Evolution of Street Lamp Technologies

Mr. Amey S. Laddad[1], Mrs. Gayatri M. Phade[2], Mr. Sagar P. Thombare[3]

Abstract- **Street lighting is a key public serviceprovided by public authorities at the local and municipal level. With relatively new technologies that are evolving rapidly, it is difficult to identify prototypical lamps for comparison. This paper presents comparative study of various lamps based on lighting efficiency, energy consumed, colour rendition, Operating life, and Thermal effects. Incandescent convert only 1/3 per cent of electricity consumed into usable light. Compact fluorescent lamps [1], represented a significant improvement in energy efficiency but they contain mercury that can present a risk when the lamps are broken or disposed of incorrectly. Energy consumption accounts for much of the impact reported for all of the lamps. For the incandescent, energy consumption during use was the most important issue. For the CFL, mercury content was the most important issue. For the LED, the heat sink was associated with many impacts. The ability to produce high power, high quality white light with LEDs is more recent and this technology is still evolving in a highly competitive market. LED lighting technology has established itself as a proven alternative to traditional high-intensity discharge or high-pressure sodium lighting.**

Keywords **- Lighting efficiency, energyconsumption, operating life, thermal effects, energy efficiency, CFL's, LED's.**

I.INTRODUCTION

- Street lighting is one of the largest areas of electrical consumption for municipalities[2].
- Along with improvements in aesthetics and safety, communities that own their street lighting systems can realize substantial reductions in operating costs by converting older lighting technologies to LEDs [3] - [4].
- We will have an overview of various lamp types.

Fig1: Evolution of Lamps [11].

II. INCANDESCENT LAMP

- In incandescent lamp, which is also called General Lighting Service Lamp (GLS), light is produced by leading current through a tungsten wire. Working temperature is about 2800 K. The typical luminous efficiency of different types of incandescent lamps is in the range between 5 and 15 lm/W.

Advantages**:**

- Easy to use, small and does not need auxiliary equipment
- Easy to dim by changing the voltage
- Excellent colour rendering properties
- Instant switching

Limitations:

- Short lamp life (1000 h)
- Low luminous efficiency.
- Heat generation& operation cost is high.

III. TUNGSTEN HALOGEN LAMP

- Inside the bulb, halogen gases limit the evaporation of the filament, and redeposit the evaporated tungsten back to the filament through the so called halogen cycle.

ISSN: 2278 – 909X

- Compared to incandescent lamp the operating temperature is higher, and consequently the colour temperature is also higher, which means that the light is whiter.
- Their lifetime spans from 2000 to 4000 hours, and luminous efficiency is 12-35 lm/W.
- The halogen lamps available for mains voltages or low voltages (6-24V).
- Low voltage lamps have better luminous efficiency.
- The latest progress in halogen lamps has been reached by introducing selective-IR-mirror-coatings in the bulb.
- The infrared coating redirects infrared radiations back to the filament. This increases the luminous efficiency by 40–60% compared to other designs and lamp life is up to 4000 hours.
- Salient Features:

- Luminous efficacy (lm/W): 12-35.
- Lamp life (hrs.): 2000-4000.
- Dimming control: Excellent.
- Re-strike time: Prompt.
- Cost of installation: Low.
- Cost of operation: High.

Advantages:

- Easy to dim
- Instant switching and full light output
- Excellent colour rendering properties

Limitations:

- Surface temperature is high

IV. FLUORESCENT LAMPS

- The A fluorescent lamp is usually in the form of a long tubular bulb with an electrode at each end, contains mercury vapour at low pressure with a small amount of inert gas for starting.
- The majority of the emission (95%) takes place in the ultraviolet (UV) region. Hence, the UV radiation is converted into light by a phosphor layer on the inside of the tube. Since one UV-photon generates only one visible photon, 65% of the initial photon energy is lost as dissipation heat.
- The luminous efficiency of the latest T5 fluorescent lamp is up to 100lm/W.
- Electronic control gear incorporates all the equipment necessary for starting and operating a fluorescent lamp.
- Salient Features:

- Luminous efficacy (lm/W): 50-100.
- Lamp life (Hrs.): 10000-16000.
- Dimming control: Good.
- Re-strike time: Prompt.
- Cost of installation: Low.
- Cost of operation: Low.

Advantages:

- Inexpensive.
- Electronic ballasts are that the light is flicker-free.
- Good luminous efficiency.
- Long lamp life, 10 000 – 16 000 h.

Limitations:

- Ambient temperature affects the switch-on and light output
- Need of auxiliary ballast and starter or electronic ballast
- Light output depreciates with age
- Contain mercury
- Short burning cycles shorten lamp life

V. COMPACT FLUORESCENT LAMPS

- A compact fluorescent lamp (CFL), also known as a compact fluorescent light or energy saving light, is a type of fluorescent lamp.
- The luminous efficiency of CFL is about four times higher than that of incandescent lamps. Therefore, it is possible to save energy and costs in lighting by replacing incandescent lamps with CFLs[12].
- Salient Features:

- Luminous efficacy (lm/W): 40-65.
- Lamp life (hrs.): 6000-12000.
- Dimming control: With Special Lamps.
- Re-strike time: Prompt.
- Cost of installation: Low.
- Cost of operation: Low.

Advantages:

- Good luminous efficiency
- Long lamp life (6000-12 000 h)

Limitations:

- Expensive
- Light output depreciates with age
- Short burning cycles shorten lamp life

ISSN: 2278 – 909X

- Current waveform of CFLs with internal electronic ballast is distorted
- Contain mercury

VI. HIGH INTENSITY DISCHARGE LAMPS

- Without any temperature limitations (e.g. melting point of tungsten) it is possible to use gas discharges (plasmas) to generate optical radiation.
- Unlike thermal solid sources with continuous spectral emission, radiation from the gas discharge occurs predominantly in form of single spectral lines.
- Discharge lamps generate light of different colour quality, according to how the spectral lines are distributed in the visible range.
- The power conversion per unit volume in high pressure arc discharge lamps is 100 to 1000 times higher than that of low pressure lamps, which leads to considerable thermal loadings on the discharge tube walls.
- The wall temperatures may be in the region of 1000°C. The discharge tubes are typically made of quartz or PCA (polycrystalline sintered alumina: Al_2O_3).
- For starting high pressure lamps (except mercury lamps) superimposed pulses of some KVs from external ignition circuits or internal ferroelectric capacitors are used.

VII. MERCURY LAMPS

- In mercury lamp light is produced with electric current passing through mercury vapour. An arc discharge in mercury vapour at a pressure of about 2 bars emits five strong spectral lines in the visible wavelengths at 404.7 nm - 579 nm. The red-gap is filled up by a phosphor-layer at the outer bulb.
- Typical values of these lamps are luminous efficiency 40-60 lm/W, CRI between 40 and 60 and CCT 4000 K. The lamp life is 12 000 h.
- Mercury lamps will be banned from European market after 2015.
- Salient Features:

- Luminous efficacy (lm/W): 40-60.
- Lamp life (Hrs.): 12000.
- Dimming control: Not Possible.
- Re-strike time: 2-5 min.
- Cost of installation: Moderate.
- Cost of operation: Moderate.

VIII. METAL HALIDE LAMPS

- To increase the luminous efficiency and CRI of mercury high pressure lamps, it is useful to add mixtures of metal components to the filling of the discharge tube. These additives emit their own line spectra in the arc discharge, leading to an enormous diversity of light colour.
- For sufficient vapour pressure, it is better to use metal halides instead of elemental metals.
- When the vapour enters the high temperature region of the discharge, molecules dissociate, metal atoms are excited and radiation is emitted.
- The lamps are available with luminous efficiency typically from 50 to100 lm/W, CCT value from 3000 to 6000 K and CRI from 70 to over 90. The lamp life is typically from 6000 h to 12 000 h.
- Salient Features:

- Luminous efficacy (lm/W): 50-100.
- Lamp life (hrs.): 6000-12000.
- Dimming control: Possible but Not Practical.
- Re-strike time: 5-10 min.
- Cost of installation: High.
- Cost of operation: Low.

Advantages:

- Good luminous efficiency.
- Alternatives with good colour rendering available

Limitations:

- Expensive
- Starting and re-starting time 2-5 min

IX. HIGH PRESSURE SODIUM LAMPS

- In high pressure sodium lamp light is produced by sodium vapour, the gas pressure being about 15 kPa.
- The golden-yellowish emission spectrum applies to wide parts of the visible area. The CRI is low (≈ 20), but the luminous efficiency is high.
- An improvement of the CRI is possible by pulse operation or elevated pressure but this reduces the luminous efficiency.
- Colour improved high pressure sodium lamps have CRI of about 65 and white high pressure sodium lamps of more than 80.

ISSN: 2278 – 909X

- Salient Features:

- Luminous efficacy (lm/W): 80-100.
- Lamp life (Hrs.: 12000-16000.
- Dimming control: Possible but Not Practical.
- Re-strike time: 2-5 min.
- Cost of installation: High.
- Cost of operation: Low.

Advantages:

- Very good luminous efficiency
- Long lamp life (12 000 h or 16 000 h)
- High luminous flux from one unit for street and area lighting.

Limitations:

- Low CRI, about 20 (colour improved 65, white 80)
- Starting and re-starting time 2-5 min

Fig 2: Replacing older lights with LED's.

X. LED

- LED technology on the other hand does not have to fight the fundamental laws of physics in a similar fashion as the phosphor conversion in fluorescent lamps. Theoretically, it can achieve a conversion efficiency of 100%.
- The luminous efficiency of a white light LED depends on the desired wavelengths and colour rendering index [8].
- Luminous efficiency of 400lm/W is reachable with three LEDs, but in that case the CRI will remain under 50 [6].
- Future lighting systems will require more intelligent features. In this regard LED-based lighting systems have an important advantage due to their easy controllability [9]-[10].
- Intelligent features combined with the inherent high energy-saving potential of LEDs will be an unbeatable combination in a wide range of applications.
- Salient Features:

- Luminous efficacy (lm/W): 20-120.
- Lamp life (Hr): 20000-100000.
- Dimming control: Excellent.
- Re-strike time: Prompt.
- Cost of installation: High.
- Cost of operation: Low.

Advantages:

- Small size (heat sink can be large) Physically robust
- Long lifetime expectancy (with proper thermal management)
- Switching has no effect on life, very short rise time
- Contains no mercury
- Excellent low ambient temperature operation.
- High luminous efficiency (LEDs are developing fast and their range of luminous efficacies is wide)
- New luminaries design possibilities.
- Possibility to change colours.
- No optical heat on radiation.

Limitations:

- High price
- Low luminous flux / package
- Risk of glare due to high output with small lamp size
- Need for thermal management.

Fig 3: Comparison between older street lights and LED Street light. Image Courtesy to wordpress.com.

XI. CONCLUSION

Good lighting is essential for road safety, personal safety and urban ambience. Street lighting is a key public service provided by public authorities at the local and municipal level. It is a major electricity consuming application in public sector. This paper has an

ISSN: 2278 – 909X

overview of the lamp technologies that are evolved through many years. We can conclude that LED lighting technology has established itself as a proven alternative to traditional lighting because of its distinct advantages in terms of size, lifetime, and high efficiency. Although it is superior to previous technologies LED's have not completely replaced present lamps.

References

[1] Celma 2007.Guide for the application of Directive 2000/55EC on Energy efficiency requirements for Ballast for fluorescent lighting. CELMA Federation of National Manufacturers.

[2] REGULATION COMMISION (EC), 244/2009.Implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to eco design requirements for non-directional household lamps.

[3] GOI (Government of India) and Central Electricity Authority, All India Electricity statistic (2010-2011).

[4] GOI (Government of India) and Central Electricity Authority, All India Electricity statistic (2008-2009).

[5] N. Holonyak, Jr. and S. F. Bevacqua, Coherent (visible) light emission from Ga(As1-xPx) junctions, Appl. Phys. Lett., vol. 1, pp. 82-83, Dec. 1962.

[6] Daniel A. et al Illumination with Solid State Lighting Technology IEEE Jr. on Select. Topics Quantum Electron. VOL. 8, NO. 2,pp-310-20, March/April 2002.

[7] R. Mueller-Mach, G. O. Mueller, M. R. Krames, and T. Trottier, High-Power Phosphor-Converted Light-Emitting Diodes Based on III-Nitrides, IEEE J. Select. Topics Quantum Electron, vol. 8, pp. 339-345, Mar.-Apr. 2002.

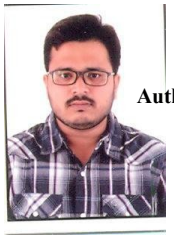
[8] S. Muthu, F. J. P. Schuurmans, and M. D. Pashley, Red, Green, and Blue LEDs for white light illumination, IEEE J. Select. Topics Quantum Electron., vol. 8, pp. 333-338, Mar.-Apr. 2002.

[9] Othman, M.K.; Salleh, M.M.; Mat, A.F.A., "Organic Light Emitting Diode (OLED) Using Different Hole Transport and Injecting Layers," Semiconductor Electronics, 2006. ICSE '06. , vol., no., pp.134,137, 2006 .

[10] LEDs for Solid State Lighting and Other Emerging Applications: Status, Trends, and Challenges, M. George Craford, Lumileds Lighting, LLC,370 West Trimble Road, M/S 91UE, San Jose, CA 95131, USA.

[11] Dr.Thomas Klett, Geschich teder Licht echnic ,History of Lighting.

[12] R.A. Jabbar, M. Al-Dabbagh, A. Muhammad, R.H. Khawaja, M. Akmal, M.R. Arif, "Impact of compact fluorescent lamp on power quality," Power Engineering Conference, 2008. AUPEC '08. Australasian Universities, Publication Year: 2008 .



Author 1: Mr.Amey S. Laddad,
Pursuing M.E. VLSI & EMBEDDED SYSTEMS,

Savitribai Phule Pune University.

23 year's age,3 Years of Working Experience

Author 2: Mrs. Gayatri M Phade,working as Head of the department of E&TC, ME EXTC.

Diploma in Business Management, Diploma in Software Management Perceiving PhD from SNDT University Mumbai. Worked for Different Universities: North Maharashtras University, Dr Babasaheb Ambedkar university, Mumbai University, Yashwantrao Chavhan Open University and Pune University.

Membership: ISTE, IETE, IEI, CSI, IEEE

Author 3: Mr.Sagar P.Thombare,
Pursuing M.E. POWER ELECTRONIC AND DRIVES, Savitribai Phule Pune University.

25 year's age, 3 Years of Working Experience

ISSN: 2278 – 909X