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# Making Solar PV Street Light – A New Convention

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**ABSTRACT:** Today's society is completely based on fossil fuels directly or indirectly for every aspect of its existence. The transformation from fossil fuels to green energy is essential for coming decade to mitigate sudden climate change and most importantly to ensure long term sustainability. Though this shifting works well in theory, but the reality is that shifting from fossil fuels is not so easy as it is considered to be most available convenient source of energy. Sustainable solution with modern creative ideas embedded with traditional practices, can reduce the dependency on fossil fuels on everything from energy to infrastructure. Today Light emitting diode (LED) lamps have replaced High intensity discharge (HID) lamps that were used at urban street light. Solar Street lights work on the principle of photovoltaic cell or solar cell. This paper presents an overview of the design and implementation of the solar PV street lights as a new convention in outdoor lighting technology. Solar PV Street lights eliminate the need of grid electricity, making it cost effective and environment friendly in urban and rural areas. The system's components include solar panel, batteries, light sources, charge controllers and a pole structure. In short, this paper is based on the idea of maintaining the maximum utilization and minimum loss of available energy and also making an approach to increase the longevity of the system's components with some common techniques and make a shift from conventional to non-conventional source of energy and thus a new convention is proposed.

**KEYWORDS:** Green energy, fossil fuels, solar PV, charge controllers, LED, sustainable solution, HID.

## I. INTRODUCTION

The demand of energy has increased in the world now. So, to fulfil the demands of energy more and more fossil fuels are used, as a result fossil fuels will extinguish in future if they are used at such a rate. To replace the loss of fossil fuels we can use renewable energy as they are freely available and adequate. Green energy refers to any energy that is generated from renewable sources such as sunlight, water or wind. Today, energy plays a key role in the development and progress of societies. The development of novel solar power technologies is considered to be one of many key solutions toward fulfilling a worldwide increasing demand for energy. In an era where sustainability is essential and technological advancements are shaping our world, the adaptation of Solar PV Street lights stands as a path of progress and innovation. From the word itself it is evident that street lights are generally a light source that is often mounted on any lighting structures, walls or commonly integrated with a pole. Solar PV Street lights or PV powered luminaire system are the new convention of this decade. Solar technology is currently the third most widely used renewable energy source after hydropower and wind power.

Solar PV works on the principle that when sunlight hits the solar panel which consists of solar cells converts solar energy into electricity. Photovoltaic means electricity from light: photo is light; voltaic is electricity. The cell consists of each a P and N type material and a PN junction bandwidth, the layer that is present is responsible for trapping the sunlight.

Beyond environmental and economic benefits, the strategic planning of solar PV Street light enhances community empowerment and social inclusion. By illuminating public spaces, these lights enhance security and safety particularly in the areas where lighting infrastructure is lacking. The widespread adaptation of solar PV Street light will bring an energy revolution towards sustainable and brighter future. However, there will be challenges ranging from regulatory frameworks, public awareness to technological limitations, which has to be solved through efforts by urban planners, manufacturers and mainly policymakers so that the implementation can be done. By implementing solar PV Street light, we are not illuminating every street, but also creating a path towards brighter, cleaner and greener future for generations to come. It is not just an approach for technological upgrade; it also symbolizes a commitment to make unconventional sources of energy to a new convention.

## II. LITERATURE SURVEY

Gurpreet Singh et al. [1] conducted a project on solar street light. The demand of energy has increased in the world now. So, to fulfil the demands of energy more and more fossil fuels are used, as a result fossil fuels will extinguish in future if they are used at such a rate. To replace the loss of fossil fuels we can use renewable energy as they are freely available and adequate. Today, LED lamps have replaced the HID lamps that were used in urban street lights.

A review of dust accumulation and cleaning methods for solar photovoltaic systems was carried out by Hussein A. Kazem and his team [2]. Large-scale photovoltaic (PV) power plants that use solar energy to create electricity have become popular as a new option that many countries have accepted. The placement of the PV power plants, including factors like orientation, tilt angle, latitude, longitude, and irradiation, determines the best way to install them. Nonetheless, a variety of environmental factors influence photovoltaic panels, which in turn affect power productivity, conversion efficiency, and energy costs. One of the key factors influencing the productivity, profitability, and performance of PV panels is dust. On the other hand, the features of the dust (kind, size, form, weather, etc.) are site-specific. Numerous researchers looked at dust mitigation and cleaning techniques for PV panels. This publication provided context for the subsequent studies on the effects of dust on photovoltaic systems and appropriate cleaning techniques.

Creating new solar power technologies is thought to be one of the most important ways to meet the growing need for energy in the globe. Even so, there are a number of technical obstacles standing in the way of the solar technology industry's rapid growth. These include low solar cell efficiencies and underperforming balance-of-systems (BOS), as well as institutional and economic barriers like inadequate infrastructure and a lack of skilled labour. This article covers the benefits and drawbacks of solar energy systems. In addition, certain technical issues pertaining to renewable energy research are emphasized, as well as the advantageous relationships between regulatory policy frameworks and their potential in the future [3].

Investigation has done by Samir Ahmed et al. [4] on enhancement of the performance of photovoltaic solar panels by a self-cleaning and hydrophobic Nano coating. Dust collection has an adverse effect on photovoltaic (PV) solar panels. The possibility of hot spots developing is increased by the variation in dust density across locations. Thus, to lessen the amount of dust that formed on the surface of the PV panels, a prepared polydimethylsiloxane/ silica (PDMS/SiO<sub>2</sub>) Nano coating was applied. However, climate and geographic conditions have a big impact on how effective these coatings are. In order to conduct comparable experimental testing concurrently, three identical PV modules were installed. The prepared PDMS/SiO<sub>2</sub> Nano coating is applied to the first module, commercial Nano coating is applied to the second, and the third module is left uncoated to act as a reference. The produced Nano coating exhibited self-cleaning properties and was hydrophobic.

Unlike traditional energy sources, which are concentrated in a small number of countries, renewable energy resources are found throughout large geographic areas [5]. Biomass energy sources, which include wood and wood waste, municipal solid waste, landfill gas and biogas, ethanol, biodiesel, hydropower, geothermal, wind and solar energy, are the main categories. Buildings can be oriented towards the sun, materials with good thermal mass or light-dispersing qualities can be chosen, and naturally air-circulating rooms can be designed using passive solar approaches.

By 2050, solar energy is predicted to overtake all other energy sources as the world's primary source of electricity. Solar photovoltaic and concentrated solar power will account for 16% and 11% of global electricity consumption, respectively. The circuit is delivered by the energy's combination of electric current and electric potential

## III. METHODOLOGY

Fig. 1 shows the making or manufacturing process of a solar panel which begins with the production of silicon ingots typically high purity silicon. Most commercially available PV modules rely on crystalline silicon as the absorber material [6]. This involves melting the silicon and then cooling it to form a solid ingot. These ingots are then sliced into thin wafers and are polished to remove imperfections and treated with dopants to create semiconductor layers. Metal contacts are added to collect the generated electricity, and several solar cells are connected to create a solar module. Encapsulation layers, usually made up of Ethylene – vinyl acetate (EVA) are applied to protect the cells from moisture and mechanical damage while allowing the sunlight to pass through followed by the application of a black sheet for further protection and also to increase the durability and then mounted on a frame typically made up of

Aluminium to provide structural support for installation purpose and after that each and every solar panel undergoes various testing's to ensure that it fulfils the quality standards and performance specifications. Once all panels pass the testing, they are packaged and prepared for shipment to customers or installation sites. Continuous research and development in technology and manufacturing techniques are applied that aims to improve the efficiency and reduce the cost of solar panel [7].

Fig. 2 shows that a Solar Photovoltaic (PV) cell works on the principle of photovoltaic effect, where sunlight is directly converted into electricity. The solar cell consists of semiconductor material, usually silicon which absorbs photons (particle from light) from sunlight [8]. When photons strike the semiconductor material, they can transfer their energy to electrons in the material, allowing them to break free from their atoms, creating electron-hole pairs. Due to the internal structure of the cell, these charge carriers are separated, with electrons moving towards the n-type layer and holes towards the p-type layer, which creates an electric field across the p-n junction. This electric field drives the flow of charge carriers generating electric current, after that the metal contacts which are present on the top and bottom of the solar cell collects that generated electricity by the movement of holes and electrons accordingly. The direct current (DC) electricity which is produced by the solar cell can be used to power electrical devices, stored in batteries for later use, or can be converted in alternating current (AC) by using an inverter for various applications including powering electrical devices etc. [8].



Fig. 1 Manufacturing of a solar panel

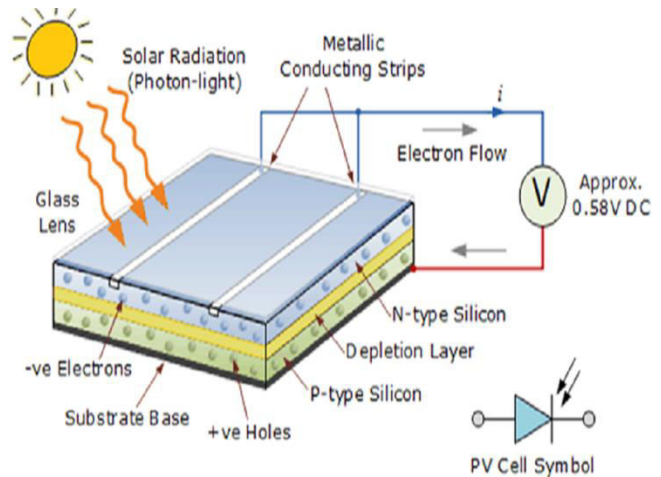


Fig. 2 Working principle of a solar cell

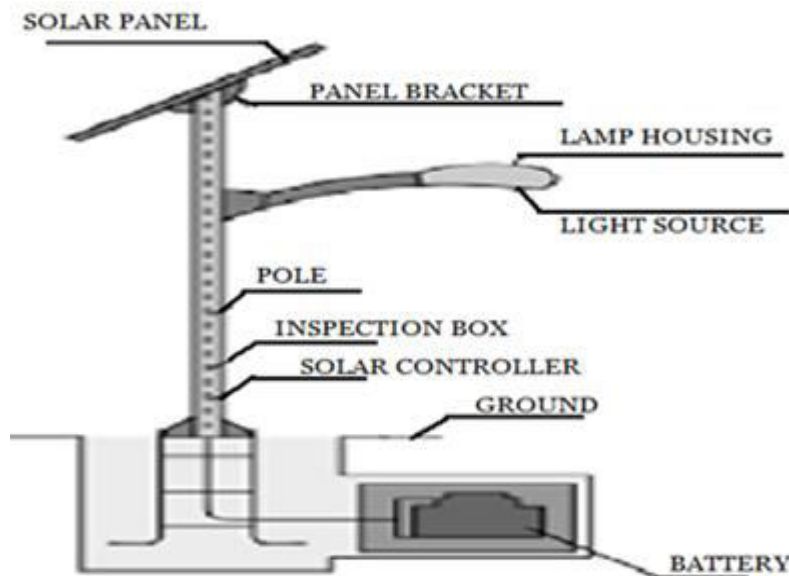


Fig. 3 Solar PV Street light

#### IV. RESULTS AND DISCUSSIONS

Solar PV Street lights (Fig. 3) harness sunlight through photovoltaic panels, converting it into electricity during the day [8]. This energy is stored in rechargeable batteries for night time use. As daylight fades, a light sensor triggers the activation of LED fixtures, which illuminate the street using the stored energy. The system operates autonomously, drawing power exclusively from solar energy, without the need for grid connection or fossil fuels. This sustainable lighting solution provides illumination for roads, pathways, and public spaces while reducing carbon emissions and reliance on traditional energy sources. Regular maintenance ensures optimal performance and longevity of the solar PV street light system, contributing to a cleaner and greener urban environment.

Table 1: List of materials used in a Solar PV Street Light

Sl. No.	Item	Description	Unit
1	Luminary	LED technologies dusk to dawn	1
2	Pole	Galvanized iron (GI) or mild steel (MS)	1
3	Solar panel	Polycrystalline panel or Mono crystalline panel	1
4	Battery	Dry battery maintenance free	1
5	Battery box	MS or GI	1
6	Wire cable	2 core DC cable	As per requirement

Our main perspective is to make a shift from conventional to non - conventional source of energy for a better future. We know that solar energy holds immense potential in shaping the future of energy production and sustainability. Continuous researches are going on all over the world regarding the advancement of solar technologies to make it more efficient, reliable, but after that also one of the common problem that has been observed is that after the installation of Solar PV Street lights they work properly for few years but unable to meet their lifespan completely and their brightness decreases day by day due to decrease in their efficiencies and for this reason we often try to replace them, which is not at all the exact solution. There can be many reasons for which this type of problem arises, but one of the major reasons that has been observed in most of the scenarios i.e. it occurs due to accumulation of dust, dirt, bird droppings and other debris on the solar panel which reduces the efficiency up to 25% [2]. Increasing the longevity can be easily done through many technical methods like by using automated cleaning systems, self-cleaning coatings or with aerial and drone cleaning. Regular cleaning of PV modules is essential to maintain their performance [4]. It can be useful and efficient but at the same time they are very costly which increases the overall maintenance cost.

Our vision is to increase the longevity of Solar PV Street light with some common non-technical methods that are easily available but people are not aware of it properly. Regular manual cleaning of solar panel with soft brushes and water, checking light fixtures to address the issues promptly and by checking proper installation and location because placing solar panels away from shaded areas automatically ensure maximum exposure to sunlight, enhances their longevity. Manual cleaning allows for a more thorough cleaning process, especially in cases of heavy soiling or specific dirt types. Manual cleaning provides flexibility in scheduling, allowing cleaning to be done as per requirement, which is particularly useful during periods of heavy soiling or after extreme weather conditions.

By considering local climate conditions and implementing appropriate weather proofing measures such as Surge protection devices (SPD), waterproof enclosures which can protect solar PV Street light from moistures, extreme temperatures, and lightning strikes, thus increasing their longevity and it also cut off the long-term maintenance cost easily.

We are proposing theoretically to make some modification to the existing models with advance solar technologies to reduce the wastage of solar energy and achieve maximum efficiency: Using advanced solar panels such as using the cells which are made up of mono crystalline and polycrystalline cells and which perform better in low- light conditions; Using MPPT charge controllers which improves overall efficiency and maximizes the charging efficiency of the battery, especially in variable weather conditions [9]; Replacing traditional lead-acid batteries with lithium-ion batteries for longer lifespan, faster charging. These batteries offer improved energy storage capacity and perform better in extreme temperatures. Using smart energy management systems which integrate smart control, sensors etc. These systems can adjust lighting levels based on ambient lighting conditions, motion detection to maximize energy savings while ensuring adequate illumination.

By applying all these technologies, Solar PV Street light can contribute to environmental sustainability and reducing various operational costs. According to a study by United Nations, replacing traditional lighting with Solar PV Street lighting can reduce carbon emission up to 90%. So, our vision is same, i.e. to produce a lighting solution that is free from greenhouse emission and also reduces the air pollution we can achieve this through Solar PV Street lighting in which sunlight is converted into electricity without emitting greenhouse gases and it does not contribute to climate change or global warming. By eliminating the need for combustion-based energy generation, Solar PV Street lighting solution will also help to reduce air pollution and will also improve the air quality. A switch to energy efficient LED technology could save over 1,400 million tons of CO<sub>2</sub> and avoid the construction of 1,250 power stations. CO<sub>2</sub> emission estimation can be done with the following equation [10].

$$E = A \times EF \times \left( \frac{1 - ER}{100} \right) \quad (1)$$

where, E = emissions, A= activity rate, EF = emission factor, and ER = overall emission reduction efficiency (%).

Some of the recent developments in this field are: Integration with Internet of things (IOT) and connectivity has been developed recently to maintain and monitor the lighting infrastructure [11]. Smart lighting controls with integration with smart technology like motion sensors, dimming controls which leads to increased energy savings and also improve reliability [11]. High efficiency solar panels, Lithium-ion battery technology and modular designs are the effective recent developments which is driving the adaptation of Solar PV Street lighting solution.

## V. CONCLUSION

As a conclusion, Solar PV Street lights offer a brighter and efficient solution for outdoor lighting needs. Solar PV Street lights harness solar energy, which reduces the dependency on traditional grid electricity thereby cutting costs, and also minimizes environmental impact. Solar power expects to become the world's largest source of electricity by 2050, with solar photovoltaic and concentrated solar power contributing 16% and 11% to the global overall consumption, respectively.

Solar PV Street lights provide reliable illumination even in remote or off grid locations, enhancing safety and visibility. This technology reduces the green emission and replace the traditional street lights hence reduces the air pollution. Solar energy is one of the best ways to reduce the carbon footprint. Future research could focus on improving energy storage capabilities, optimizing system design, and integrating smart technologies for enhanced performance and energy management. To maximize effectiveness continuous research and development in maintenance and technologies advancement are crucial. Overall, Solar PV Street lights represent a promising pathway towards brighter, cleaner and greener future. It not only illuminates every street but also a commitment to make unconventional source of energy to a new convention of this generation.

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