Design and development of High MAST Solar Street Light

Prof.P.B.Pimpalkar, Prof.R.K.Pohane, Prof.S.P.Daf, Prof.V.P.Pode

Abstract

In recent years there have been a number of failures of traffic light poles and other signage, indicating that the existing design rules and fabrication methods are not adequate in addressing fatigue and fracture issues associated with the connection of MAST arms to the vertical poles and the connection of the poles to the foundations of traffic light pole. The strategic overall objective of the proposed research is to develop an efficient and cost effective solar energy system for electrical energy production that uses direct solar radiation as the primary energy source. In order to achieve these objectives we are presenting an innovative concept of Photovoltaic (PV) solar system which is based on a combination of the latest developments in photovoltaic technology, a product that is able to produce electricity.

Keywords: *Solar Panel, LED Light, MAST, Highway Lighting, Cradle*

INTRODUCTION

The sun is a reliable, non-polluting and inexhaustible source of energy. Since the beginning of life on earth, the energy that was received by all living forms was radiated from the sun. It is the time now when the mankind is on a standpoint to again depend and reply upon the sun as the main source of energy. With rapid rise in prices, concern over pollution, deletion of resources and environment degradation the awareness for limited resources around the world has increased dramatically. Use of fossil fuels which causes greenhouses emission, inefficient use of energy and release of harmful pollutants to the atmosphere causing threat such as acid rain must be addressed seriously in new buildings. Government with vision have come to realize that generation of electrical power through non-renewable sources of energy in not enough. The power of the future must be environment friendly as well. Photovoltaic is a way by which energy from the sun can be directly used of power generation. This method for electricity generation causes no environmental pollution, has no rotating of moving parts, and causes no material depletion. Photovoltaic are also multifunctional. It can generate and operate illuminations, pump water, operate any house hold equipment and appliances, can operate any electric gadgets and communication equipment. The photovoltaic finds its wide application in village electrification in the developing countries and electricity production for the building, commercial areas and industrial sector in cities. High-mast lighting is a tall pole with lighting attached to the top pointing towards the ground, usually but not always used to light a highway or recreational field. The pole that the lighting is mounted on is generally at least 7.7 meters (25 ft) tall (under this height it is referred to as conventional lighting system), while the lighting consists of a luminary ring surrounding the pole with one or several independent lighting fixtures mounted around it. Some units have the lighting surrounded by a circular shield to prevent or reduce light pollution or light trespass from affecting neighborhoods adjacent to the highway. Providing street lighting is one the most important and expensive responsibilities of a city: Lighting can account for 10–38% of the total energy bill in typical cities worldwide (NYCGP 2009). Street lighting is a particularly critical concern for public authorities in developing countries because of its strategic importance for economic and social stability. Inefficient lighting wastes significant financial resources each year, and poor lighting creates unsafe conditions. Energy efficient technologies and design can cut street lighting costs dramatically (often by 25-60%); these savings can eliminate or reduce the need for new generating plants and provide the capital for alternative energy solutions for populations in remote areas. These cost savings can also enable municipalities to expand street lighting to additional areas, increasing access to lighting in low-income and other underserved areas.

In recent years there have been a number of failures of traffic light poles and other signage, indicating that the existing design rules and fabrication methods are not adequate in addressing fatigue and fracture issues associated with the connection of mast arms to the vertical poles and the connection of the poles to the foundations of traffic light poles. A literature review is an evaluative report of information found in the literature related to the selected area of study. The review should describe, summarize, evaluate and clarify this literature.

It should give a theoretical base for the research and determine the nature of the research. Works which are irrelevant should be discarded and those which are peripheral should be looked at critically.

In this, solar radiation strikes on the solar panel, the maximum amount generated by PV module is then stored in the battery and it gives this energy to the street light when needed.

Today, street lighting commonly uses high-intensity discharge lamps, often (HPS) high pressure sodium lamps. Such lamps provide the greatest amount of photopic illumination for the least consumption of electricity. However, when scotopic/photopic light calculations are used, it can be seen how inappropriate HPS lamps are for night lighting. White light sources have been shown to double driver peripheral vision and improve driver brake reaction time by at least 25%; to enable pedestrians to better detect pavement trip hazards and to facilitate visual appraisals of other people associated with interpersonal judgments. Studies comparing metal halide and high-pressure sodium lamps have shown that at equal photopic light levels, a street scene illuminated at night by a metal halide lighting system was reliably seen as brighter as and safer than the same scene illuminated by a high pressure sodium system.

New street lighting technologies, such as LED or induction lights, emit a white light that provides high levels of scotopic lumens allowing street lights with lower wattages and lower photopic lumens to replace existing street lights. However, there have been no formal specifications written around Photopic/Scotopic adjustments for different types of light sources, causing many municipalities and street departments to hold back on implementation of these new technologies until the standards are updated.

Photovoltaic-powered LED luminaries are gaining wider acceptance. Preliminary field tests show that some LED luminaries are energy-efficient and perform well in testing environments.

In 2007, the Civil Twilight Collective created a variant of the conventional LED streetlight, namely the Lunar-resonant streetlight. These lights increase or decrease the intensity of the streetlight according to the lunar light. This streetlight design thus reduces energy consumption as well as light pollution.

DESIGN CALCULATION

Design calculations:

4.0 Selection of solar panel

Selection of solar panel: Solar panel which is selected by the following formula Capacity of solar panel = power of equipment x number of running hours

Number of charging hours

$$= \frac{(16 * 4) * 9}{6}$$

$$= 96 \text{ Wp}$$

So we selected this much capacity of solar panel for our project.

If there is a change in no. of running hours then the calculations becomes as follows. If the number of running hours become 10 then

$$= \frac{(16 * 4) * 10}{6}$$

$$= 106 \text{ Wp}$$

If the number of running hours become 11 then

$$= \frac{(16 * 4) * 11}{6}$$

$$= 117 \text{ Wp}$$

If the number of running hours become 12 then

$$= \frac{(16 * 4) * 12}{6}$$

$$= 128 \text{ Wp}$$

If there is a change in the number of Charging hours then the calculations becomes as follows. If the number of Charging hours become 7 then

$$= \frac{(16 * 4) * 9}{7}$$

$$= 82 \text{ Wp}$$

If the number of Charging hours become 8 then

$$= \frac{(16 * 4) * 9}{8}$$

$$= 72 \text{ Wp}$$

If the number of Charging hours become 9 then

$$= \frac{(16 * 4) * 9}{9}$$

$$= 64 \text{ Wp}$$

4.2 Selection of Battery

Selection of battery: The battery which is selected by the following formula

$$\text{Battery capacity} = \frac{\text{load} * \text{backup}}{\text{Volt}}$$

$$= \frac{100 * 10}{12}$$

$$= 83 \text{ Ahr}$$

So we selected this much capacity of battery for our project

If there is a change in Backup hours of Battery then the calculations becomes as follows. If the number of Backup hours become 11 then

$$= \frac{100 * 11}{12}$$

$$= 91 \text{ Ahr}$$

If the number of Backup hours become 12 then

$$= \frac{100 * 12}{12}$$

$$= 100 \text{ Ahr}$$

If the number of Backup hours become 13 then

$$= \frac{100 * 13}{12}$$

$$= 108 \text{ Ahr}$$

4.3 SOLAR PANEL SPECIFICATIONS:-

250Watt Mono-crystalline Solar Panel Specification:-

Dimension (mm)	1581(L) x 809(W) x 40 (D)
Net weight	15.6 kg
Module efficiency	15.6 %
Rated Maximum Power (Pmax)	200 W
Current at Pmax : (Imp)	5.32 A
Voltage at Pmax: (Vmp)	37.6 V
Open-Circuit Voltage: (Voc)	46.0 V
Short-Circuit Current: (Isc)	5.6 A
Nominal Operating Cell Temp. (Tnoct)	46° C
Maximum system Voltage	1000 V DC
Maximum series fuse Rating	10A

Component List

COMPONENT	**QUANTITY**
SPV (100 Wp)	1
BATTERY (90 Ahr)	1
CABLES	As per requirement
LOAD (light's)	4 of 75 Wp
POLE	1
CRADLE	1
CHARGE CONTROLLER	1
INVERTORS	1

Area required

Area of single solar panel: for 100 Wp = 1600 x 1000 mm

So total maximum area of panels will be = 1600 x 1000 mm

We can set up a SPV modules on the top of the pole

Dimensions & Specifications

Description	**2.5 Watt**	**5 Watt**	**10 Watt**	**20 Watt**	**30 Watt**	**45 Watt**
Brand	PowerUp	Suntech	Suntech	Suntech	Suntech	Suntech
Panel Dimension in mm	238x156 x16	306x216 x18	368x310 x18	656x306 x18	680x426 x18	665x537 x30
Open Circuit Voltage (Voc)	21.0V	21.4V	21.6V	21.2V	21.6V	21.9V
Optimum Operating Voltage (Vmp)	17.0V	16.8V	17.2V	16.8V	17.2V	17.6V
Short Circuit Current (Isc)	0.17A	0.32A	0.66A	1.32A	1.93A	2.7A
Optimum Operating Current (Imp)	0.15A	0.3A	0.58A	1.19A	1.74A	2.56A

Maximum Power at STC (Pm)	2.5Wp	5Wp	10Wp	20Wp	30Wp	45Wp	

4.3.1 Solar panel

Name	**Specifications**
Technology	Photovoltaic Type Flexible solar Panel
Dimensions	1600x1000x2 mm
Watts Peak (Wp)	100 Wp
Weight	5 kg
Cost	20000 Rs

4.3.2 Rechargeable Battery

Name	**Specifications**
Voltage	12V
Capacity	100 Ahr
Cost	10000 Rs

4.3.3 Lighting Fixture

Name	**Specifications**
Capacity of LED Light	75 W
Quantity	4
Cost	26000 Rs

4.3.4 Charge Controller

Name	**Specifications**
Capacity	20 A
Cost	1000 Rs

4.3.5 Pole

Name	**Specifications**
Height of mast	15 mtrs
Material	G.I Pole
Base dia. and top diameter of Pole	Top- 150mm, Bottom- 360 mm
Diameter of base plate	520 mm
Thickness of base plate	25mm
Cost	25000 Rs

4.3.6 Invertors :-

Name	Specification
Modified sine wave	12 V DC to 220 AC
Capacity	600 Watt
Cost	4000 Rs.

FABRICATION

A proto type Model of High mast solar street light is constructed from the various component in the workshop it consist of following parts which were used to manufacture the model.

A **pole** of diameter 60 mm with the height of 900 mm is used to hold the construction of the system and provide the height of the system. It consists of the cradle and all the part on the cradle like led and solar panel.

Winch mechanism is used to lift the whole cradle from the base to height of the system. In this system a rope of 5mm thickness is used to hold the whole cradle and other equipment hold on the system. Winch mechanism operates both manually or motor operated, but in our model we are running the winch mechanism by 12 volt dc motor present in the base of the model. It wound the rope as well as wire of the system. By using this motor this whole cradle goes up and down in very low time.

Cradle of M.S bar and it is rounded in the circular shape by pulley system. And two ends are joint by welding it consist of various parts like LED light wire and rope. Basic purpose of this cradle is to hold the light system. It operates through the winch mechanism which operates either manually or by motor.

Solar plate used in this system is of silicon material of size and it is the main part of the project it acts as a solar radiation absorber it is fitted on the top of the pole so as to absorb the maximum amount of the solar radiation and it is inclined with $45^{0.}$ It is connected from the top of the plate to the battery fitted in the base whenever we feel the battery is fully charged we can start the system to illuminate the entire area.

LED light Start without delay, Electricity is to reach normal brightness, Pass on electricity immediately reach normal brightness, no need waiting, Eliminates the traditional street lamp for a long period of time the boot process.

LED Light shade is a transparent shade and made of polycarbonate plastic injection molding material, high strength, good light; using LED as the light source, and LED is light emitting diodes, has the characteristics of high efficiency and long life. At present, the lamp is shaping up as mainstream lighting products of new generation.

LED light of 2.5 watt is fitted on the circumference of the cradle facing toward the ground to illuminate the area .It has six no of the light to illuminate entire area of the square. This led light run on the current supply from ht 12volt battery fitted in the base.

Motor is fitted on the base along with the winch mechanism .Basically this motor is only used for the winch mechanism to provide the forward and reverse motion of the winch system at the time of installation and maintenance purpose.

Base plate is made from the M.S angle and square in shape. This base plate is boxtype; hence it can be accommodate the whole winch mechanism, motor and wiring of the system. It provides the support to the entire construction.

Wire is connected from the solar plate to the battery and entire led light system.

5.2 Cost Estimation

Costing for Electricity (traditional system):

One light of 250 w * 10 hr back up = 2500 w

So it Consume = 2500 w

Unit = 2500/1000

= 2.5 unit

And Electricity is 8 Rs/ unit = 2.5*8

= 20 Rs /light Light So for four Light= 20 * 4

= 80 RS/ day

Costing for Solar:

Led lights	75 W x 4 Pcs 6500 Rs x4 26000 Rs
Battery (90 Ahr)	10000 Rs
Solar panel 100 Wp	20000 Rs
Charge controller	1000 Rs
Invertors	4000 Rs .
Pole	25000 Rs
Cradle	3000 Rs
Wire	1000 Rs
Labour	1500 Rs
Transportation	2000 Rs
Total	**93,500 Rs**

Total	93,500 Rs / (5 Yrs x 365 days)
	50Rs / day

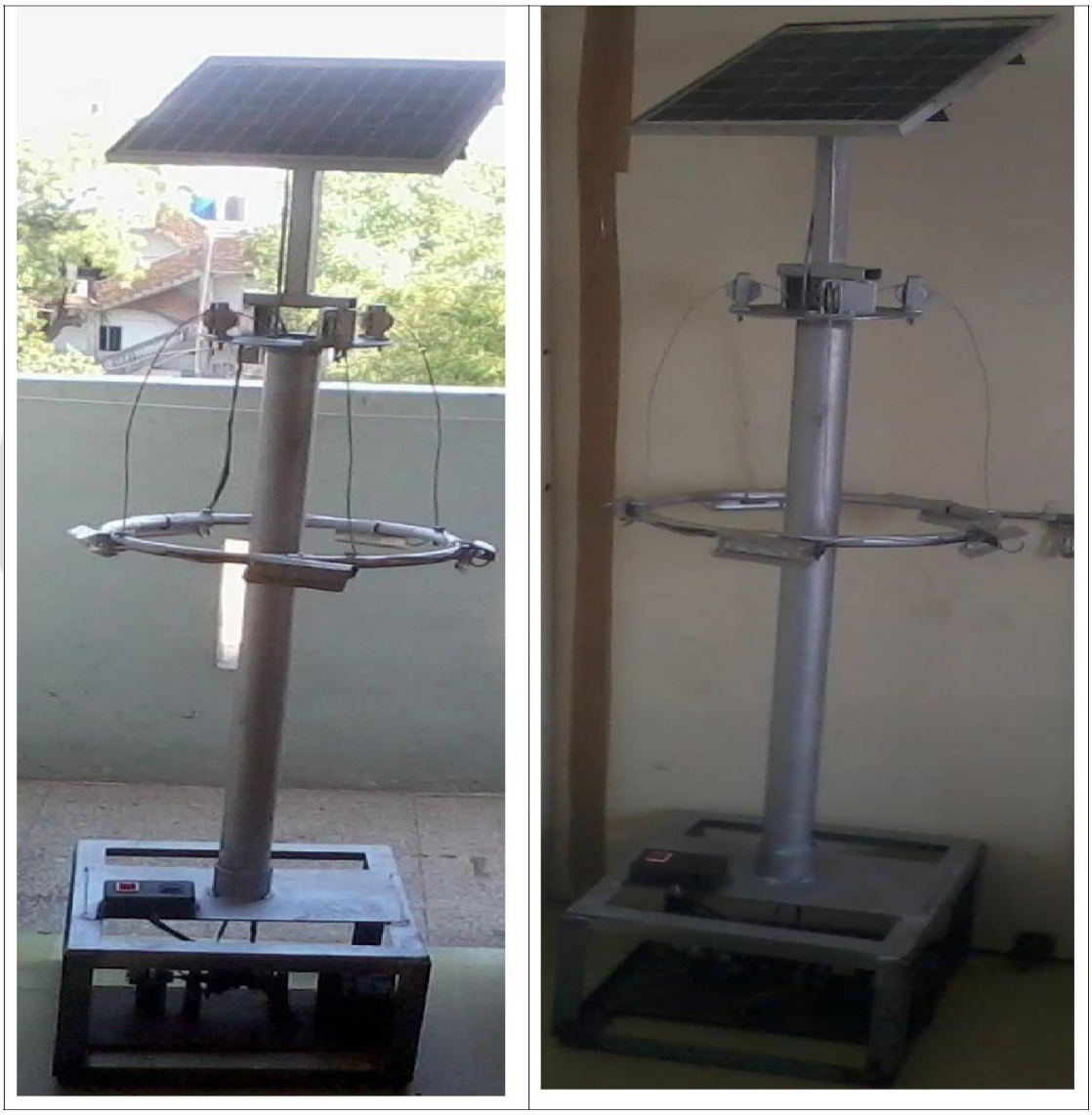
5.3 Savings

Electric consumption / day	80 RS
On Solar consumption /day	50 RS

Saving	30 Rs/day

Actual Cost of High mast solar operated street light Prototype

Solar Panel	2000 /-
DC Motor	500/-
Battery	1000/-
Fabrication	6000/-
Wire fitting charges	500/-
Total	10000/-



CONCLUSION AND DISCUSSION

CONCLUSION

Solar energy is abundant form of renewable energy resources available in the world it can be used where power supply is not available and it is ecofriendly and does not cost green house effect Installation cost solar operated high mast street light is more while the running cost of solar operated high mast street light is less than traditional type lighting system.

The high mast pole have good strength to withstand wind force or load acting on the pole it is made aerodynamic in shape to cut the force of flowing air.

DISCUSSION

We are discussing about a lot of parameter regarding our project from that we gives some important discussion which as follows.

We are discussing about the:

- Size of Solar panel
- Capacity of Solar panel
- Weight of Solar panel
- Capacity of Battery
- Voltage of Battery
- About Installation
- Capacity of Charge Controller and
- About the Costing

Advantages:

1. Solar energy is very cost effective and beneficial for home use. You can easily reduce your bill by using solar energy at your home.
2. It makes you environment very neat and clean that's why solar energy is said to be environment friendly.
3. The use of solar energy bulb is very easy
4. It makes you environment very neat and clean that's why solar energy is said to be environment friendly.
5. It is constrstrion &working easily.
6. Solar street lights are independent of the utility grid. Hence, the operation costs are minimized.
7. Solar street lights require much less maintenance compared to conventional street lights.
8. Since external wires are eliminated, risk of accidents is minimized.

5. This is a non-polluting source of electricity.

6. Separate parts of solar system can be easily carried to the remote areas

7. They require very little to no maintenance as they have no moving parts

12.It is very light in weight.

13.More efficient

14.They are especially useful in area where power grid is difficult or overly expensive to access.

COST SAVING:-

After the recovery of initial investment, the Sun's energy is practically FREE.

The payback period for the investment can be short depending on electricity usages of household. The

government provides financial incentives so as to reduce the incurred.

Independent / Semi-Independent

Solar Energy can be utilized to balance out consumption of energy supplied by utility. It does not only reduce the electricity bill, but will also supply our business / home with electricity whenever there is a power outage.

These systems can operate completely independent, without a connection to a gas or power grid at all. Therefore they can be installed in remote locations, like holiday log cabins, thus these are more practical as well as cost effective as compared to the supply of utility electricity to a remote and new site. Solar Energy enhances local job opportunities and wealth creation, thus contributing to local economics.

Low / No Maintenance

Solar Energy system once installed will last for decades and are almost maintenance free. .Once installed, there are recurring costs.

They do not consist of moving parts, creates no noise, do not release any offensive smells and do not require addition of any fuel.. Addition of solar panels is easy in case your family's needs grow in future.

The dependence on non-renewable sources of energy could be reduced and lesser threat on environment will be posed if we find channels of efficient utilization of solar energy.

RESULT AND FUTURE SCOPE

7.1 RESULT

So we have concluded by using High Mast Solar Street Light.
Large amount of capital is saved on operation cost
More light is being provided
Independently as it produce power from itself operating
Producing clean source of energy saving fossil fuel and
Which is not harmful to the environment

7.2 FUTURE SCOPE

Modification is nothing but the change we make in order to improve the systems, quality, its working, and capacity, maintainability etc. by using advanced knowledge, broad ideas & contribution of experts.

This project could be further extended through the installation of wind and photo voltaic solar panels on High Mast Poles, so that it will help in the reduction of energy usage and CO_2 emissions. This could be achieved by installing the panels as a separate section on the top of the high mast poles or installing them on the hexagonal sides of the pole so that it could absorb the light throughout the day in any direction.

Sensor may be used for the rotating the solar panel in sun's light direction like sunflower, so that the panel may absorb much high intensity as possible.