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Solar High Mast Lighting System

Harshvardhan Rathod[1], Soham Munjal[2], Ritesh Gujar[3], Dharmendra Chavan[4], Mr.S.S.Yewale[5]

[1,2,3,4] Student, of mechanical Engineering, Karmaveer Bhaurao Patil Polytechnic Satara, India

[5]Mr.S.S.Yewale, Dept. of Mechanical Engineering, K.B.P POLYTECHNIC SATARA

Abstract – *Solar energy is catching on all over the world. People like photovoltaic (PV) systems because they turn sunlight into electricity pretty efficiently. Homeowners, manufacturers, and businesses all find them useful. To really make PV panels work well, you've got to make sure they're in spots with lots of sunlight and not too much shade. Most folks stick them on rooftops to keep shading to a minimum, but that leaves the panels exposed to lightning strikes when storms roll through. To tackle that risk, engineers add direct lightning protection.*

This paper digs into those direct lightning protection strategies, especially the role of the earth grid and what makes it work well. It also introduces a new way of laying out lightning masts, designed for PV systems with east-west aligned panels packed closely togethersomething there isn't much published research on yet. A detailed case study backs up the equations used for designing around direct lightning strikes. Plus, using equations 2 to 12 makes life easier for designers, helping them stay lightning compliant with the rolling sphere method.

This paper dives into the design and analysis of a Solar High Mast Lighting System, paying close attention to extra loading, structural stability, and how well the system works. It suggests some upgrades to boost the mast's ability to handle loads and make sure it runs safely, reliably, and sustainably in real-world weather.

(Keywords: Solar Energy, Photovoltaic Systems, Lightning Protection, Earth Grid, Rolling Sphere Method, Lightning Mast Design, PV System Safety)

1. INTRODUCTION

These days, you see a lot more people investing in photovoltaic (PV) systems. Everyone's looking for ways to cut down on greenhouse gases and make energy cleaner. PV panels work by grabbing sunlight and turning it straight into electricity, so you usually spot them out in big open fields, soaking up every bit of sun. It makes sense more sun, more power. But leaving them out in the open comes with a pretty big risk: lightning. If a storm hits and you're not prepared, one strike can wreck both the equipment and the whole structure [1].

That's why solid lightning protection can't be an afterthought. You've got things like lightning masts and good grounding setups to keep these systems safe. But here's the catch the effectiveness of a grounding system depends a lot on the soil. Wet soil, dry soil, frozen ground it all changes how electricity moves through it [1]. If you want your system to survive some nasty weather, those details really matter.

Now, think about high mast lighting. You know those towering poles lighting up highways and big parking lots? People are starting to mount solar panels on them. Sure, it's great for saving energy, but it comes with a whole new set of problems. Besides handling strong winds and heavy loads, now these poles have to deal with electrical and structural stresses from the solar panels too. If we want these Solar High Mast Lighting Systems to truly work, we need to design them tougher and smarter. That means combining renewable energy with stronger structures and better protection, so they keep shining safely, no matter what nature throws their way.

1.1 System Components

A Solar High Mast Lighting System is made up of a few important parts that work together to light up large areas. The PV panels grab sunlight during the day and turn it into electricity. A charge controller keeps the battery charging right, so it doesn't get damaged from too much power. Then, when night falls, the batteries supply electricity to the LED lights.

The tall mast holds everything up high, so the light covers a wide space. To keep things safe, there's an earthing system and lightning protection, which help shield the structure and electrical gear from lightning and harsh weather. It all adds up to lighting that's dependable, eco-friendly, and keeps working without a hitch.

1.2 Working Principle

A Solar High Mast Lighting System uses sunlight to power LED lights. During the day, the photovoltaic panels collect sunlight and turn it into DC electricity. A charge controller manages this power, making sure the batteries charge safely and efficiently. At night or when it's cloudy, the system automatically draws power from the batteries to light up the LEDs. Most setups have a dusk-to-dawn sensor, so the lights

switch on and off by themselves without any fuss. The high mast design lifts the lights up high, spreading the illumination evenly over a big area while cutting down on wasted energy. To keep everything running smoothly and safely even in rough weather the system includes proper earthing and lightning protection. That way, it keeps working reliably, no matter what the weather throws at it.[4] The charge controller keeps everything running smoothly. It regulates voltage and current, making sure the batteries don't overcharge or get damaged while recharging. When night comes, all that stored energy powers the high-efficiency LED lights. An automated system manages it, so you don't have to worry about anything. The tall masts do a nice job spreading the light across a wide area—perfect for lighting up big spaces. Plus, grounding and lightning protection are built right in, so the whole setup stays protected from electrical surges and bad weather..

2. LITERATURE REVIEW

Solar high mast lighting systems are getting a lot of buzz these days, and it's easy to see why. They're pretty much tailor-made for lighting up big outdoor spaces especially in remote spots where the power grid just doesn't reach. The concept is straightforward: solar panels collect energy from the sun all day, store it in batteries, and then power the lights at night. That means less dependence on conventional electricity, and it's a win for the environment too.What really matters here are the parts that make up the system: the solar panels, charge controllers, batteries, inverters, and—most importantly the LED lights. If you want these setups to work well, you need all those pieces working together. Maximum Power Point Tracking (MPPT) technology pushes the solar panels to deliver as much energy as they can [5].LEDs are the go-to for lighting because they're efficient, they last, and they rarely need fixing compared to those old-fashioned bulbs .Getting the system right means paying attention to the details—like how much power you actually need, choosing the right size for the batteries, and tilting the solar panels at just the right angl[6]'Small touches can make a big difference too. Dusk-to-dawn sensors, for example, make sure the lights only come on when you need them, saving even more energy. These systems really shine in places like highways, parking lots, industrial areas, or out in the countryside anywhere plugging into the grid just isn't possible[3].Of course, these systems aren't perfect. The upfront costs can be steep, and they rely on decent sunlight. Batteries need regular checkups, and replacing them isn't cheap, so you have to factor in those long-term costs. But honestly, solar technology keeps getting better and less expensive, so these lighting systems are becoming a lot more practical (International Energy Agency, 2020).In the end, the research makes it clear: solar high mast lighting is a smart, sustainable way to brighten up outdoor spaces. They help cut down energy use, lower carbon emissions, and move us a step closer to greener ways of lighting the world[5].

Recent research has concentrated on enhancing the operational efficiency and structural efficiency of solar high mast lighting systems through improved pole design and advanced control methods. Improved structural stability and reduction in material use with appropriate foundation designs, and safety under load through the use of tapered circular hollow sections [1]. Recent developments provide more effective surge protection and lightning protection for photovoltaic systems without creating shading losses, providing improved system performance and dependability [4]. Additionally, integrating "smart" monitoring features and refined energy management techniques using MPPT techniques have enabled greater efficiency in both operating energy use, identifying faults, and sustaining long-term operational viability in today's solar light systems [6].

2.1. RESEARCH GAP

Most current research on solar high mast lighting systems focuses on structural design, component selection, and fundamental photovoltaic performance; however, there is a scarcity of comprehensive analyses regarding the cumulative impact of structural loading, energy generation, and storage efficiency under diverse environmental conditions. The interplay among wind loads, temperature variations, solar irradiance fluctuations, and battery efficiency is not thoroughly examined within a singular framework.

Consequently, this research emphasizes a comprehensive assessment of structural and electrical performance, seeking to enhance overall system reliability, efficiency, and design optimization in actual operating conditions.

Table -1: Sample Table format

Parameter	Solar High Mast System	Conventional Lighting System
Energy Source	Solar Energy (Renewable)	Grid Electricity(non renewanle)
Operating Cost	Very LOW	High
Intial Cost	High	Moderate
Maintenance	Low	Moderate to high
Carbon Emission	Zero	High

3. METHODOLOGY

I. The development of a Solar High Mast Lighting System begins with figuring out how much lighting is needed in the area where it will be installed.

II. This helps in choosing parts like solar panels, batteries, LED lights and charge controllers that can handle the required load.

III. The solar panels are placed at an angle to catch as much sunlight as possible during the day.

IV. Then all the electrical connections between the panels, controller, battery and lighting units are made to ensure that energy flows smoothly.

V. The system is tested in conditions to check how well it works how efficient it is and how reliable it is.

VI. When installing, safety measures and strong structural support for the mast are ensured to prevent problems.

VII. The solar panels, batteries and LED lights all play a role in the Solar High Mast Lighting System

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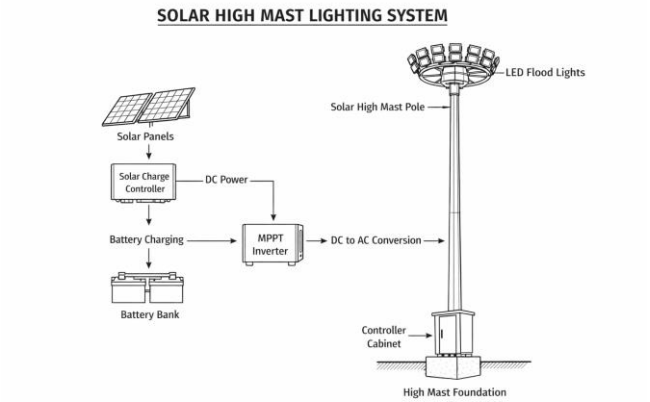
VIII. While researching about the capston project this is review we did to get an conceptual idea about the Project



4. WORKING PRINCIPLE

The solar high mast lighting system works by taking sunlight and turning it into electricity. It uses this electricity to give us light at night. When the sun is out solar panels on the mast take in the sunlight. Turn it into electricity. This electricity is controlled by a device that makes sure the battery gets charged just right. The battery stores the electricity so it can be used when the sun is not shining.

At night the electricity, in the battery is used to power the lights on the mast. These lights are special because they use little electricity to give a lot of light. Usually a sensor turns on the lights when it gets dark. The solar high mast lighting system is great because it does not need to be connected to the power grid. It works by itself to give us light in big outdoor areas. The solar high mast lighting system is a way to have reliable and sustainable lighting. The solar high mast lighting system uses panels and a battery to give us light at night.

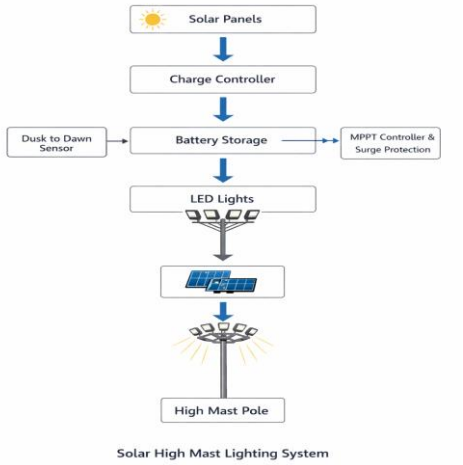


Fig.-1: Flowchart of Working Principle of Solar High Mast Lighting System

5. CONCLUSIONS

In conclusion, this study proves that designing solar high mast lighting systems really hinges on picking the right materials, figuring out the best structure, and making sure the solar technology fits in well. Mild steel gets the spotlight it's strong and flexible, so it works well for these towers. From all the design possibilities, the tapered circular hollow section stands out as the safest and most efficient [1], [2].

The structural analysis shows the system stays reliable, even when put through real-world stresses. Everything holds up, which means you don't have to worry about safety or performance in practical conditions [4]. Adding smart lighting and networking tools makes a big difference, too. You get better monitoring, easier fault detection, and smoother operations [1].

The study dives into some tough spots like lightning protection and shading stuff that can trip up PV systems and suggests fixes that actually boost safety without cutting down on power output [3]. Using MPPT techniques and designing the system carefully pulls more energy out of the sun, making the whole setup more efficient [5], What's more,

simple layouts and streamlined design cut down the costs of installation and maintenance, so you save money but still get a system that works as well as ever. All of these points matter for real-world uses and push the goal of building smarter, more sustainable solar high mast lighting systems forward [3].

Fig-2: Conclusion of Research

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BIOGRAPHIES

Author 1-Harshvardhan Mohan Rathod
-3rd Year Mechanical Engineering Student at Karmaveer Bhaurao Patil Polytechnic Satara

Author 2-Soham Dattaraya Munjal
-3rd Year Mechanical Engineering Student at Karmaveer Bhaurao Patil Polytechnic Satara

Author 3-Ritesh Rahul Gujar
--3rd Year Mechanical Engineering Student at Karmaveer Bhaurao Patil Polytechnic Satara

DharmendRA Vilas Chavan
--3rd Year Mechanical Engineering Student at Karmaveer Bhaurao Patil Polytechnic Satara

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