ENERGY EFFICIENT LIGHTING USING LED's IN POWER INDUSTRY

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DECLARATION BY THE GUIDE

This is to certify that the Mr. Shyam K.Menon, a student of MBA (Power Management), Roll No. 500022305 of UPES has successfully completed this dissertation report on "Energy Efficient Lighting Using LED's in Power Industry" under my supervision. Further, I certify that the work is based on the investigation made, data collected and analyzed by him and it has not been submitted in any other University or Institution for award of any degree. In my opinion it is fully adequate, in scope and utility, as a dissertation towards partial fulfillment for the award of degree of MBA.

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ABBREVIATIONS

A	Ampere
AC	Alternating Current
ANSI	American National Standard Institute
CFL	Compact Fluorescent Lamp
CRI	Color Rendering Index
CAGR	Compound Annual Growth Rate
CO_2	Carbon di Oxide
DC	Direct Current
DOE	Department of Energy
EISA	Energy Independence and Security Act
HPS	High Pressure Sodium
IESNA	Illuminating Engineering Society of North America
K	Kelvin
kWh	Kilo Watt Hour
LED	Light Emitting Diode
mA	Milli Ampere
MH	Metal Halide
PC	Phosphor Converted
RGB	Red Green Blue
ROI	Return On Interest
SWOT	Strength Weakness Opportunity Threat
USD	United States Dollar
V	Voltage/Volts
W	Watts

EXECUTIVE SUMMARY

Until recent years, most of the lighting installation in the Power industries has employs low pressure & high pressure discharge lamps for most of its lighting applications. These are technically acceptable and have been used for ages. However in the present day scenario of energy shortages and the world moving towards energy conservation, one must think twice before putting up these light sources in his/her installation for lighting up the facility. The conventional light sources such as tungsten halogen lamps, fluorescent lamps, high pressure sodium vapor lamps, high pressure mercury vapor lamps, high pressure metal halide lamps etc... have been used extensively in the commercial, residential and industrial areas. However these lamps when installed in a large installation can form a substantial part of the total electrical load. More over these conventional lamps generates substantial amount of heat, both at its surface as well as at the surface of its control gear. Because of this, when such sources are used indoors, the air conditioning load increases due to the increase in heat load of the lighting installation. All this results in increased energy consumption. Also most of the conventional discharge lamps contain a multitude of chemical materials like mercury that are dangerous for the environment.

This project is an attempt to propose an energy efficient lighting solution for Power industries considering main aspects like energy consumption, life of the lighting installation, effect on environment, cost etc.. Case studies shall be carried out considering typical lighting requirements for indoor & outdoor applications. Comparison of traditional light sources with the proposed light source as well as a cost benefit analysis shall also be studied as part of this project.

1. INTRODUCTION

1.1 Overview:

This project aims to study the use of LED (Light Emitting Diode) as a light source. LED's consume less energy, emit less heat and have more life compared to any of the conventional light sources. LED lights are free of toxic chemicals and are 100% recyclable, and will help to reduce carbon footprint by up to a third. LED lights are thus are environmental friendly. The long operational life time span mentioned above means also that one LED light bulb can save material and production of 25 incandescent light bulbs. A big step towards a greener future.

1.2 Background:

The conventional light sources such as tungsten halogen lamps, fluorescent lamps, high pressure sodium vapor lamps, high pressure mercury vapor lamps, high pressure metal halide lamps etc... have been used extensively in the commercial, residential and industrial areas. However these lamps, when installed in a large installation, can form a substantial part of the total electrical load. More over these conventional lamps generates substantial amount of heat, both at its surface as well as at the surface of its control gear. Because of this, when such sources are used indoors, the air conditioning load increases due to the increase in heat load of the lighting installation. All this results in increased energy consumption. Also most of the conventional discharge lamps contain a multitude of chemical materials like mercury that are dangerous for the environment.

1.3 Purpose of Study:

This project attempts to study and propose an energy efficient and environmental friendly solution to overcome the above situation and thereby achieve reduction in electrical energy consumed. It also attempts to calculate the payback period of the proposed solution.

1.4 Research Hypothesis:

This study is based on LED's potential to provide an energy efficient lighting solution for the present as well as for the future. Having known the core issues related lighting industry, various theory and techniques can bring in to solve it. The study is focused on various estimates and results that have been proven reality. Economically viable suggestions provided for so that with minimum capital various lighting projects can be undertaken to narrow down the demand supply gap. This study also emphasizes the need for opening a new lighting market in the country, which emphasizes on the promotion of LED lights, which would eventually revive the entire energy business.

2. INTRODUCTION TO LED LIGHTING

2.1 Basics of LED

A light-emitting diode (LED) is a two-lead semiconductor light source. It is a p–n junction diode, which emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence, and the color of the light (corresponding to the energy of the photon) is determined by the energy band gap of the semiconductor.

An LED is often small in area (less than 1 mm2) and integrated optical components may be used to shape its radiation pattern.

Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared light. Infrared LEDs are still frequently used as transmitting elements in remote-control circuits, such as those in remote controls for a wide variety of consumer electronics. The first visible-light LEDs were also of low intensity, and limited to red. Modern LEDs are available across the visible, ultraviolet, and infrared wavelengths, with very high brightness.

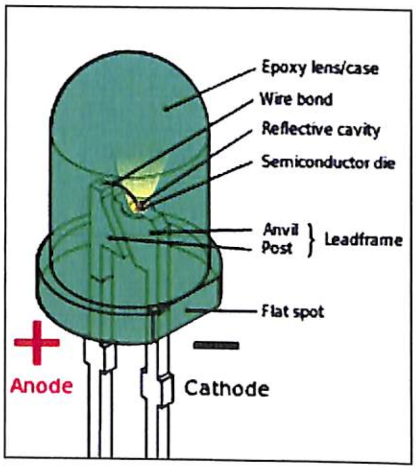

Fig 1: Typical constructional details of LED

The LED consists of a chip of semiconducting material doped with impurities to create a p-n junction. As in other diodes, current flows easily from the p-side, or anode, to the n-side, or cathode, but not in the reverse direction. Charge-carriers—electrons and holes—flow into the junction from electrodes with different voltages.

When an electron meets a hole, it falls into a lower energy level and releases energy in the form of a photon.

The wavelength of the light emitted, and thus its color, depends on the band gap energy of the materials forming the p-n junction. In silicon or germanium diodes, the electrons and holes usually recombine by a non-radiative transition, which produces no optical emission, because these are indirect band gap materials. The materials used for the LED have a direct band gap with energies corresponding to near-infrared, visible, or near-ultraviolet light.

LED development began with infrared and red devices made with gallium arsenide. Advances in materials science have enabled making devices with ever-shorter wavelengths, emitting light in a variety of colors.

LEDs are usually built on an n-type substrate, with an electrode attached to the p-type layer deposited on its surface. P-type substrates, while less common, occur as well. Many commercial LEDs, especially GaN/InGaN, also use sapphire substrate.

Most materials used for LED production have very high refractive indices. This means that much light will be reflected back into the material at the material/air surface interface. Thus, light extraction in LEDs is an important aspect of LED production, subject to much research and development.

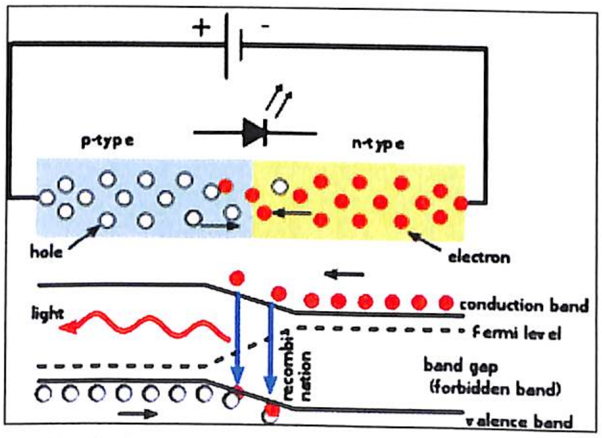

Fig 2: Operational details of LED

Unlike incandescent lamps, LEDs are not inherently white light sources. Instead, LEDs emit nearly monochromatic light, making them highly efficient for colored light applications such as traffic lights and exit signs. However, to be used as a general light source, white light is needed. White light can be achieved with LEDs in three ways:

- Phosphor conversion, in which a phosphor is used on or near the LED to convert the colored light to white light
- RGB systems, in which light from multiple monochromatic LEDs (e.g., red, green, and blue) is mixed, resulting in white light
- A hybrid method, which uses both phosphor-converted (PC) and monochromatic LEDs.

The potential of LED technology to produce high-quality white light with unprecedented energy efficiency is the primary motivation for the intense level of research and development currently supported by the U.S. Department of Energy.

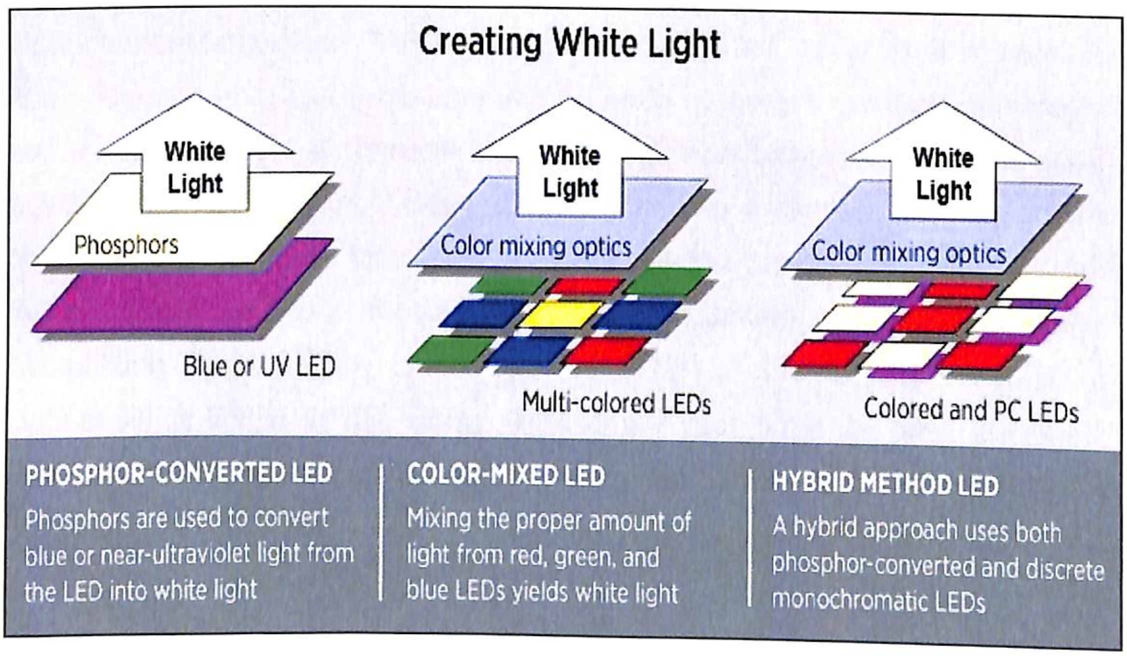

Fig 3: Producing white light from LED

There are many white LED products available on the market, and the number continues to grow, with new generations of devices constantly emerging. While many of these products perform quite well, their quality and energy efficiency can vary widely. There are standards, test procedures, and ENERGY STAR® criteria that can enable buyers to make informed decisions when evaluating LED lighting

2.2 Development and Adoption History

The first LEDs were developed in the early 1960s, however, they were low-powered and only produced light in the low, red frequencies of the spectrum. The first high-brightness blue LED was demonstrated by Shuji Nakamura of Nichia Corporation in 1994. The existence of blue LEDs and high-efficiency LEDs quickly led to the development of the first white LED, which employed a phosphor coating to mix down-converted yellow light with blue to produce light that appears white. Isamu Akasaki, Hiroshi Amano and Nakamura were later awarded the 2014 Nobel Prize in physics for the invention of the blue LED.

The Energy Independence and Security Act (EISA) of 2007 authorized the Department of Energy (DOE) to establish the Bright Tomorrow Lighting Prize competition, known as the "L Prize", the first government-sponsored technology competition designed to challenge industry to develop replacements for 60W incandescent lamps and PAR 38 halogen lamps. The EISA legislation established basic requirements and prize amounts for each of the two competition categories, and authorized up to $20 million in cash prizes. The competition also included the possibility for winners to obtain federal purchasing agreements, utility programs, and other incentives. In May 2008, they announced details of the competition and technical requirements for each category. Lighting products meeting the competition requirements could use just 17% of the energy used by most incandescent lamps in use today. That same year the DOE also launched the Energy Star program for solid-state lighting products. The EISA legislation also authorized an additional L Prize program for developing a new "21st Century Lamp".

Philips Lighting ceased research on compact fluorescents in 2008 and began devoting the bulk of its research and development budget to solid-state lighting. On 24 September 2009, Philips Lighting North America became the first to submit lamps in the category to replace the standard 60W A-19 "Edison screw fixture" light bulb, with a design based on their earlier "Ambient LED" consumer product. On 3 August 2011, DOE awarded the prize in the 60W replacement category to a Philips' LED lamp after 18 months of extensive testing.

Early LED lamps varied greatly in chromaticity from the incandescent lamps they were replacing. A standard was developed, ANSI C78.377-2008 that specified the recommended color ranges for solid-state lighting products using cool to warm white LEDs with various correlated color temperatures. In June 2008, NIST announced the first two standards for solid-state lighting in the United States. These standards detail performance specifications for LED light sources and prescribe test methods for solid-state lighting products.

Also in 2008 in the United States and Canada, the Energy Star program began to label lamps that meet a set of standards for starting time, life expectancy, color, and consistency of performance. The intent of the program is to reduce consumer concerns due to variable quality of products, by providing transparency and standards for the labeling and usability of products available in the market. Energy Star Light Bulbs for Consumers is a resource for finding and comparing Energy Star qualified lamps. A similar program in the United Kingdom (run by the Energy Saving Trust) was launched to identify lighting products that meet energy conservation and performance guidelines.

The Illuminating Engineering Society of North America (IESNA) published a documentary standard LM-79, which describes the methods for testing solid-state lighting products for their light output (lumens), efficacy (lumens per watt) and chromaticity.

In January 2009, it was reported that researchers at Cambridge University had developed an LED bulb that costs £2 (about $3 U.S.), is 12 times as energy efficient as a tungsten bulb, and lasts for 100,000 hours. Honeywell Electrical Devices and Systems (ED&S) recommend worldwide usage of LED lighting as it is energy efficient and can help save the climate.

2.3 LED as a Light Source for Industrial & Commercial Application

An LED lamp, when assembled into a lamp (or light bulb) for use in lighting fixtures, forms a major source of light for industrial & commercial applications. LED lamps have a lifespan and electrical efficiency that is several times better than incandescent lamps, and significantly better than most fluorescent lamps, with some chips able to emit more than 100 lumens per watt. The LED lamp market is projected to grow by more than twelve-fold over the next decade, from $2 billion in the beginning of 2014 to $25 billion in 2023, a compound annual growth rate (CAGR) of 25%.

Like incandescent lamps and unlike most fluorescent lamps (e.g. tubes and compact fluorescent lamps or CFLs), LEDs come to full brightness without need for a warm-up time; the life of fluorescent lighting is also reduced by frequent switching on and off. Initial cost of LED is usually higher. Degradation of LED dye and packaging materials reduces light output to some extent over time.

Some LED lamps are made to be a directly compatible drop-in replacement for incandescent or fluorescent lamps. An LED lamp packaging may show the lumen output, power consumption in watts, color temperature in Kelvin or description (e.g. "warm white"), operating temperature range, and sometimes the equivalent wattage of an incandescent lamp of similar luminous output.

Most LEDs do not emit light in all directions, and their directional characteristics affect the design of lamps, although omni-directional lamps which radiate light over a 360° angle are becoming more common. The light output of single LEDs is less than that of incandescent and compact fluorescent lamps; in most applications multiple LEDs are used to form a lamp, although high-power versions (see figure 4 below) are becoming available.

Fig 4: High power LED's

LED chips need controlled direct current (DC) electrical power; an appropriate circuit is required to convert alternating current from the supply to the regulated low voltage direct current used by the LEDs. LEDs are adversely affected by high temperature, so LED lamps typically include heat dissipation elements such as heat sinks and cooling fins.

General-purpose lighting needs white light. LEDs emit light in a very narrow band of wavelengths, emitting light of a color characteristic of the energy band-gap of the semiconductor material used to make the LED. To emit white light from LEDs requires mixing light from red, green, and blue LEDs, or using a phosphor to convert some of the light to other colors.

One method (RGB or trichromatic white LEDs) uses multiple LED chips, each emitting a different wavelength, in close proximity to generate white light. This allows the intensity of each LED to be adjusted to change the overall color.

The second method uses LEDs in conjunction with a phosphor. The CRI (color rendering index) value can range from less than 70 to over 90, and color temperatures in the range of 2700K (matching incandescent lamps) up to 7000K are available.

A significant difference from other light sources is that the light is more directional, i.e., emitted as a narrower beam. LED lamps are used for both general and special-purpose lighting. Where colored light is needed, LEDs that inherently emit light of a single color require no energy-absorbing filters.

White-light LED lamps have longer life expectancy and higher efficiency (more light for the same electricity) than most other lighting when used at the proper temperature. LED sources are compact, which gives flexibility in designing lighting fixtures and good control over the distribution of light with small reflectors or lenses. Because of the small size of LEDs, control of the spatial distribution of illumination is extremely flexible, and the light output and spatial distribution of an LED array can be controlled with no efficiency loss.

Fig 5: Architectural lighting using LED's

LEDs using the color-mixing principle can emit a wide range of colors by changing the proportions of light generated in each primary color. This allows full color mixing in lamps with LEDs of different colors. Unlike other lighting technologies, LED emission tends to be directional (or at least lambertian), which can be either advantageous or disadvantageous, depending on requirements. For applications where non-directional light is required, either a diffuser is used, or multiple individual LED emitters are used to emit in different directions.

2.4 Replacement for Existing Conventional Lighting

LED lamps are made of arrays of SMD modules that replace screw-in incandescent or compact fluorescent light bulbs, mostly replacing incandescent bulbs rated from 5 to 60 watts. Such lamps are made with standard light bulb connections and shapes, such as an Edison screw base, an MR16 shape with a bi-pin base, or a GU5.3 (bi-pin cap) or GU10 (bayonet fitting) and are made compatible with the voltage supplied to the sockets. They include driver circuitry to rectify the AC power and convert the voltage to an appropriate value, usually Switched-mode power supplies.

As of 2010 some LED lamps replaced higher wattage bulbs; for example, one manufacturer claimed a 16-watt LED bulb was as bright as a 150 W halogen lamp. A standard general-purpose incandescent bulb emits light at an efficiency of about 14 to 17 lumens/W depending on its size and voltage. According to the European Union standard, an energy-efficient bulb that claims to be the equivalent of a 60 W tungsten bulb must have a minimum light output of 806 lumens.

Some models of LED bulbs are compatible with dimmers as used for incandescent lamps. LED lamps often have directional light characteristics. The lamps have declined in cost to between US$2.49 to $33.98 each as of 2015. These bulbs are more power-efficient than compact fluorescent bulbs and offer life spans of 30,000 or more hours, reduced if operated at a higher temperature than specified. Incandescent bulbs have a typical life of 1,000 hours, and compact fluorescents about 8,000 hours. The bulbs maintain output light intensity well over their lifetimes. Energy Star specifications require the bulbs to typically drop less than 10% after 6,000 or more hours of operation, and in the worst case not more than

15%. LED lamps are available with a variety of color properties. The purchase price is higher than most other, but the higher efficiency may make total cost of ownership (purchase price plus cost of electricity and changing bulbs) lower.
Several companies offer LED lamps for general lighting purposes. The technology is improving rapidly and new energy-efficient consumer LED lamps are available.
LED lamps are close to being adopted as the mainstream light source because of the falling prices and because 40W and 60W incandescent bulbs are being phased out. In the U.S. the Energy Independence and Security Act of 2007 effectively bans the manufacturing and importing of most current incandescent light bulbs. LED bulbs have decreased substantially in pricing and many varieties are sold with subsidized prices from local utilities.

2.5 LED tube lamps

LED tube lights are designed to physically fit in fixtures intended for fluorescent tubes. Some LED tube lamps are intended to be a drop-in replacement into existing fixtures. Others require rewiring of the fixtures to remove the ballast. An LED tube lamp generally uses many individual LEDs which are directional. Fluorescent lamps emit light all the way around the lamp. Most LED tube lights available can be used in place of T8, T10, or T12 tube designations, T8 is D26mm; T10 is D30mm, in lengths of 590mm, 1200mm and 1500mm.

2.6 Lighting designed for LEDs

Newer light fittings designed for LED lamps, or indeed with long-lived LEDs built-in, have been coming into use as the need for compatibility with existing fittings diminishes. Such lighting does not require each bulb to contain circuitry to operate from mains voltage.

2.7 Comparison to other lighting technologies

Incandescent lamps (light bulbs) generate light by passing electric current through a resistive filament, thereby heating the filament to a very high temperature so that it glows and emits visible light over a broad range of wavelengths. Incandescent sources yield a "warm" yellow or white color quality depending on the filament operating temperature. Incandescent lamps emit 98% of the energy input as heat. A 100W light bulb for 120V operation emits about 1,700 lumens, about 17 lumens/W; for 230V bulbs the figures are 1340lm and 13.4 lm/W. Incandescent lamps are relatively inexpensive to make. The typical lifespan of an AC incandescent lamp is 750 to 1,000 hours. They work well with dimmers. Most older light fixtures are designed for the size and shape of these traditional bulbs. In the U.S. the regular sockets are E26 and E11, and E27 and E14 in some European countries.

Fluorescent lamps work by passing electricity through mercury vapor, which in turn emits ultraviolet light. The ultraviolet light is then absorbed by a phosphor coating inside the lamp, causing it to glow, or fluoresce. Conventional linear fluorescent lamps have life spans around 20,000 and 30,000 hours based on 3 hours per cycle according to lamps NLPIP reviewed in 2006. Induction fluorescent relies on electromagnetism rather than the cathodes used to start conventional linear fluorescent. The newer rare earth triphosphor blend linear fluorescent lamps made by Osram, Philips, Crompton and others have a life expectancy greater than 40,000 hours, if coupled with warm-start electronic ballast. The life expectancy depends on the number of on/off cycles, and is lower if the light is cycled often. The ballast-lamp combined system efficacy for the current linear fluorescent systems in 1998 as tested by NLPIP ranged from 80 to 90lm/W.

Compact fluorescent lamps' specified lifespan typically ranges from 6,000 hours to 15,000 hours.

Electricity prices vary in different areas of the world, and are customer dependent. In the US generally, commercial (0.103 USD/kWh) and industrial (0.068 USD/kWh) electricity prices are lower than residential (0.123 USD/kWh) due to fewer transmission losses.

2.7.1 Comparison table

	Incandescent	Halogen	CFL	LED (Cree)	LED (Philips)	LED (LED Novation)	LED (Nanoleaf NL02-1200)
Purchase price	$0.41	$1.50	$0.99	$9.97	$4.35	$31.50	$24.99
Power used (watts)	60	43	14	9.5	8.5	9.4	10
lumens (mean)	860	750	775	800	800	810	1200
lumens/watt	14.3	17.4	55.4	84	94.1	86.2	120
Color Temperature Kelvin	2700	2900	2700	2700	2700	2700	3000
CRI	100	100	82	80	80	94	80
Lifespan (hours)	1,000	1,000	10,000	25,000	10,000	50,000	30,000
Bulb lifetime in years @ 6 hours/day	0.46	0.46	4.6	11.4	4.6	22.8	13.7

Energy cost over 20 years @ 13 cents/kWh	$342	$245	$80	$54	$48	$54	$57
Total cost over 20 years	$360	$311	$84	$72	$67	$81	$93
Total cost per 860 lumens	$360	$356	$93	$77	$73	$86	$67
Comparison based on 6 hours use per day (43,800 hours over 20 yrs)							

Table 1: Comparison for 60 watt incandescent equivalent light bulb (U.S. residential electricity prices)

In keeping with the long life claimed for LED lamps, long warranties are offered. One manufacturer warrants lamps for professional use, depending upon type, for periods of (defined) "normal use" ranging from 1 year or 2,000 hours (whichever comes first) to 5 years or 20,000 hours. A typical domestic LED lamp is stated to have an "average life" of 15,000 hours (15 years at 3 hours/day), and to support 50,000 switch cycles.

2.8 Energy Star Qualification

Energy Star is an international standard for energy efficient consumer products. Devices carrying the Energy Star service mark generally use 20–30% less energy than required by US standards.

Energy Star LED qualifications:

- Reduces energy costs — uses at least 75% less energy than incandescent lighting, saving on operating expenses.

- Reduces maintenance costs — lasts 35 to 50 times longer than incandescent lighting and about 2 to 5 times longer than fluorescent lighting. No bulb-replacements, no ladders, no ongoing disposal program.
- Reduces cooling costs — LEDs produce very little heat.
- Is guaranteed — comes with a minimum three-year warranty — far beyond the industry standard.
- Offers convenient features — available with dimming on some indoor models and automatic daylight shut-off and motion sensors on some outdoor models.
- Is durable — won't break like a bulb.

To qualify for Energy Star certification, LED lighting products must pass a variety of tests to prove that the products will display the following characteristics:

- Brightness is equal to or greater than existing lighting technologies (incandescent or fluorescent) and light is well distributed over the area lighted by the fixture.
- Light output remains constant over time, only decreasing towards the end of the rated lifetime (at least 35,000 hours or 12 years based on use of 8 hours per day).
- Excellent color quality. The shade of white light appears clear and consistent over time.
- Efficiency is as good as or better than fluorescent lighting.
- Light comes on instantly when turned on.
- No flicker when dimmed.
- No off-state power draws. The fixture does not use power when it is turned off, with the exception of external controls, whose power should not exceed 0.5 watts in the off state.

2.9 Efficiency droop

- The term "efficiency droop" refers to the decrease in luminous efficacy of LEDs as the electric current increases above tens of milliamps (mA). Instead of increasing current levels, luminance is usually increased by combining multiple LEDs in one bulb. Solving the problem of efficiency droop would mean that household LED light bulbs would need fewer LEDs, which would significantly reduce costs.

- In addition to being less efficient, operating LEDs at higher electric currents creates higher heat levels which compromise the lifetime of the LED. Because of this increased heating at higher currents, high-brightness LEDs have an industry standard of operating at only 350mA. 350mA is a good compromise between light output, efficiency, and longevity.
- Early suspicions were that the LED droop was caused by elevated temperatures. Scientists proved the opposite to be true that, although the life of the LED would be shortened, elevated temperatures actually improved the efficiency of the LED. The mechanism causing efficiency droop was identified in 2007 as Auger recombination, which was taken with mixed reaction. In 2013, a study conclusively identified Auger recombination as the cause of efficiency droop.

3. RESEARCH METHODOLOGY

The various sets/process involved in identifying and solving a research problem is:

3.1 Formulating the research problem

Formulating the research problem is the key ingredient to the whole research process (i.e.) at the very first step the researcher must choose the research topic by narrowing down from the various option that he/she would like to carry out the research. Initially the problem may be stated in a broad generic way, the researcher also need identify the feasibility in carrying out the research on the chosen topic. It's important at this stage the researcher is clear on the topic as rest of the steps involved in the research cycle and the final analysis and report has an influence too. Thus careful consideration & taught needs to be given at this stage.

3.2 Extensive review of literature

Once the problem has been identified the researcher need to review / examine all available literature associated to problem and gather more associated information. The two possibility of literature review are conceptual literature covering the concepts and theories and empirical literature consisting of studies made from earlier associated research. The outcome of this literature review will lead to next steps where in the researcher rephrases the problem into analytical and operational terms. This task of formulating or defining the research problem is of great importance to the research process.

3.3 Collection of data

Having set the methodology for sampling the researcher now to gathers the data to experiment his research problem, thus various methods of data collection are used and further analyzed in association to the problem Data collection methods used are:

By observation b) Personal interview c) Telephonic interview d) Mailing

3.4 Analysis of data

Once the data is collected, it needs to be analyzed in light of the main research problem; the analysis of data requires a number of closely related operations such as establishment of categories, application of categories to raw data through coding and tabulation and then draws a statistical interference.

3.5 Generalization and Interpretation

Is the hypothesis is tested and upheld several times, it may be possible to build a theory, the real value of research lies in its ability to arrive at certain generalization.

3.6 Preparation of report and presentation of results

Having concluded the research process from establishment of research problem definition, passing thru various stages of data gathering& analysis, and checking with respect to the hypothesis developed, the researcher now needs to conclude the research by reporting the research findings in a detail report.

4. FINDINGS & ANALYSIS

4.1 Brief Statistics

While incandescent lamps are typically cheaper upfront and have a shorter payback period, LEDs are shown to have a better long-term investment, making them better for an energy efficient lighting retrofit.

4.2 Simple Payback Analysis & Return on Investment:

4.2.1 Costs:

Incandescent: $0.50 - $1.50

LEDs: $25-60 (Consumer Reports)

4.2.2 Efficiencies:

Incandescent: 10% efficient (90% of energy is lost as heat, 10% is used for light)

LEDs: 85-90% more efficient

Lifetimes: Incandescent: 1,000 - 2,000 hours

LEDs: 25,000 - 100,000 hours

Keep in mind that the rated lifetime of a lighting product may be shorter than the actual lifetime of the bulb. For example, an LED's lifetime is typically determined by the time when the lighting will be at 70% quality. It will still work after this lifetime, but may just provide weaker lighting.

4.2.3 Return on Investment: Comparing the ROIs

Now, let's estimate a simple payback and ROI for replacing a traditional $0.50 60W incandescent light bulb with LED.

We'll estimate that you use the incandescent light bulb for 3 hours each day. This means that in our example, it will use 180 Watt-hours per day (60W x 3 hours), or 65,700Watt-hours per year. This is the equivalent of 65.7 kilowatt-hours (kWh) per year.

If the electricity in your area costs $0.10 per kWh, then the incandescent bulb costs $6.57 to run for the year.

The incandescent bulb will last for 1,000 - 2,000 hours, so if it lasted for 1,500 hours. If it is used for 3 hours per day, then it would last a total of 500 days, or 1.4 years.

In an average household, lighting accounts for 20% of the electricity bill. Therefore, replacing your lighting with more energy efficient fixtures could cause a significant decrease in your energy costs.

4.2.3.1 Incandescent vs. LEDs

First, let's compare the pricing, efficiencies and lifetimes of conventional residential lighting choices: incandescent and LEDs. The lifetime is an important factor to consider because the longer the lifetime, the cheaper the replacement costs for lighting over time.

4.2.3.2 Replacement Incandescent Lamp with LED Lamp:

For the LED example, let's assume that it is a 12W model (60 W incandescent equivalent), or 5 times more efficient. This will use 36W-hours per day if turned on for three hours, and will use 13.140 Watt-hours per year. This is the equivalent of 13.1kWh annually.

At $0.10/kWh, the LED will cost $1.31 per year in electricity costs.

The LED costs $30 in our example, but lasts for 30,000 hours. This means it would last 27.4 years if used for 3 hours per day.

Money Saved Over Lifetime:
The LED costs $1.31 in electricity per year, while the incandescent costs $6.57, which is a savings of $5.26 per year. Over 27.4 year lifetime, the LED will save $144.12.

Simple Payback Period:
The LED costs $29.50 more than the incandescent bulb ($30 - $0.50). The LED costs $1.31 in electricity per year, while the incandescent costs $6.57. The amount of time for the LED to pay for itself is approximately 5.6 years, because it costs $5.26 more per year to run the incandescent light bulb. The additional price of the LED pays for itself after this amount of time. (Calculation: $29.50/$5.26 = 5.6 years).

ROI:

The LED's gain from investment is the $5.26 saved in electricity per year times 27.4 years (the lifetime of the fixture), or $144.12. Then, we must add the cost of the incandescent bulb replacements over the LED's lifetime, which is 20 times, or $10 (20 x $0.50).

Therefore, the ROI = ($144.12 + 10 - 30)/$30 = 4.1

Sl.No.	Parameter	LED Lights	Incandescent Lamp	Savings
	Input Values			
1	No. of lights (nos)	10		
2	Average hours of use per day	3		
3	Power cost, $ per kW/hr	0.1		
4	Light wattage (W)	12	60	
5	Purchase cost per bulb ($)	30	0.5	
6	Average bulb life time in years	27.4	0.46	
	Output Values			
1	Power consumption per year (kW/h)	131.4	657	525.6
2	CO_2 saved per year (kg)	115.6	578.2	462.5
3	Running cost per year ($)	13.14	65.7	52.56
4	Total cost over 1 year ($)	313.14	70.7	-242.44
5	Total cost over 3 year ($)	341.42	212.1	-129.32
6	Total cost over 5 year ($)	372.61	353.5	-19.11
7	Total cost over 10 year ($)	465.27	707	241.73

Table 2: Payback analysis of LED installation Vs Incandescent lamp installation

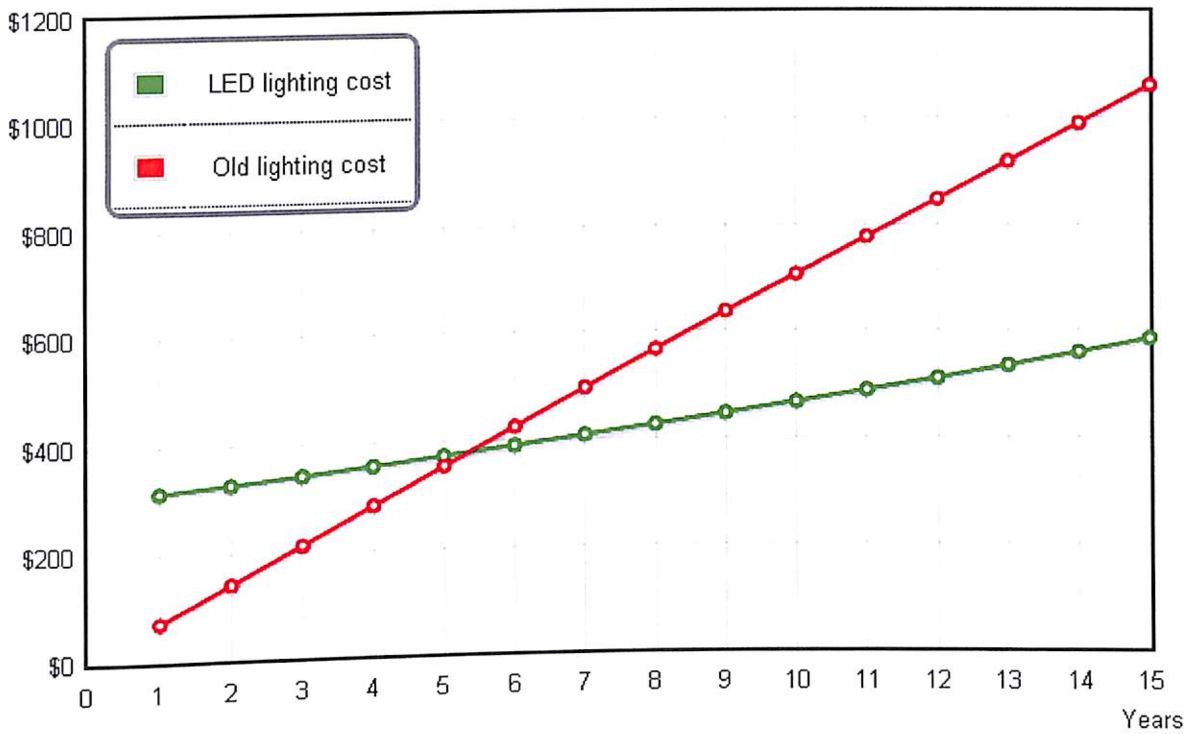

Fig 6: Return on Investment graph of LED Vs Incandescent lamp

Assumptions & Notes

- The payback period is when the green line crosses the red line. If the green line is always below the red line, then the payback period is < 12 months.
- Total cost over X years, is the cost of globes + the cost of electricity
- All bulbs are assumed to need replacement at the same time, at the end of their lifetime. There is an assumption that the man power required to initially install & than change globes is free, but you could add this to the globe purchase cost if required.
- A conservative estimate of compounding electricity price increases of 5% per year is included in the calculation. You should enter in the price you are currently paying.
- LED lights are currently expensive relative to traditional lights, but the price is coming down rapidly. We assume a 10% fall in the price of LED globes per year.
- Typical power costs vary around the world. Check your last power bill for details. Values of $0.15 to $0.45 per kW/h are typical.

- We have seen some manufacturers claim life times of 30+ years for LED lights. But at the same time offer only a 1 year warranty. We suggest a conservative approach and assume lights will need replacing after 5 to 10 years. Or even shorter if installed in a hot environment.
- While a reasonable effort has been made to provide a reasonable cost estimate, your circumstances may vary significantly from our assumptions. We recommend that you do your own calculations taking into account your own circumstances before any lighting purchase.
- For CO_2 (carbon dioxide), the emissions intensity of Australia's electricity generation was around 880g CO_2 per kWh in 2008, as compared to around 740g CO2 in China, 540g CO_2 in the US and less than 500g CO_2 in the United Kingdom, Germany and Japan. Source: Vivid Economics and Norton Rose carbon emissions report, May 2011. Being based in Australia, we have used the Australian number. If you live elsewhere your CO_2 saving will probably be less.
- Using LED lights in an air conditioned environment can reduce air conditioning costs. This is not taken into account in the chart above.

4.3 SWOT Analysis

SWOT analysis is a strategic planning method used to evaluate the **S**trengths, **W**eaknesses, **O**pportunities, and **T**hreats involved in a project or in a business venture. It involves specifying the objective of the business venture or project and identifying the internal and external factors that are favorable and unfavorable to achieve that objective. A SWOT analysis must first start with defining a desired end state or objective. A SWOT analysis may be incorporated into the strategic planning model. Strategic Planning has been the subject of much research. **S**trengths: characteristics of the business or team that give it an advantage over others in the industry. **W**eaknesses: are characteristics that place the firm at a disadvantage relative to others. **O**pportunities: *external* chances to make greater sales or profits in the environment. **T**hreats: *external* elements in the environment that could cause trouble for the business. Identification of SWOTs is essential because subsequent steps in the process of planning for achievement of the selected objective may be derived from the SWOTs. First, the decision makers have to determine whether the objective is attainable, given the SWOTs. If the objective is NOT attainable, a different objective must be selected and the process repeated.

Positive		**Negative**	
Sl.No	**Strength**	**Sl.No.**	**Weakness**
1	Long life of LED lights	1	More initial cost
2	Long life of the lighting installation	2	More sensitive to electrical surges
3	Less energy consumption		
4	Less heat generation		
5	No toxic chemical are involved		
	Opportunities		**Threats**
1	Industrial Plant lighting	1	Supply overflow
2	Hazardous area lighting	2	Pricing
3	Architectural lighting	3	Political effect
4	Sports & outdoor area lighting		
5	Street & road lighting		
6	Traffic signal lighting		

Table 3: SWOT analysis of LED lamp/installation

5. INTERPRETATION OF RESULTS

5.1 Comparison of LED Lighting System with Conventional Lighting System

In a power plant, typical areas like Substation & Switchyard were selected for the study. For these areas, both indoor & outdoor lighting with traditional lights like fluorescent for indoor and Sodium vapor & Metal Halide lamps for outdoor area were studied. A comparison of the traditional light source load with LED loads, for the above areas were done. The figures below show the advantage of LED light fixtures over the traditional light fixtures.

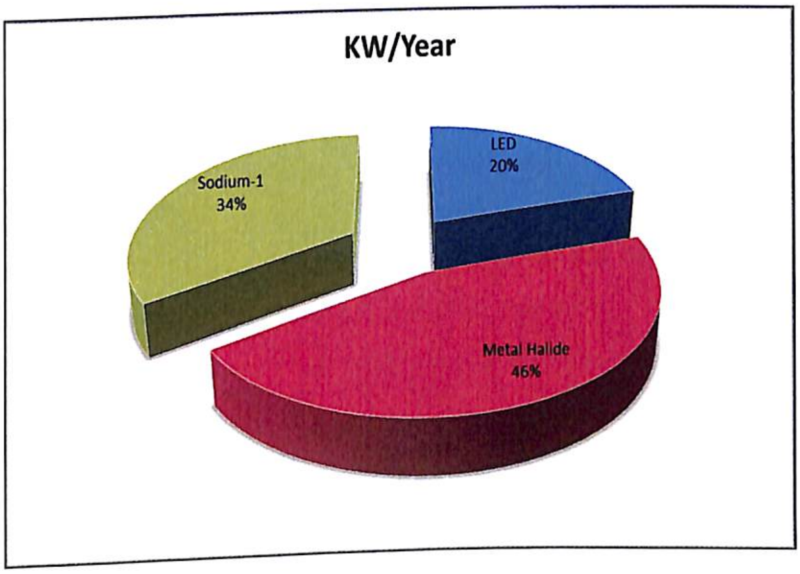

Fig 7: Energy Consumption Pi Chart for Substation area per year

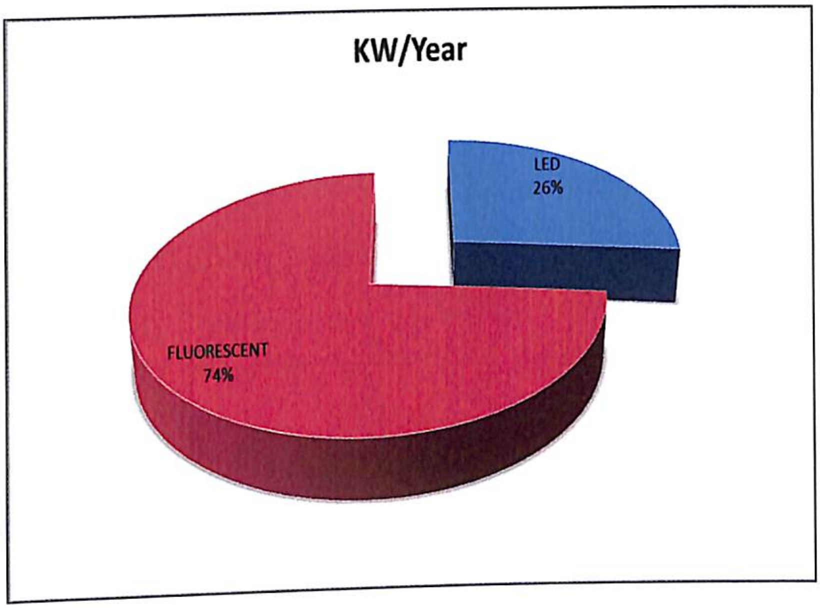

Fig 8: Energy Consumption Pi Chart for Switchyard area per year

5.2 General Comparison of LED with Conventional Light Sources.

This section compares the use of LED lighting system for an existing area which is already being illuminated by a conventional lighting system.

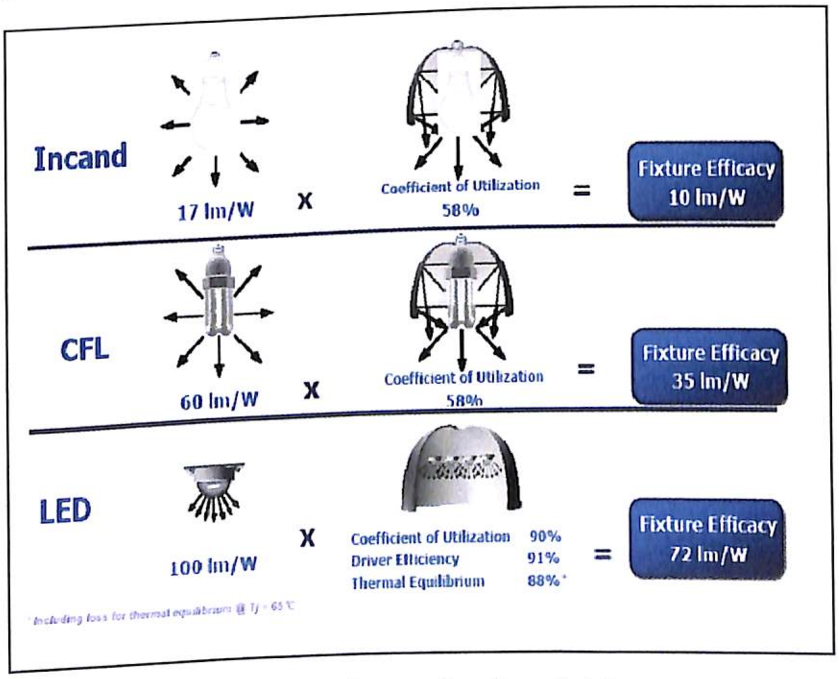

Fig 9: Fixture efficiency of various light sources

Light Type	Data Sheet lm/W	Usable* lm/W	Lifetime (hrs)
Incandescent	17	10-17	3k
Halogen	20	12-20	10k
T12 fluorescent	60	45-50	20k
Metal halide	70	<40	5k-15k
T8 fluorescent	74	55-60	20k
Best-in-Class Power LED	135	60-80	> 60k
High-pressure sodium	91	<50	20-24k
T5 fluorescent	107	96	20k
Low-pressure sodium	120	65-70	18k

Table 4: Comparison of various light sources

*** Usable lm/w – Based on Delivered Lumens**

6. CONCLUSION

In today's world where everyone talks of energy efficiency, energy conservation and environmental protection, energy efficient lighting is becoming the norm as inefficient bulbs are phased out. Energy efficient lighting technology is developing quickly and a range of products are now available to choose from. LED lamps are the newest addition to the list of energy efficient light sources. LED lighting concept is an answer to key issues like rising energy prices, global climate change, security of energy supply, economic growth and environmental contamination.

LED lamps have made their way into numerous lighting applications including exit signs, traffic signals, under-cabinet lights, and various decorative applications. Though still in their infancy, LED lamp technologies are rapidly progressing and show promise for the future.

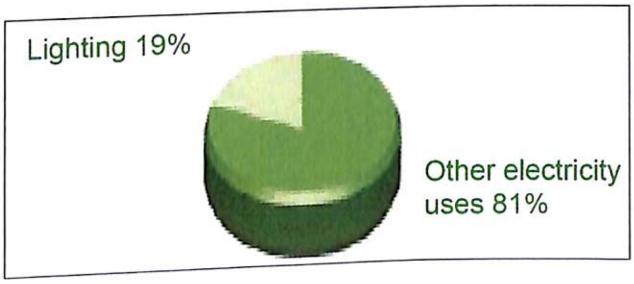

Fig 10: Energy Consumption of typical lighting installation

The benefits of LED lamps & lighting system are as summarized below:

- No filaments like incandescent lamps and no electrodes like gas discharge lamps (HPS, MH, and Fluorescent) and hence longer life.
- Devices are Robust, Vibration & Impact proof; very rugged and durable
- Instant On, Full Color, 100% Light; Cold Start Capable
- No Mercury in the Light Source and lower carbon emission and hence environmental friendly
- Long Life – Reduced Maintenance Costs
- Energy efficient Lighting

- New lighting technology exists now, and current adoption rate is accelerating
- The environment benefits from lower energy/ CO_2 emissions
- Business / country competitiveness is strengthened
- Legislation plays a crucial role in realizing lighting's savings potential
- Energy efficient Lighting is a public and private opportunity for all Countries and will equally benefit its population as well as its future competitiveness

Hence it can be clearly concluded that future of lighting is LED technology.

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