament was changed to tungsten, which could last longer as compared to the lamps have filaments made up of carbonized elements. The incandescent lamps usually start emitting light at around 2700K. Since the element can emit light only at high temperatures the filament evaporates quickly and hence the life of incandescent lamps is very less. Most of the energy of incandescent lamps is emitted in the form of infrared radiations or heat. A mere 5% of the energy emitted by the lamp is visible in the form of light; hence they are highly inefficient in terms of the amount of light generated. These shortcomings in the incandescent lamps led to the development of fluorescent lamps.

It was in the 19th century when two Germans Heinrich Geissler and Juluis Plucker discovered that light could be produced by removing almost all of the air from a long glass tube and passing an electrical current through it. It was later on known as the Geissler Tube. Peter Cooper Hewitt's breakthrough in 1900 became the precursor to fluorescent lamps. He created a blue-green light by passing an electric current through mercury vapor and incorporating a ballast (ballast is a device connected to the light bulb in order to regulate the flow of current through the tube). Even though they were more efficient as compared to the incandescent lamps, they had their own short comings and their applications were limited because of the color of the light. In the early 1930's experiments were done on neon tubes with phosphorous coating which would absorb the ultraviolet light and convert the invisible light into useful white light. These were more efficient and lasted longer as compared to incandescent lamps. Edward Hammer while working at General Electric, in the year 1976 figured out how to bend the fluorescent tube into a spiral tube, creating the first ever compact fluorescent lamp (CFL). Improvements have been

done in the terms of performance, price, efficiency and lifetime, this has made them a viable option.

LED lamps are one of the fastest developing lighting technologies. As discussed above LED's use a semiconductor to convert the electricity into light and are often small in area. They emit light in specific direction, reducing the need for reflectors and diffusers that can trap light. LED lamps are the most efficient source of light available in the market. In 1962, Nick Holonyak Jr. while working for General Electric invented the first visible spectrum LED in the form of LED diodes. In 1970's while the companies worked towards improvements in the red diodes and the manufacturing process, LED's started appearing in indicator lights and calculator display. The blue diodes were invented in the 1990's, the discovery of blue LED's led to the discovery of white LED's. The researchers coated the blue diodes with phosphor to make it appear white. The researchers also demonstrated white light using red, green and blue LED's. These breakthroughs led to LED's being widely used in a variety of applications.

III. NEED FOR TRANSITION TO LEDs

LED lamps are taking over the market at a very fast pace and the traditional light sources are slowly disappearing from the market.

Traditional light sources like incandescent and fluorescent lamps emit light in all directions as compared to LED lights. LED's are directional sources and offer better optical control. The structure of the LED lamps allows them to emit light hemi-spherically instead of emitting light in a spherical manner as compared to the traditional light sources. The better directional output increases the efficacy of LED lamps. LED lights are excellent replacements for conventional lights in locations like corridors where only directed light is needed because conventional lamps spread light in all directions unnecessarily. Savings in such cases can be up to 90% by replacing conventional lights with LED lights. Similarly very high savings can be obtained in case of "task lighting".

LED lamps are highly impervious to vibrations as they do not have filaments or any glass enclosures. This makes the LED light source quite robust and allows the LED lamps to be used in a wide variety of applications where the lamps are subject to vibrations. Also, the small size and the scalability of arrays allows the LED to offer innovative and compact lighting products.

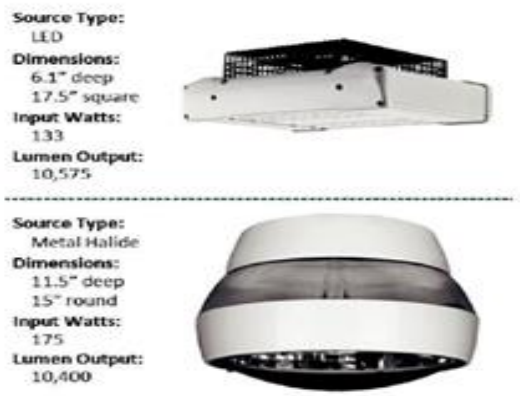

Fig. 1. Size difference between LED and GLS lamp.

The efficacy i.e. lumens obtained per unit of energy consumed in case of LED lamps is much more as compared to that of the traditional light sources, though it depends on a number of factors such as driver efficiency and luminaire optical losses. The efficacy of LED lamps has been continuously improving since their introduction.

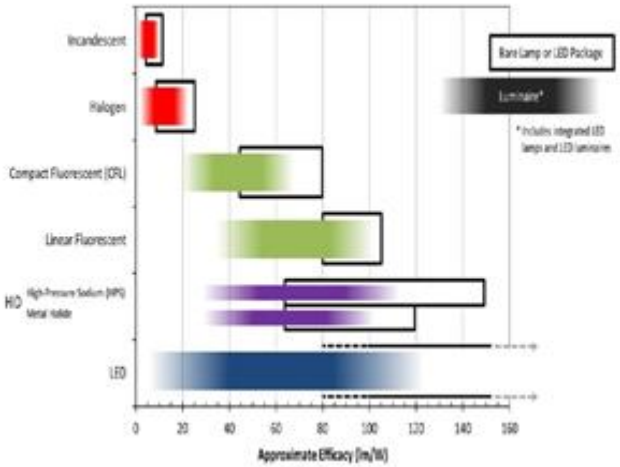

Fig. 2. Graph representing efficacy of different kinds of lamps.

The expected lifetime of LED lamps is way more than the traditional light sources. LED lamps have a lifetime of around 50,000 hours whereas the traditional lamps have an expected life span for max 5000 hours, though the useful lifetime of LED's is dependent upon the usage conditions, power and internal temperature. Also, as the LED components are highly sensitive to the electric influences, sudden surges in the input drive current can reduce their life.

Most of the traditional lamp sources do not provide us with full brightness immediately after being on. Fluorescent lamps take a minimum of three minutes to reach their full brightness and halogen lamps take longer than that i.e. around five to six minutes. In contrast to traditional lamp sources the LED lamps turn on almost instantly. This feature of LED lamps is beneficial for emergency or high security situations.

LEDs generate less heat during use and hence associated cooling costs are comparatively lower. Incandescent bulbs release 90 percent of the energy as heat. While LED lamps lose around 5 percent of the energy generated to heat, the rest is converted to light.

IV. ENVIRONMENTAL GAINS WITH LEDs

A much higher life span (10 to 20 times more) as compared to traditional lamps means that for a give population lesser number of lamps have to be produced per year. This in turn means that less number of lamps have to be packed, transported and ultimately disposed of when they reach the end of their life, thereby greatly reducing environmental impact over time.

While generating light, emission of ultraviolet or infrared radiation is an unavoidable aspect for traditional light sources. The LED lamps do not emit any infrared or ultraviolet radiations at all. These emissions apart from being harmful also result in reduced efficacy of the lamp.

Use of LED lamps is found to reduce carbon dioxide emissions by about 80%. LED lamps are free from mercury unlike the CFL. This means that the contamination of soil and underground water can be prevented by using LED lamps.

V. BARRIERS IN USE OF LEDs IN INDIA

Limited availability of LED technology and low consumer awareness in India act as major barriers in adoption of LED bulbs. The high initial cost of LEDs makes the pay-back period very long which dissuades the consumers. Also, there is an absence of National standards for LEDs and consequently, the industry is prone to import substandard products. Lack of testing protocols, facilities and accredited laboratories at the national level sometimes puts a question mark on the quality of LED lamps available in the country.

VI. CONCLUSION AND WAY FORWARD

LEDs are the lighting solutions for the future. Their light efficiency makes them superior to CFL and incandescent lamps with much less total ownership costs. They are much more environment friendly being mercury free. However, in a country like India where the consumer is extremely sensitive to initial price, the manufacturers shall have to further reduce the costs by increasing automation and output in the industry.

The Government of India had enacted "Energy Conservation Act 2001" to catalyze implementation of energy efficiency measures. The "Energy Efficiency Services Limited" (EESL), which is promoted by the Ministry of Power, Government of India, has taken initiative to achieve large scale energy savings by replacing about 76 crores incandescent lamps with LED lamps in India. The cost barrier is overcome by monetizing the energy savings in the households and attract investments.

It is estimated that if India is able to achieve replacement of all the household electric bulbs with LED bulbs, the carbon dioxide emissions can be reduced by approximately 60 million tonnes in one year. This would also lead to savings up to Rs 40,000 crores in a year which can be used to cross subsidize the LED bulbs in the price sensitive Indian market.

With increase in public awareness in India regarding long term cost benefits, the use of LED lights is increasing and it has been estimated by the Electric Lamp and Component Manufacturers Association (ELCOMA) that the LED industry in India will grow from Rs 40,000 million in 2014 to Rs 200,000 million by 2020.

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