Review of an energy efficient Smart Street Lighting System

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Abstract –

In a modern society there is a constant increase in electrical use but at the same time the environmental awareness among consumers is rising. Lighting control systems are studied from an energy saving perspective and the relation to reduction of carbon dioxide emission is addressed. In these days many lamps are available which are used for lighting .Today's latest technology LED based smart street lighting system come in picture which reduced energy consumption and make us lighting system more reliable and economic. The preferred lighting source is LED considering its photometric such as efficacy, life span, cost, efficiency and power consumption.

Keywords –

Energy efficient system, light sources, light emitting diodes, Compact Fluorescent lamp, Smart Street lighting.

INTRODUCTION

An electric light is a converter; its prime purpose is the transformation of electrical energy into visible electromagnetic radiation. It is the most common form of artificial lighting and it is essential to modern society, providing interior lighting of buildings and exterior light for day and night time activities. A smart city has six characteristics: smart economy, smart mobility, smart living, smart people, smart environment and smart governance. The energy distribution is very huge and expensive. Public lighting owns 10% from the electrical energy consumer categories. The main scope of street lighting is the extension of human life quality for the dark period of the day. Life quality comprises the crime prevention, human behavior, traffic safety and many more. The energy consumption reduced by using the smart street lighting system. Many researches are made to make our Outdoor lighting system less power consuming. The latest technology of LED based system is treated as energy efficient and reliable lighting technology that reduced the public lighting cost. By replacing the common bulbs with energy saving LED lamps can reduce energy consumption by up to 80 percent. Outdoor lighting consumes about 2% of world wide electric power and it is also responsible for the reduction of Co_2 emissions.

Originality/value – This paper introduce the energy efficient street lighting, various types of lighting system comparison, benefits and design of street lighting and view of smart street lighting system differ from a classical street light.

I. Different types of lamps
   a) Incandescent
   b) Compact Fluorescent lamp
   c) High- intensity discharge
   d) Light-Emitting diode

Incandescent: When solids and liquids are heated, they emit visible radiation at temperatures above 1,000 K; this is known as incandescence. Such heating is the basis of light generation in filament lamps: an electrical current passes through a thin tungsten wire, whose temperature rises to around 2,500 to 3,200 K, depending upon the type of lamp and its application.

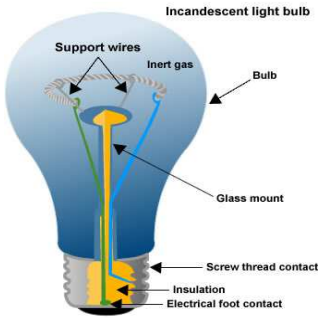

Fig. 1: Incandescent light bulb

It has the lowest efficiency or the highest power consumption among the lights, which the Powers are mostly wasted in the bulb heating. By controlling the intensity of the incandescent bulb, it will greatly improve its power efficiency hence achieve power saving. Filament lamps can thus be effective heating devices and are used in lamps designed for print drying, food preparation and animal rearing.

Compact Fluorescent lamp: The fluorescent tube is not a practical replacement for the incandescent lamp because of its linear shape. The lamps use a tube which is curved or folded to fit into the space of an incandescent bulb, and compact electronic ballast in the base of the lamp. Compared to general-service incandescent lamps giving the same amount of visible light, CFLs use one-fifth to one-third the electric power, and last eight to fifteen times longer. A CFL has a higher purchase price than an incandescent lamp, but can save over five times its purchase price in electricity costs over the lamp's lifetime. Like all fluorescent lamps, CFLs contain mercury, a neurotoxin especially dangerous to children and pregnant women, which Complicates their disposal. In many countries, governments have established recycling schemes for CFLs and glass generally. Most CFLs have built-in electrical ballast and fit into a standard screw or bayonet base. Some make use of separate ballast so that the ballast and tube can be replaced separately. Typical average lifetime ratings for linear fluorescent tubes are 10,000 and 20,000 hours, compared to 750 hours (110 V) and 1000 hours (240 V) for filament lamps.

Fig. 2: Compact Fluorescent lamp

Some types of fluorescent lamp ballast have difficulty starting lamps in very cold conditions, so lights used outdoors in cold climates need to be designed for outdoor use to work reliably.

High- intensity discharge: A HID are a type of electrical gas-discharge lamp which produces light by means of an electric arc between tungsten electrodes housed inside a translucent or transparent fused quartz or fused alumina arc tube. This tube is filled with both gas and metal salts. The gas facilitates the arc's initial strike. Once the arc is started, it heats and evaporates the metal salts forming plasma, which greatly increases the intensity of light produced by the arc and reduces its power consumption. High-intensity discharge lamps are a type of arc lamp. High-intensity discharge lamps make more visible light per unit of electric power consumed than fluorescent and incandescent lamps since a greater proportion of their radiation is visible light in contrast to heat. Various types of chemistry are used in the arc tubes of HID lamps, depending on the desired characteristics of light intensity, correlated color temperature, color rendering index (CRI), energy efficiency, and lifespan.

Different types of HID lamps are

- Mercury-vapor lamps
- Metal-halide (MH) lamps
- Ceramic MH lamps
- Sodium-vapor lamps
- Xenon short-arc lamps

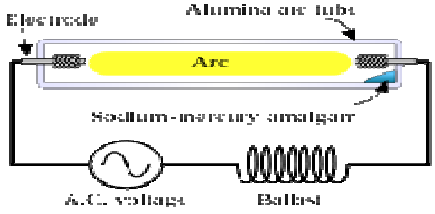

Fig.3: High pressure sodium lamp

The light-producing element of these lamp types is a well-stabilized arc discharge contained within a refractory envelope arc tube with wall loading in excess of 3 W/cm² (19.4 W/in²). Like fluorescent lamps, HID lamps require a ballast to start and maintain their arcs. The method used to initially strike the arc varies: mercury vapor lamps and some metal halide lamps are usually started using a third electrode near one of the main electrodes while other lamp styles are usually started using pulses of high voltage. HID lamps are typically used when high levels of light over large areas are required, and when energy efficiency and/or light intensity are desired. These areas include gymnasiums, large public areas, warehouses, movie theaters, football stadiums, outdoor activity areas, roadways, parking lots, and pathways.

Light-Emitting diode: Solid state LEDs has been popular as indicator lights since the 1970s. In recent years, efficacy and output have risen to the point where LEDs are now being used in niche lighting applications. Indicator LEDs are known for their extremely long life, up to 100,000 hours, but lighting LEDs are operated much less conservatively (due to high LED cost per watt), and consequently have much shorter lives. Due to the relatively high cost per watt, LED lighting is most useful at very low powers; typically for lamp assemblies of fewer than 10 W. LEDs are currently most useful and cost-effective in low power applications, such as nightlights and flashlights. Colored LEDs can also be used for accent lighting, such as for glass objects, and even in fake ice cubes for drinks at parties. They are also being increasingly used as holiday lighting.

Fig. 4: LED Street light

The main characteristics of LED differ from other lamps are following:

- It offer very short switching times as compared to other lamps.

- It can be switched back on right after they have been switched off but other lamps take some time to reach the full light intensity.
- They have capability of lighting in different colors.
- They are unaffected from numerous switching.
- They are dimmable from zero to hundred percent intensity and also back from 100 to 0 percent.

LED efficiencies vary over a very wide range. Some have lower efficiency than filament lamps, and some significantly higher. LED performance in this respect is prone to being misinterpreted, as the inherent directionality of LEDs gives them a much higher light intensity in one direction per given total light output. LED technology is useful for lighting designers because of its low power consumption, low heat generation, instantaneous on/off control, and in the case of single color LEDs, continuity of color throughout the life of the diode and relatively low cost of manufacture. For general domestic lighting, total cost of ownership of LED lighting is still much higher than for other well established lighting types.

Comparing different lighting technologies:

The table below summarizes some key criteria for evaluating different lighting technologies.

Technology	**Efficacy (Lumen/W)**	**Life time (hrs)**
Compact fluorescent	60-70	6,000-10,000
Incandescent	12-18	750-1500
Linear fluorescent	80-100+	20,000
Halogen	16-29	2000-4000
White LED	20-50	45,000

Table no.1: Comparison between different technologies

II. Difference between CFL and LED

Features	**CFL**	**LED**
Rated Avg. life	10,000 hrs	45,000 hrs
Life Span	Long	Very Long
Watts	3 – 120	2.5 – 16
Cost to operate	Low	Low
Price to Product	Medium	High
Lumen per Watt(LPW)	60 LPW	45 LPW
Color temp.(K)	2700 -6500	2700-6500
Environmental impact- contains the Toxic Mercury	Yes	No
$C0_2$ emissions (30 bulb per year)	1051 pounds/yr.	451 pounds/yr.
Kilowatts of electricity used(30 incandescent bulbs per year equivalent)	767 KWH/yr.	329 KWH/yr.
Sensitivity to low temp.	Yes	None
Sensitive to humidity	Yes	No
Turns on instantly	No-takes time to warm up	Yes
Durability	Not very durable- glass can break easily	Very durable
Heat emitted	30 btu's/hr	3.4 btu's/hr
Failure mode	Yes smoke	Not typical
Switching effect	Yes-can reduce life span	No effect

Table no.2: Difference between LED and CFL

Benefits of street lighting:

Modern well designed, installed and maintained street lighting provides many benefits.

1. Reducing street crime.
2. Reducing the fear of street crime.
3. Preventing night time personal injury accidents.
4. It allows the effective use of CCTV systems in cities at night.
5. Assisting the emergency services to identify locations and carry out their duties.
6. Promoting sustainable transport, public transport, cycling and walking.
7. Promoting economic development by support a 24 hrs leisure economy.
8. Facilitating social inclusion by provide the freedom to use our street after dark.
9. Facilitating lifelong learning by encouraging after dark access to educational facilities.
10. Promoting 24-hr use of the existing road infrastructure, night time distribution and travel.

Design of street lighting:

- Energy efficient
- Reliable and safe
- Technically advance
- Cost effective
- Convenient for maintenance

Classical Street light differ from a smart street light:

A Street light, lamppost, street lamp is a raised source of light on the edge of a road or walkway, which is turned ON at a certain time every night. In old street lights, the bulbs which are used they consume more power and at that time there is no controlling technique available so energy wastage was more.

Fig. 5: Classical Street light

The street lights remain switched ON even there is no traffic .The bulbs like incandescent which are much less efficient and it convert less than 5% of the energy they use into visible light and the remaining energy being converted into heat.

But in smart street light technologies such as LED, emit a white light that provides high level of scotopic lumens allowing street lights with lower wattages and lower photopic lumens to replace existing street lights. In these days smart street lights are controlled by various techniques such as wireless sensor network, zigbee based street light control system, microcontroller based control scheme and many more. example in zigbee control system, street light control are composed of three parts, centralized control center, remote concentrator and street light control terminals. Centralized control center are reside in local government office usually. At the centralized control center, operators monitor and control street lights by using operator's terminal. Centralized control center computers communicate with remote concentrator which control lights installed alongside every road.

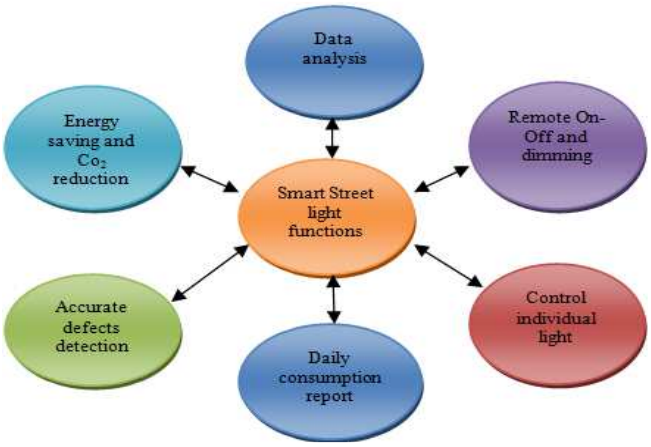

Fig. 6: Intelligent Street light functions

Remote concentrators control lights and gather status information. Third components of street light control system is street light control terminals. To control each light individually, this street light control terminal is needed. It is installed to every street light pole to detect status of light and to control lights. It communicates with remote concentrator to give and receive command and status information for control center. Zigbee is rising communication protocol which used for data transfer with in Centralized control center, remote concentrator and street light control terminals. With the help of these above control techniques, the energy consumption of street lights also reduced by following methods.

- By switching the street lights in a good manner.
- By control the light intensity of bulbs from 0 to 100 percent.
- Switch off the lights at selected locations where there is no traffic after midnight.

CONCULSIONS

The paper has presented an efficient street lighting system with reduced power consumption in comparison to classical lighting systems. This is accomplished by case study of various street lighting lamps. We are developing Street light control system which can save maintenance time and costs and which can improve safety level. The power consumption is decreased using a smart light control device. Using smart control devices increases the street lighting system's autonomy. Using LED luminaries instead of other light sources will further decrease the power consumption with the advantage of increased light output efficiency, longer life and environmental friendly.

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