# Application of Sensors for Streetlight Automation in Industry and Energy Conservation – A Case Study

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**Abstract:-**
*Sustainable development of the country is possible by adapting various energy conservation measures. Energy conservation helps in using energy in effectivemanner. Application of advanced technology and improved operation and maintenance practices contributes towards energy conservation. Smart streetlight framework is an essential piece of the smart city, which represents 10-40% aggregate power utilization in the city. In this paper the energy audit report is presented for streetlights in the industry and also presented various energy conservation measures with the help of sensors and automation. It was observed that Passive Infra-red (PIR) sensor helps a lot in saving energy where movement of people is low.*

**Keywords:-** Energy conservation**,** Light Dependent Resistor (LDR), Passive Infra-red (PIR) sensor, Photocell Sensor, Streetlight.

## 1. INTRODUCTION

Street lighting is provided for people during the evening and night hours for movement of vehicles and persons. Street lighting is switched ON for 10-14 hour in India. In municipal area it is the responsibility of local governing body to provide the proper illumination for commuters. In industry it is the responsibility of industry owner to provide the sufficient light at various working places and on streets for workers and other staff to reduce the rate of accidents in the industry. For industry, providing sufficient illumination is a costly affair due to high electricity tariff for industry. Researchers has published various research papers to suggest reduction in energy bill for lighting by energy conservations or by use of better and efficient fixtures for illumination.

Garcia-Llera et. al in their paper proposed new designs for sending the light in proper direction with desired intensity. Staggered arrangement for street lighting with advantage of Power LED's efficiency, is suggested. Considering real geometry for City of Oviedo in Spain, two experimental lamps design for street lighting were proposed to validate the established methodology [1].Gul Shahzad et. al proposes the new concept of street lighting based on traffic-flow using LED for energy optimization. The low power ZigBee mesh network is used to provide maximum energy efficiency based on adaptive traffic on the road. Smart LED lights with wireless network offers improved reliability, reduced cost, and more user satisfaction [2]. Serge Kalinowsky and John Martello in their paper done analysis for various combinations of F40-Tl2, F96-T12, and compact energy-savings fluorescent lamps by applying voltage less than rated voltage [3]. C. Subramani et. al presented the project based on automated streetlamps with less consumption and provides sustainable output. Sodium vapour lamps replaces with LEDs which detect the vehicle traffic and control the lighting of the lamps [4]Basil Paul and Vedavyasa Kamath in their papers presents the lighting audit results with

economic analysis in pharmaceutical industry. They propose new lighting fixture LED to replace old streetlight with matching lux level and usage of day lighting wherever possible [5] [6].John Peck et. al in their paper presents safe lighting for hazardous area with human physiology knowledge and new advances in lighting [7].EdilsonMineiro S. Jr. et. al presents the work for development of a photovoltaic system for power supply to the illumination places in public during peak demand in the distribution network. Charge controller with MPPT and half bridge circuit is used in the electronic reactor, to assemble the low-cost electronic reactor. Advanced commutation techniques,zero volt switch (ZVS), reduces the losses and increases the circuit efficiency with reduction in electromagnetic interface (EMI) [8].Deepu Vijay M. et. al presented the Solar PV-LED combination for outdoor lighting. Based on solar power available and traffic on street the intensity of light is varied from from 0% to 100% automatically using DC-DC converter [9].Wei Yan and S.Y.R. Hui in their paper presented the test results for lighting based on high-intensity-discharge (HID) lamps. For appropriate power level requirement various techniques such as energy-saving, use of energy efficient devices and dimming characteristics of magnetic-ballast-driven HID lamp is used. Authors in their work used Central dimming unit and vary the voltage from 170 to 220 V [10].
In this paper a case study is presented for the industrial streetlights. Paper presents the applications of various sensors used for automation and their effect on energy conservation and related cost saving.

## 2. ENERGY AUDITING OF STREETLIGHTS

In India, the streetlight consumes energy of 1.5% of total energy consumption. The need of streetlights is during the highest consumption period of 6 pm -10 pm and lowest load period 12 midnight to 6 am. The objective of doing the energy audit of streetlight is to reduce the load on the distribution system during peak period and provide good visibility, comfort, and safety on roads. At many places, these streetlights are designed in improper manner and not maintained properly which results into poor performance of the streetlights [11].
Bureau of Indian Standards (BIS) has established standards for safety of Indian citizens (IS 1944) for lighting levels for streetlight. Few decades back, manual operation of ON/OFF of streetlight was possible due to smaller geographical area of towns and cities. Now, due to expansion of towns and cities with wider roads and increase in speed of vehicles it is expected that during evening and night hours also the light like day light should be available. Bigger geographical area than before expects automatic and hassle-free operation of streetlights. Proper design for street illumination from sunset to sunrise with the help of streetlights, improves visibility and reduces risk of accidents on road. High Intensity Discharge (HID)lamp due to its high luminous efficacy, longer life and compact size are preferred for streetlight installations. HID lamp has higher surface brightness, optics of road lighting luminaires must be specially designed for proper light distribution on the road surface and to prevent the direct glare from the luminaries [12].
BIS has developed code of practice for industrial lighting as IS 6665-1972, which has mentioned that lighting in the industry should be such that the industrial workers able to convert the raw material into finished goods without any physical injury and damage to the material and equipment. To achieve this objective illumination in the work area should have features like sufficient visibility, minimum time for visual perception, proper distribution of brightness etc. Performance of the workers can be enhanced if they have visual comfort in terms of no glare, uniform distribution of light over workspace, proper light for colour luminance [13].

### 2.1:-Methodology of Automatic Street Lighting: -

The automatic streetlights control is possible using the block diagram as shown in Figure 1. The main component of the system is the light dependent resistor (LDR) or photosensor.

Regulated power supply is used to power the microcontroller. LDR senses the ambient light and send a corresponding magnitude signal to microcontroller. The variation in LDR resistance is shown in Figure 2. Based on LDR resistance setting, microcontroller send a signal to transistor, which will then act either in conduction mode or blocking mode. Relay send signal to streetlight based on conduction of transistor to make the streetlight ON/OFF.

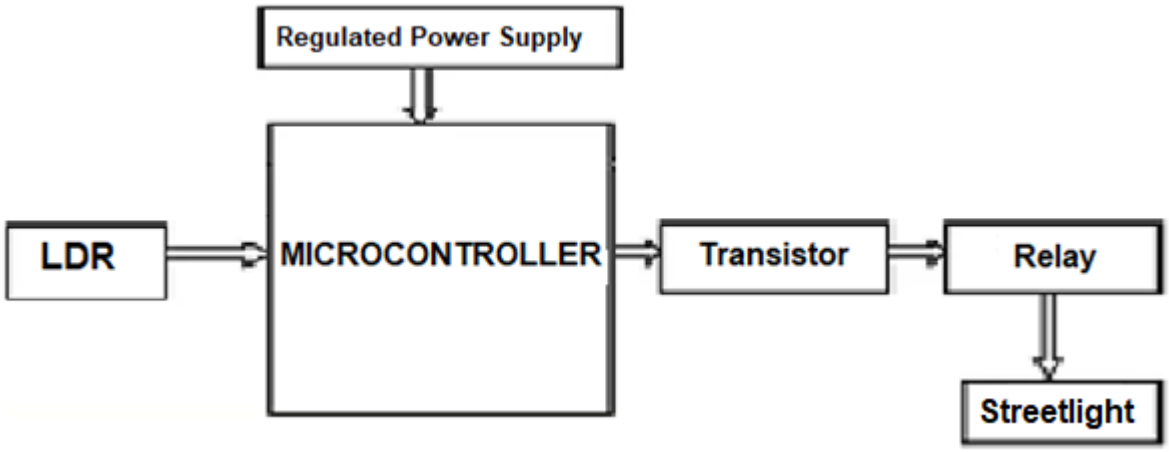


**Figure1. Block diagram for Automated streetlight Control System**

LDR have better reliability, low weight, and wide spectral response for ambient temperature range. PIC16F877A is a 8 bit microcontroller with 40 pins. Relay consist of coil which get energized when it gets supply. When relay active, normally close contact disconnect the circuit and Normally Open (N/O) contact connect the circuit when relay is inactive. Power supply is 415V DC. Photocell Sensor used for automatic switching of streetlights. It's working principle uses ambient light. Turning ON/ OFF light is based on ambient light intensity and lights switch ON/OFF automatically. Ambient temperature and humidity cannot affect this automatic operation. In darkness the light is automatically turned ON & in the daytime it gets turned OFF automatically. No manpower is required for ON/OFF operation.


**Figure 2. Variation in LDR Resistance with light**

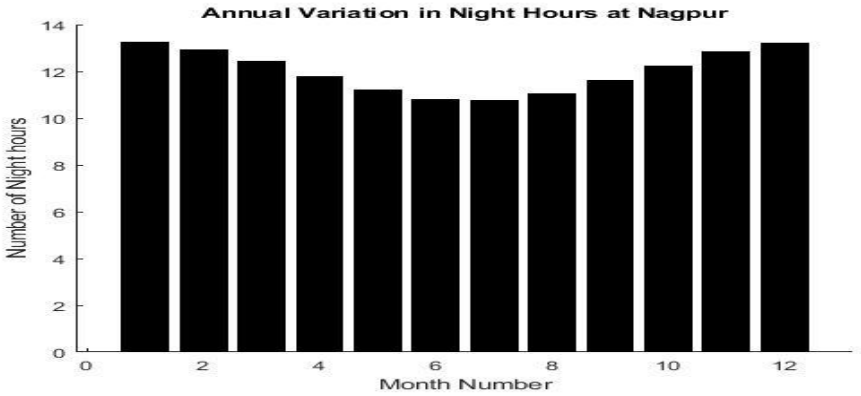


**Figure3. Annual Variation in Night hours in Nagpur**

Passive Infrared Sensor (PIR) has an ability to to identify a person being moving around approximately 5 m to 10 m from sensor. PIR are fundamentally made of Pyro electrical sensor. They are commonly used in automatically activated lighting system. When human body comes in the range of sensor lights will glow for 50 sec and then automatically switched off.

## 3. CASE STUDY IN TAL INDUSTRY

TAL manufacturing Solution Limited (TAL) has set up its unit in Nagpur in Maharashtra state of India located at 21.15°N 79.09° E. TAL supply advance composite floor Beams to Boeing for its 787-9 Dreamliner-aircraft. TAL has designed and build machine tools, material handling system, test rigs, painting shops, assemblies including tooling & Process lines, robotics welding cells, fixtures & tooling, hydraulic tipping kits & axial piston pumps for a wide range of industrial applications. Company has two major shops Boeing shop and Generic shop. The distribution of streetlights in the company are as shown in table 1.

Table 1:- Lighting Load of the Industry

| Sr No | Parameter | Total lighting load | Sr No | Parameter | Total lighting load |
|---|---|---|---|---|---|
| 1 | Generic Entrance Gate | 650 W | 7 | Substation 1 | 918 W |
| 2 | Chiller Plant | 250 W | 8 | Hot Water Generator Section | 1056 W |
| 3 | Canteen | 750 W | 9 | Boeing Shop | 4875 W |
| 4 | Furnace | 250 W | 10 | Generic Shop | 1875 W |
| 5 | Substation 3 | 2200 W | 11 | Car Parking | 112 W |
| 6 | Substation 2 | 643 W | 12 | Cooling Tower | 250 W |
| | | | | Total Street Lighting Load | 4743 W |

Figure 3, shows the variation in night hours (sunset to sunrise time) at Nagpur over the year. It is observed that minimum night hours areduring summer season and lowest value is 10.73 hours and higher night hours in winter season and highest value is 13.26 hours.

Timer switches are installed in diesel generator house and substation. Table 2, shows the energy consumption calculation in DG house & substation. Total consumption in a day is 62.7 kWh.

Table 2: Calculation of timer switch in DG house

| Parameter | Sr No | Light type | Number | Rating (watt) | Total Rating | Time(hour) | Energy Consumption(Kwh) |
|---|---|---|---|---|---|---|---|
| DG House | 1 | Bay light | 10 | 400 | 4000 | 12 | 48 Kwh |
| | 2 | Tube light | 10 | 28 | 280 | 12 | 3.3 Kwh |
| Substation | 1 | Bay light | 3 | 250 | 750 | 12 | 9 Kwh |
| | 2 | Tubelight | 7 | 28 | 196 | 12 | 2.4 Kwh |

Table 3 shows the saving of power in rupees for three months after connection of timer switch in the DG house and substation section. The Passive infrared Sensor is installed in the passage of Controlled Contamination Area. The area is like only single incoming door and single outcoming door. When timer switch was not installed in industry lights was glowing for 15 hours. This leads to energy wastage. Because it was done with manual control. So the timer switch is installed for the purpose of saving energy.

Table 3: Saving in timer switch

| Months | Saving in Rs |
|---|---|
| August | 2170 |
| September | 2100 |
| October | 2170 |

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Table 4: Calculation of Passive infrared sensor

| Type of light bulb | No of bulb | Rating (watt) | Total Rating (W) | Time(hour) | Energy Consumption with PIR(KWH) | Energy Consumption without PIR |
|---|---|---|---|---|---|---|
| **LED Bulb** | 9 | 36 | 324 | 50 sec x 30 =1500 sec =25 min = 0.4166 hour | 0.134978 | 4.86 |
| **Tubelight** | 3 | 28 | 84 | | 0.0349944 | 1.26 |
| **Total Energy Consumption per day in Kwh** | | | | | **0.169972** | **6.12** |

Passive infrared sensor is installed in the passage of Controlled Contamination Area. The area is like only single incoming door and single outcoming door and very less moments were observed in the area. A person comes from door 30 times in a day. The calculation of passive infrared sensor is shown in Table 4; From passage 9 LED lights and 3 tubelights are ON by sensor. The total energy consumption is 0.1699 unit. Table 4 shows the calculations for PIR sensors. Comparing the values, it can be concluded that the power requirement has drop down to 2.78% of the earlier requirement. The annual saving due to PIR is Rs. 9300/- and payback period of PIR is around 4.33 months.

The lighting investment consider here for two major shops:Boeing and generic shop. The Investment is Rs. 42 lacs. Table 5 shows wattage and quantity of mercury and LED lights and the total annual saving of shops.

Table5: Quantity & wattage of lights

| Name of Shop | Existing(Mercury) | | LED | | Saving in Watt | Per day KWH Saving | Per annum KWH Saving | Cost Saving in Rs lacs |
|---|---|---|---|---|---|---|---|---|
| | Watt | Quantity | Watt | Quantity | | | | |
| Boeing Shop | 250 | 320 | 160 | 320 | 90 | 345.6 | 1,26,144 | 5.64 |
| Generic Shop | 400 | 300 | 160 | 320 | 240 | 864 | 3,15,360 | 14.1 |

The lights which are controlled by photocell sensor will glow according to sunrise and sunset timing of every day. There are total 13 sensors installed in the different sections of industry and total 115 streetlights & 23 Tube lights operated by Photocell sensor. The saving in photocell sensor from August to July month are calculated on the basis of sunrise and sunset timing of every day. The payback period of investment for LED with photosensor is 2.14 years.

## 4. CONCLUSION

This paper presents the case study of industry streetlights based on energy saving using different types of sensors like photocell sensor, motion sensor and timer switch. These sensors are efficiently installed which are economical. From the analysis of case study done in the paper, it can be concluded that motion sensors are very effective in energy conservation, where people movement is very low. Use of automatic timer saves the human efforts of daily ON/OFF streetlights. Photocell sensor further reduces the consumption based on sunrise and sunset timings. Use of LED bulb has lot of potential in conserving energy keeping the same lux level in lighting in the commercial, household and mainly industrial areas. One-time investment is required in photocell sensors and PIRsensors. Payback period for both sensors is less than three years. After payback period is over both the sensors save lot of money. Peak load reduction during evening peak is possible by energy conservation in streetlights. Further these saving of electrical energy may result into greener environment due to less pollution of the atmosphere.

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