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INNOVATIVE SOLUTION FOR TUNNEL LIGHTING BY SOLAR SENSOR LIGHT

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ABSTRACT
The innovative solution for tunnel lighting by solar sensor lights is an innovative approach designed to enhance user experience while minimizing energy consumption. By utilizing advanced lighting. The solar sensor light project aims to develop an intelligent, energy-efficient lighting system for tunnels using LED light, solar system for electricity. Traditional lighting systems in tunnels often remain on continuously, leading to unnecessary energy consumption. This project introduces an automated solution where lights only activate when needed. The PIR sensors that detect light and movement. This intelligent system automatically adjusts lighting levels to match the environment, eliminating the need for manual adjustments and minimizing energy waste.

Keywords:
Energy Efficient, Solar System, Energy Consumption**.**

1. INTRODUCTION

Tunnel lighting is a critical component of road safety, especially in tunnels where natural light is insufficient. Proper lighting is essential for visibility, driver safety. Traditional tunnel lighting systems often rely on grid electricity, which can be costly and environmentally unfriendly. Moreover, maintaining these systems, including the need for energy- consuming bulbs and maintenance costs, can be expensive. Traditionally, tunnel lighting systems rely on electricity from power grids, which can be expensive and contribute to environmental pollution. In recent years, there has been a growing need for more sustainable and cost-effective alternatives. This is where solar sensor lights come in. These lights use energy from the sun to power the tunnel lights, reducing the need for electricity from the grid. The lights are equipped with sensors that only turn them on when needed, such as when a vehicle enters the tunnel, making them even more energy-efficient.

The Solar Sensor Light Project presents an innovative solution for tunnel lighting that emphasizes energy efficiency, sustainability, and enhanced user experience. Traditional tunnel lighting systems often run continuously, leading to unnecessary energy consumption even during daylight. This project seeks to tackle that issue by introducing an intelligent lighting system powered by solar energy, using LED lights and sensors to automatically adjust lighting based on real-time environmental conditions.

The system utilizes solar panels to generate electricity, providing a renewable energy source for the tunnel lights. This reduces reliance on the electrical grid, leading to significant energy savings and lower operational costs. Solar energy is especially valuable in locations with abundant sunlight, as it minimizes the tunnel's carbon footprint and contributes to environmental sustainability.

The core of this lighting solution involves the use of LED lights, known for their high energy efficiency, long lifespan, and low maintenance requirements. These lights consume significantly less power compared to traditional lighting systems, ensuring that the tunnel remains brightly lit while consuming minimal energy. This approach not only reduces the operational costs of tunnel lighting but also enhances the safety and visibility for drivers or pedestrians using the tunnel.

The system integrates PIR [passive infrared sensor], which play a crucial role in regulating the lighting. These sensors detect the ambient light level in the tunnel, adjusting the brightness of the LED lights based on the surrounding light conditions. For example, the lights will remain off during the daytime when natural light is

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sufficient, and will automatically turn on as daylight fades or when the tunnel becomes darker. In this way, the system ensures that the lighting is used only when necessary, eliminating wasteful energy consumption.
Furthermore, the intelligent nature of this system allows for automatic adjustments to lighting levels depending on traffic and environmental factors. If the tunnel is empty, the system can lower the brightness to save energy. Conversely, if traffic increases or visibility decreases, the system will adjust the lighting to ensure optimal visibility for safety.
This innovative solar sensor lighting system offers a sustainable, cost- effective, and user-friendly solution for tunnel lighting. By combining solar energy, efficient LED lighting, and automated sensor technology, it provides an environmentally friendly alternative to traditional systems, significantly reducing energy waste while maintaining a safe and well-lit environment for tunnel users.
The Solar-Powered Tunnel Lighting System offers a significant reduction in operational and maintenance costs, making it an efficient and sustainable solution for tunnel lighting. By utilizing solar energy, the system eliminates the need for electricity bills, which are a major expense for traditional tunnel lighting. Solar panels capture sunlight and convert it into energy, providing a renewable power source that operates independently from the grid, resulting in substantial long-term cost savings.
Additionally, the system uses LED lights, which are known for their long lifespan and low maintenance requirements. Unlike conventional lighting systems that need frequent bulb replacements and repairs, LED lights can last for tens of thousands of hours, significantly reducing maintenance costs. The need for manual upkeep is minimal, and since the lights are powered by solar energy, the risk of failures related to electrical grid disruptions is reduced.

2. OBJECTIVES

The objectives of this project are:
Energy Efficiency: To use solar energy and sensors to reduce electricity consumption while keeping the tunnel well-lit, especially during off-peak times or when no vehicles are present.
Cost Reduction: To lower operational and maintenance costs of tunnel lighting. Traditional lighting systems incur high electricity costs and regular maintenance. Solar-powered systems, however, eliminate the need for grid electricity and reduce maintenance requirements due to the long lifespan of solar-powered LED lights.

3. METHODOLOGY

Material selection will focus on eco-friendly, renewable, affordable, and sustainable options. The materials should be:

1] Light

CK16BMAX IP68 LED Module

Specifications:
Wattage Options: 40W / 50W / 60WProtection Rating: IP68 (Dust-tight, Waterproof, Suitable for harsh environments)
Luminous Efficiency: High luminous efficiency, optimized for energy savings without compromising brightness.
Luminous Flux:
40W: Approximately 4,000 lumens 50W: Approximately 5,000 lumens 60W: Approximately 6,000 lumens
Design calculations:

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- Assume a tunnel of 500m long now calculate the no. of LED lights required by the tunnel to calculate the energy consumption to install suitable capacity of solar panels.

Step 1: Determine Coverage Per Light
Each 60W light covers average 10 meters of the tunnel.
Step 2: Calculate the Number of Lights Needed
No. of lights required = tunnel length / coverage per light = 500M / 10M = **50 lights**

2] Solar Panels

- **Calculate solar capacity**

Total energy consumption (kWh) = (no. of lights x wattage per light) / (1000 = 50 x 60w) / 1000 = **3kWh**.
The total energy consumption for 50 lights of 60W each for 1 hour is 3 kWh.
now take average lights active time of tunnel 15 hours therefore **the energy required per day is : 15 x 3 : 45 kWh.**

- For instance, if each panel is rated at 300W (0.3 kW), you would need:

45 kWh / 0.3 kW = 150 panels (for a full day of energy production, assuming 5 peak sunlight hours per day).

- Sun Power Maxeon 6 (400W) Capacity of each solar panel 0.3 kWh

3] Motion sensors
HC-SR501 PIR Motion Sensor
Key Points for the HC-SR501 PIR Sensor in Tunnel Lighting Detection Range: 7-10 meters, with an adjustable sensitivity to fine-tune the coverage area. Power Supply: Operates on 5V to 12V DC, ideal for solar- powered systems. Motion Detection: Detects vehicles based on infrared radiation, triggering the lights when a vehicle is present. Durability: Durable and reliable, but may require additional protection (weatherproof housing) in tunnels with harsh conditions.

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4] Battery
Exide ELT12B Lithium Exide Battery for 45 kWh
Storage: Number of Units Needed : **9 units of 5 kWh. Total Capacity: 45 kWh** .
Cost per Unit: ₹50,000 to ₹1,00,000. Total Cost Range: ₹4,50,000 to ₹9,00,000. Install a backup battery of 90kWh for in case of solar failure

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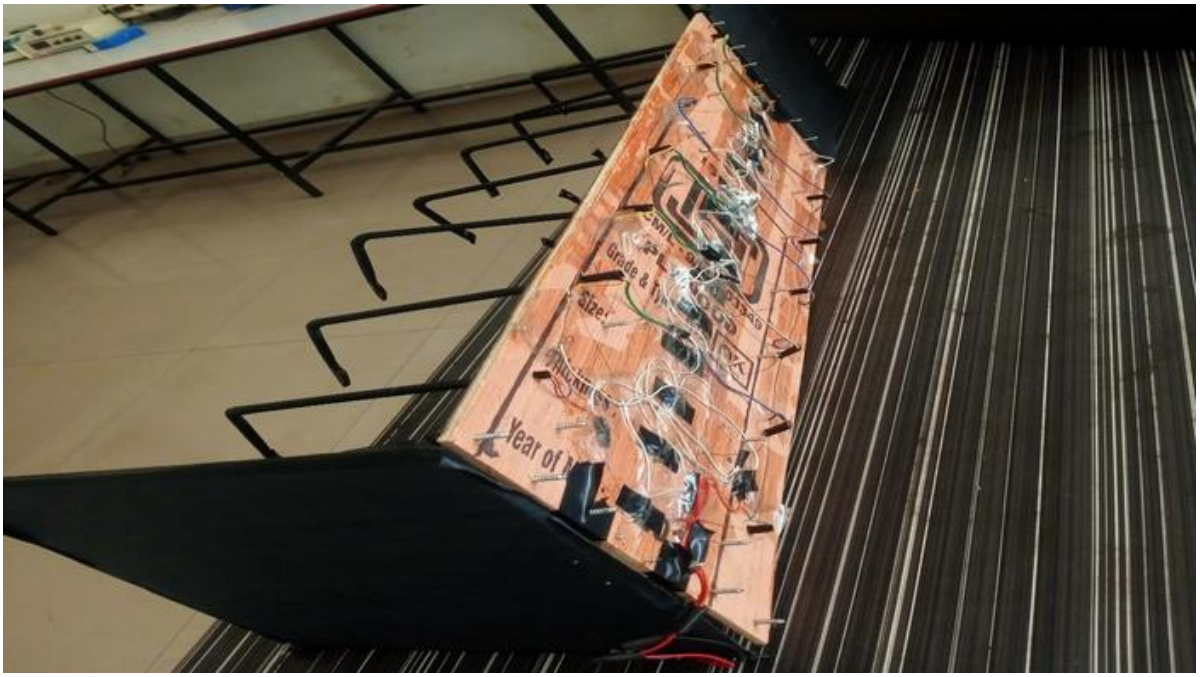

Fig: showing connection provide to sensor light from pavement

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Fig: model of sensor light placing in tunnel

4. CONCLUSION

Adopting solar sensor lights for tunnel lighting offers substantial benefits. it saves energy and money, reduces reliance on fossil fuels, cuts down on maintenance costs, and offers a sustainable, eco-friendly solution that contributes to environmental protection. By making this transition, we not only improve the operational efficiency of tunnel lighting systems but also align with the global push for cleaner and greener energy alternatives.

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