

Positioning of Lighting Products: A Frontier from Traditional to Modern Approach

Aafreen Haque¹ Dr. Urvashi Shrivastava²

Student, Bhilai Institute of Technology¹

Associate Professor, Bhilai Institute of Technology²

Email: aafreen63@gmail.com¹

urvashi.bitdurg@gmail.com²

ABSTRACT

The emergence of a new lighting technology at the beginning of the 1980s has created a situation of technological competition with an existing and mature technology. This paper presents a detailed comparative analysis between domestic lighting lamps (DLLs) use for producing artificial light. DLLs include incandescent lamp (IL), fluorescent lamp (FL) and compact fluorescent lamp (CFL). Light emitting diodes (LED) based lamp technology is relatively new in comparison with conventional incandescent and discharge lamps. The result shows that with the current technology, the use of FL and LED lamp is beneficial for utility as well as for consumer. However, with the current pace in the development of LED technology, it is possible LED lamps will lead the lighting market in the near future. The paper has also presented the uncertainties that exist in lighting market and proposed the guidelines that will help in making future energy policy.

KEYWORDS : Lighting Lamps, Life cycle assessment, performance of lamps.

INTRODUCTION

In the developing countries, where there is a gap between demand and supply, measures are being taken for reduction in electricity consumptions as a part of their demand side management. As per research in Trifunovic et al. (2009), it is estimated that the energy reduction up to 27% in residential and 30% in commercial sector could be achieved by switching towards energy efficient technologies. This has resulted in the growth of power electronic based energy saving devices. The tremendous increment in unit electricity charges is also one of the reasons for the penetration of such devices in existing power system. In the 19th century, the first practical incandescent lamp was invented by Thomas Edison and Joseph Swan. Since then there has been significant improvements in different types of bulbs and their efficiencies. There are different types of lights or lamps around, and they all being designed with a conceived image in mind. Major types of lamps or bulbs are commonly found in the lighting systems of homes, offices, factories, electrical devices etc. The performance of a light fixture depends on the bulb we use. Different types of light bulbs produce different lighting.

The different types of lights or lamps include the following

- Incandescent lamps
- Compact fluorescent lamps
- Halogen lamps

- Metal halide Lamps
- Light Emitting Diode
- Fluorescent tube
- Neon lamps
- High intensity discharge lamps
- Low pressure sodium lamps

Overview of incandescent lamps, discharge lamps and LED lamps

Incandescent lamp

Incandescent lamps (IL) are those lamps in which the light is produced by heating the tungsten filament. Efficacy of IL lies in the range of 10–20 lm/W depending on their construction and the filament operating temperature (DoE, 2012a). The rated lifetime of IL is usually around 1000 h (OSRAM, 2009; Simpson, 2008). ILs are considered highly inefficient source of light because 90% of the input energy is lost as heat output (Brunner et al., 2010). To increase the rated lifetime of IL, halogen gas is added inside the IL glass. Halogen gas reacts with the evaporated tungsten element and re-deposited the evaporated tungsten back to the filament. The complete cycle of re-deposition is known as halogen cycle. Such lamps are known as halogen lamps (HL). The latest development in HL is in the form of aluminium based dichloric-reflector which reflects the visible light to the object and allows infrared radiation to pass through it. Such reflector present cool-effect of light output and could be placed nearer to the illuminated object. HL has a longer lifetime of 2000– 4000 h and an efficacy around 12–35 lm/W (Halogen; et al., 2010). Some researchers claim that HL may be able to achieve efficacy greater than 45 lm/W; however, these results have not been verified (ECEEE, 2011).

Discharge lamps

Discharge lamps are those lamps in which the light is created by an electric discharge within a gas or a vapour. A small amount of Mercury “Hg” is introduced in the fluorescent tube for illumination purpose. Special phosphor material is used to convert the ultra-violet light into the visible light output. Discharge lamps have a significantly higher efficacy and longer life than an IL. Fluorescent lamp (FL) and compact fluorescent lamp (CFL) come under the category of discharge lamp (Simpson, 2008). The major difference between FL and CFL is that CFL is a point source of light while FL is a linear source of light. In CFL, the luminous flux changes inversely proportional to the square of the distance between light source and illuminated object while in FL luminous flux changes inversely proportional to the distance of the light source and illuminated object . CFLs are also referred as “Energy Saving Lamps” in comparison with IL only. CFL has an advantage over FL, it could be directly placed in the same socket where IL has been used in the past. CFL consumes much less power and gives much more lumens than an equivalent IL (Simpson, 2008). FL and CFL both work on the same principle of discharge gases and having negative voltage-current characteristics; however, these lamps widely differ in their basic design. In discharge lamps, electrical or electronic ballast is used to provide the starting voltage and limit the avalanche current. In FL, either electromagnetic or electronic ballast is used while in CFL electronic ballasts are used due to heavy weight of electromagnetic ballast. In electronic ballasts weight is reduced by changing the system frequency from 50 Hz to 50 kHz using electronic circuits.

Light emitting diodes (LED) lamps

Light emitting diodes (LEDs) are semiconductor devices, filled with gases and coated with different phosphor materials. LEDs are used to produce artificial light. Like FL and CFL, LED light output is also not inherently white in colour. LED light output is monochromatic in nature. This makes it useful for special purposes like traffic signs and cars' indicating light. The efficacy and lifetime of LEDs lamps are highly sensitive to heat dissipation rate and optical design of the luminaire (DoE, 2009). LED luminaire refers to an integrated assembly comprises of LED light emitting element, LED driver and other optical, thermal, mechanical and electrical components (ANSI, 2005). LED light emitting element could be in form of LED package (a single LED) or LED arrays (modules). LED package protects the LED die, disperses the internally generated heat and contains a primary optical system to direct the generated light out of the device (ETAP, 2009). Presently in commercially available LED lamps, huge deviations from manufacturer claims have been observed particularly in terms of lamps' efficacy and lifetime. In 2006, the US Department of Energy (DOE) has initiated a program "Commercially Available LED Product Evaluation and Reporting (CALIPER)" to investigate the performance of luminaires and replacement lamps which use LEDs as their light source. This is a quite positive step to hold the consumer trust and ensure only good quality product reach to the consumer. It is expected with the current pace in development, LED based lighting will lead the lighting market in near future.

LITERATURE REVIEW

Based on a 2012 phone survey of 604 Massachusetts households, customers generally buy CFLs or LEDs for energy savings and long lamp lifetime, and incandescent (or other lamp types) for light color or brightness (NMR 2012a). A study for SCE generally confirmed these findings (ODC 2012). When asked what types of information they look for on packaging, 96% of respondents report that they consider wattage, 92% consider price, and 70% consider wattage equivalency; other characteristics considered by more than one-half of the respondents include lamp life, colour appearance, the ENERGY STAR label, and lamp shape .

Price and Energy Savings: Studies have shown that customers are motivated by both price and money from energy savings, but price is more critical (OSG 2011). A customer survey for Southern California Edison (SCE) by ODC (2012) found that products with prices \$20 or less sold the best in all categories, and that sales at prices above \$40 were virtually non-existent. Customers indicated that they would pay as much but no more than \$10 for LED A-Lines and \$30 for LED Reflectors (ODC 2012).

RESEARCH METHODOLOGY

The research process provides a systematic, planned approach to the research project and ensures that all aspects of the research project are consistent with each other. A research process consists of stages or steps that guide the project from its conception through the final analysis, recommendations and ultimate actions. Research studies evolve through a series of steps, each representing the answer to a key question.

Descriptive research design: Determining the relationship between two or more variables. It is well structured. It is more economical, we can gather more information. Problems can be found after the questionnaire preparation. It needs less time

The primary data was collected through survey that was systematically carried within Pune, Maharashtra, India. The responses of the respondents were recorded in the questionnaire prepared for them through questionnaires with one to one interview, the sample of 23 respondents is taken in survey.

A part of a population, which is provided by some process on other, usually by deliberated selection with the object of investigating the properties of the parent population set. Non probability sampling method is in deterministic method where the sample size is numerous and can't be determined. So for our convenience we take convenience-sampling method where all the population in sample is given equal opportunity.

Sampling Method: - Convenience sampling method.

1. **Universe:** Customers/Clients/Retailers.

2. **Source of data:** The two important sources of data are the primary data and secondary data. The primary data is collected through survey method with the help of questionnaire and personal interview. The secondary data is been collected from other websites and reference books and articles.

3. The information is collected through survey in Pune city

4. **Sample unit:** The sample unit consists of Customers/Clients/retailers in Pune.

5. **Sample size:** The sample size is 23 respondents.

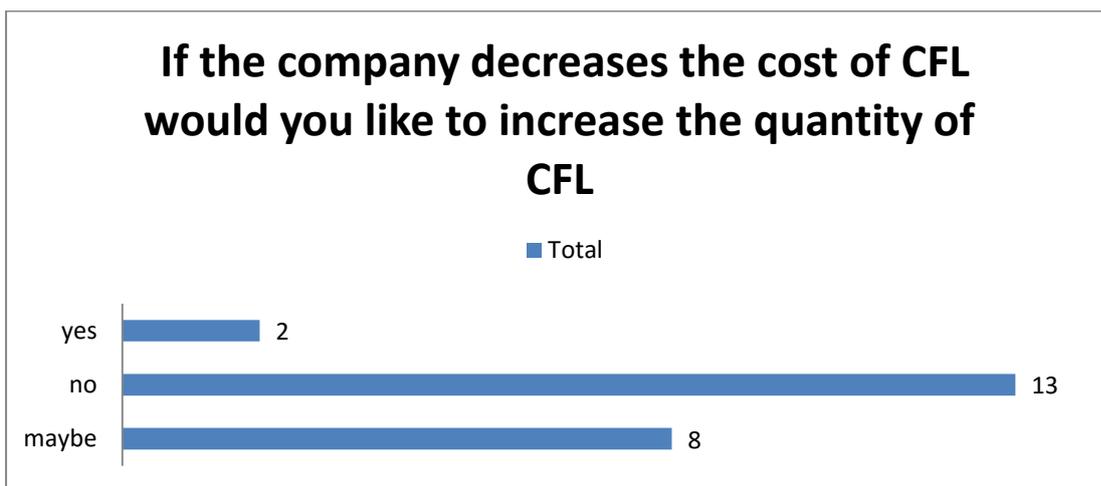
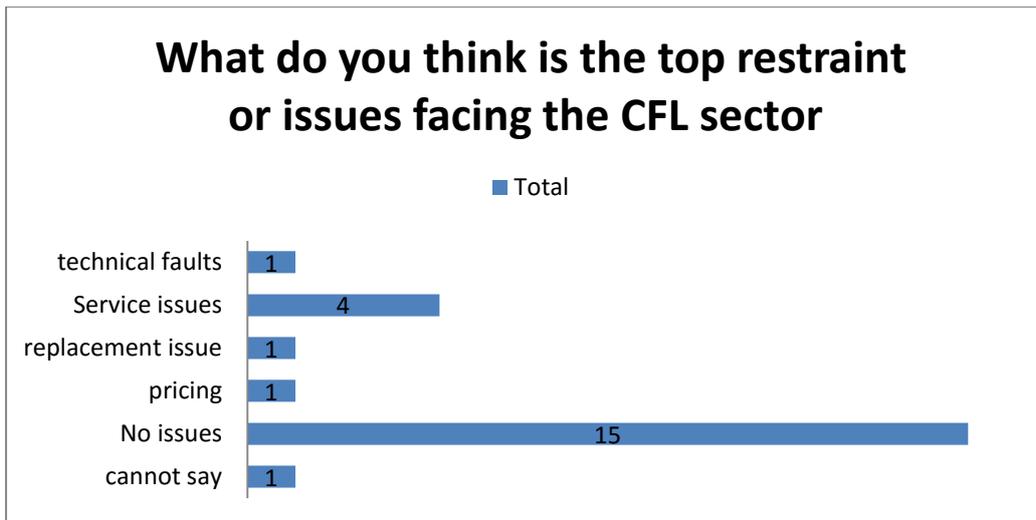
6. **Sample method:** the sample method used is non-probability. In non-probability sampling the chance of any particular unit in the population being selected unknown. The procedure used for sampling is convenient sampling in this method the sample unit is chosen primarily on the basis of the convenience to the investigator.

7. The survey consists of structured questionnaire.

8. The maximum questions in questionnaire consisted of closed-ended questions.

DATA ANALYSIS AND INTERPRETATION-

The data has been collected through survey by interviews and questionnaires. The interviews were taken during the process of sales visit and finding out the way to increase the sales potential and listing down the factors affecting the sales of the organization (Bajaj Electricals Ltd.). Similarly the feedback was taken from the previous as well as the new customers/clients on the basis of questionnaires. The data is further collected and analyzed in excel and the results are been calculated and presented graphically.



FINDINGS

Comparison between incandescent lamp, discharge lamps and LED lamps

Incandescent

An incandescent light bulb works by heating a wire filament heated to a high temperature by passing an electric current through it, until the filament glows with visible light. This means that the bulb is primarily powered by heat, rather than actually creating light. In fact, as the bulb continues to operate, the filament slowly evaporates due to the heat, until it eventually breaks down completely and the bulb needs to be replaced.

Discharge

A compact fluorescent light bulb (CFL) is a standard fluorescent light bulb that has been compressed into the size of a standard-issue incandescent light bulb. A CFL Light Bulb uses a low pressure mercury-vapor gas-discharge that uses fluorescence to produce visible light: an electric current in the gas excites mercury vapor which produces short-wave ultraviolet light that then causes a phosphor

coating on the inside of the lamp to glow. As a result, most CFL bulbs shine with a more white light than other bulb types.

LED

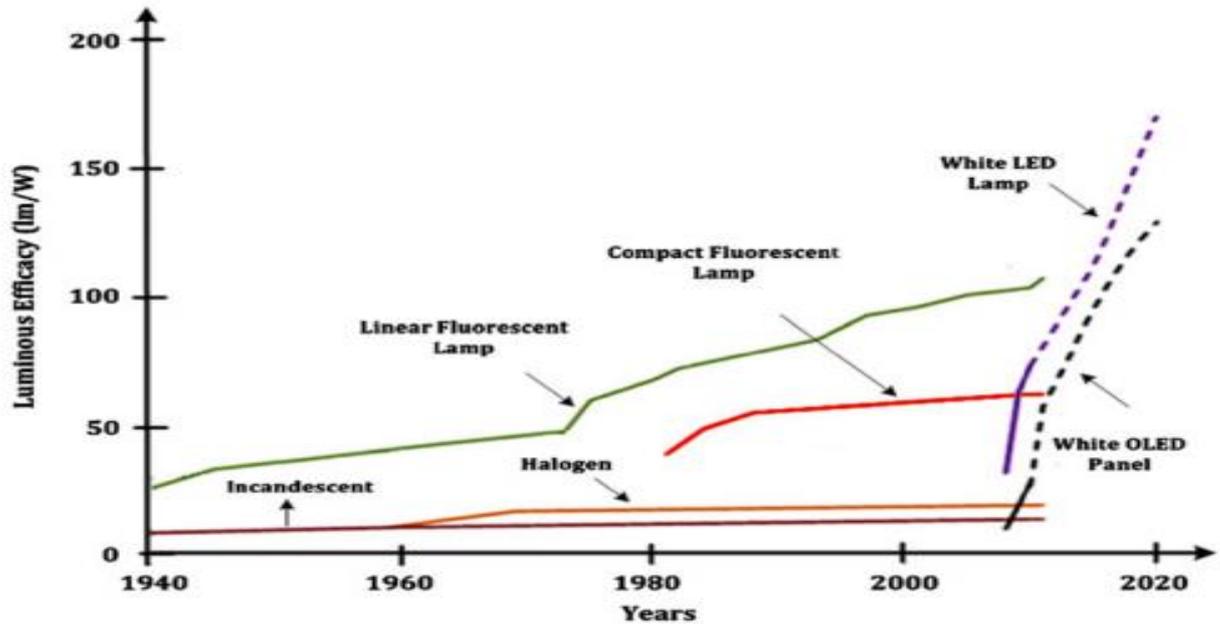
Light Emitting Diodes (LEDs) produce light when voltage is applied to negatively charged semiconductors, causing electrons to combine and create a unit of light. This effect is called electroluminescence, which unlike incandescent bulbs create light directly without too much heat. LEDs have many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster power time.

Interesting Facts about LED

- LEDs use about 75% less energy than a typical incandescent bulb
- LEDs contain no mercury, and have a much smaller environmental impact compared to CFL bulbs
- LED Light lasts up to 50 times longer than the conventional halogen light bulb and 10 times longer than a CFL light bulb
- LED Lights are instant on so they do not require any warm up time compared to other light bulbs
- LEDs don't give off heat making it cooler to operate and may even lower your A/C Bill.
- Switching to LEDs can reduce electrical and maintenance costs of a commercial building by up to 30%
- An incandescent lamp converts about 10% of the energy fed to it into light, whereas LEDs convert nearly 100% of the energy they consume as light. LED lights are way more cost effective than the traditional incandescent.

Efficacy

To compare the average efficacy of IL-FL-CFL and LED lamps, the complete data of all the lamps from the online PHILIPS Product Selector database (Philips, 2012a) are tabulated in Microsoft Excel and the efficacy of each lamp is calculated. Using statistical software SPSS, box plot for each category of lamps is also plotted to see the variation and finding the mean efficacy. ILs have much lower efficacy as compared with other lamps. Average efficacy of CFL and LED lamps are quite same. However, LED tubes have higher efficacy as compared to LED lamps. The highest lamp efficacy in case of LED is 93.4 lm/W and CFL is 76.25 lm/W. FLs as compared to other lamps have much better average efficacy. The maximum efficacy in case of FL is 127.78 lm/W.



Historical and predicted efficacy of light sources, (DoE, 2012h).

Costing-

The cost of IL is much lesser than any other lighting lamps. Most of the input energy in IL is lost as heat output which results in lower efficacy. CFLs and LED cost is much higher than an IL. However, CFL and LED lamps are 75% more energy efficient than an IL and having longer lives (NEMA, 2011). The cost comparisons for the light sources are typically compared on per kilo-lumen basis. It could be observed that the initial cost of FL is twice in comparison with CFL and HL for the same amount of light flux (lumens). However, the rated lifetime of FL luminaire is three and 30 times of CFL and HL respectively. In case of LED, LED lamps have high initial cost and longer lifetime than any other lighting source. It is expected from cost trend, LED lamp cost will decrease in the near future.

Rated lifetime of traditional and LED lamps (DoE, 2011d).

S. no.	Light sources	Rated life (h)
1	Incandescent	750-2000
2	Compact fluorescent lamps	8000-10,000
3	Metal halide	7500-20,000
4	Linear fluorescent lamp	20,000-30,000
5	High Power White LED ^a	35,000-50,000

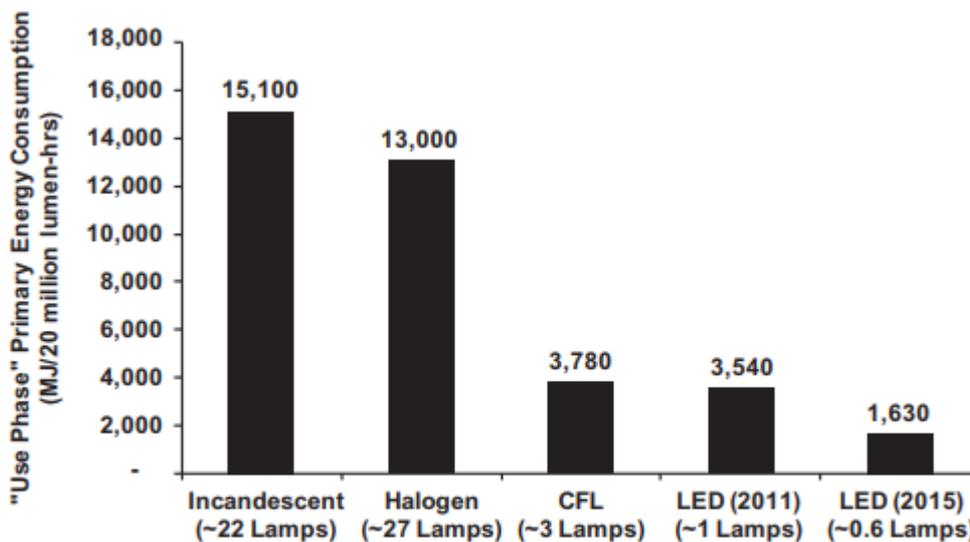
^a Based on estimated useful life L₇₀.

Cost comparison of traditional and LED lamp (DoE, 2012h).

Lamp	Cost (\$/kilo-lumens)	Rated Life (h)	Cost (\$/kilo-lumens-h)
Halogen lamp (A19 43 W; 750 lm)	2.5	5,000	0.00050
CFL (13 W; 800 lm)	2	12,000	0.00017
CFL (13 W; 800 lm dimmable)	10	12,000	0.00083
Fluorescent lamp and ballast system (F32T8)	4	25,000	0.00016
LED lamp (A19 60 W; 800 lm dimmable)	30	25,000	0.00120
		50,000	0.00060

Life cycle assessment of IL-FL-CFL-LED

One of the ways to assess the overall environmental impact of lamps is through Life Cycle Assessment (LCA) analysis. LCA evaluates energy and raw material consumption, gases emissions, and other wastes generated during the entire life-cycle.



Life-cycle primary energy consumption of lighting lamps (DoE, 2012f).

CONCLUSION

A few years ago, consumers were predominantly purchasing incandescent lamp and CFL bulbs because they were cheapest over the LED light bulbs. But today, with the increase in LED technology and the obvious long term cost efficiency and energy savings, more production of LED light bulbs have brought down the costs dramatically. Because of the rapid decline in price of the LED light bulb over the past few years and its energy savings and long term cost benefits, it's very possible we will see an increase in consumer preference for the LED light bulbs over CFLs. Consumers are preferring the LED lights over traditional and CFL lights as LED lights are more environmental friendly compared to CFL and incandescent lamps. LED manufacturing companies are making such LED lights which consume less energy thereby reducing the carbon footprint on the environment. The

ever-changing technology we see in today's society has influenced the lighting market drastically already, and will make it easier for us to change our purchasing decisions in the future.

RECOMMENDATIONS

1. Sub-standard or low quality lamp should not be allowed to penetrate in the market by making stringent standards and developing a separate task force for their effective enforcement.
2. Media campaign could be started to literate the general consumer about the basic lighting terminologies.
3. The current development shows a tremendous improvement in LED lighting performance and at the same time reduction in their development cost. Hence, it is expected that the major portion of lighting system will be provided by LED lamps in near future.

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