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# IOT PLATFORM TO AUGMENT SOLAR TREE AS SMART HIGHWAY STREET LIGHT WITH AMBIENT MONITORING CAPABILITY

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## ABSTRACT

An integrated multi-server Internet of Things network for smart solar tree monitoring and control is described in the work that is being presented. Introduced as a smart street light with the capacity to monitor air quality, the Internet of Things enabled solar tree has been installed at the Central Electronics Engineering Research Institute in Pilani. A sensor node for gathering sensor data is located at the bottom of the three-layer design of the network that is being shown. By initiating the program for the sensor node, the solar tree server situated above it carries out the data sampling process. After data collecting is complete, the tree server sends the information to the central server, which manages the control, aggregation, storage, analysis, and display of all the linked solar trees. The network's implementation is also covered in this publication.The data gathered from the solar tree is included in the paper along with a discussion of the network's implementation. With the help of the IoT network that is being provided, the solar tree's potential will be expanded beyond its current use as a power generating device to include security, surveillance, pollution monitoring, and many other uses. Currently, self-sustaining street lights with ambient monitoring capabilities are the focus of discussion.

**Keywords-** Solar Tree, M2M, IoT enabled, IoT network, Monitoring, and Control.

## 1. INTRODUCTION

In scientific circles, there is currently a great deal of discussion on the veracity of the global warming phenomena and the best course of action for humanity to avoid its consequences. As a result of this realization, efforts have been made to decrease the consumption of fossil fuel-based energy and replace it with renewable energy sources like wind and solar power. Up until now, we have generated electricity only via the use of solar panels (which harness the power of the sun) or windmills (which harness the power of the wind), but we have not combined the two sources of energy into a single system. We can undoubtedly have a more efficient system than we have ever had if we take this action. Thus, we will show in this study how an artificial tree may generate electrical energy by utilizing both sun and wind energy.

Building the nano tree is the initial step towards building the artificial tree. Two transparent conducting layers—one at the top and one at the bottom—will make up the Nano leaf. Thin film photovoltaic and thin film thermovoltaic layers are positioned between these two layers, respectively, to transform solar radiation into electrical energy and heat energy. The Nano tree was then joined to twigs and branches by means of microscopic piezoelectric devices, which generate additional power from the motions of the tree brought on by wind and rain. It will be intriguing tobe aware that a single tree, depending on its size and position, can emit anywhere from 2000 to 12000 kHz annually in addition to serving as a windbreak and source of shade.

Our primary goal in this initiative is to preserve electricity for streetlights. Arduino is the project's primary component. This controller will manage every procedure and every streetlight. In our project, we use car sensors to automatically regulate lamps. The controller will use relays to turn on the streetlights if any cars enter at that time. The IR sensor will detect any vehicles and transmit the information to the controller. The preceding streetlight will automatically turn off as a car passes it, and the following Streetlights will turn ON We are using Light Detection and Ranging (LDR) sensor to show the day and night time. All streetlights will turn OFF automatically during the day and turn ON with more intensity during the night. We are also using LDR to check fault detection of all streetlights. We are also adding Coin based Mobile Charging to this project. With the increasing usage of mobile phones, charging is becoming more and more important, so we are introducing this concept in the society. When you insert a coin, your mobile will start to charge. The main message of this project is to reduce energy consumption. We are utilizing solar panels to generate the power. Sunlight is naturally available, so we can use solar panels to generate power. The generated power is then stored in a rechargeable battery, which we can then use to power streetlights and mobile chargers.

## 2. SOLAR TREE

Solar energy has emerged as a pivotal player in the global shift towards renewable energy sources, offering a sustainable solution to meet our growing energy demands. Among the innovative applications of solar technology, solar trees have garnered attention for their dual functionality - harnessing solar power while adding aesthetic value to urban landscapes. These towering structures mimic the form of trees, with branches outfitted with solar panels to capture sunlight efficiently. The integration of solar trees into urban infrastructure presents a promising avenue for sustainable development. By leveraging solar energy, these structures offer a renewable source of power that reduces reliance on traditional fossil fuels, mitigating carbon emissions and combating climate change. Furthermore, their presence in public spaces serves as a tangible reminder of our commitment to environmental stewardship.

Beyond their role as renewable energy generators, solar trees offer multifaceted applications that extend to urban amenities such as street lighting, fault detection systems, and USB charging stations. Integrating these functionalities enhances the utility and versatility of solar trees, transforming them into integral components of modern urban landscapes. Street lighting powered by solar trees not only illuminates thoroughfares but also promotes safety and security in communities. Fault detection systems ensure the reliability and longevity of streetlights, minimizing downtime and maintenance costs. Additionally, the inclusion of USB charging ports caters to the needs of urban dwellers, offering a convenient solution to power mobile devices while on the go.

In this review paper, we delve into the concept of solar trees and explore their applications in urban infrastructure, with a focus on street lighting, fault detection systems, and USB charging. By examining current research, case studies, and advancements in the field, we aim to elucidate the potential of solar trees as sustainable solutions for enhancing urban living environments.

## 3. FAULT DETECTION SYSTEM

Timely fault detection in solar-powered street lighting systems is crucial for ensuring reliable operation and minimizing maintenance costs. Here's why:

1. Reliability: Solar-powered street lights often operate autonomously, relying on stored solar energy. Timely fault detection ensures uninterrupted operation, maintaining public safety and security during the night.
2. Cost Efficiency: Detecting faults promptly allows for swift repairs or replacements, preventing prolonged downtime. This reduces overall maintenance costs by addressing issues before they escalate into larger problems.
3. Energy Efficiency: Faulty components in solar-powered systems can lead to energy wastage or inefficient operation. Identifying and rectifying faults promptly helps optimize energy usage, maximizing the system's efficiency and reducing operational costs.
4. Safety: Faulty street lights can pose hazards such as dark spots or flickering lights, increasing the risk of accidents or criminal activity. Timely fault detection ensures that lighting systems function as intended, enhancing public safety.
5. Longevity of Equipment: Addressing faults promptly extends the lifespan of street lighting equipment. Regular maintenance and quick repairs help prevent minor issues from causing extensive damage, ultimately reducing the need for premature replacements and associated costs.

In summary, timely fault detection in solar-powered street lighting systems is essential for maintaining reliability, minimizing maintenance costs, optimizing energy efficiency, ensuring public safety, and prolonging the lifespan of equipment.

## 4. STREET LIGHTING APPLICATION

Several studies and projects have explored the implementation of solar-powered street lighting, including solar tree-based systems. Here's an evaluation of their effectiveness in terms of energy efficiency, cost savings, and environmental impact:

1. Energy Efficiency: Solar tree-based street lighting systems harness renewable solar energy, reducing reliance on grid electricity. By capturing sunlight during the day and converting it into electricity, these systems can provide illumination at night without drawing power from the grid. The efficiency of solar panels has improved over time, enhancing the overall energy yield of solar tree installations.
2. Cost Savings: Solar-powered street lighting systems offer significant cost savings over traditional grid-connected systems. While the initial investment may be higher due to equipment and installation costs, solar-powered systems eliminate ongoing electricity expenses. Additionally, solar tree designs optimize space utilization, making them suitable for urban areas where land is scarce or expensive.
3. Environmental Impact: Solar tree-based street lighting contributes to environmental sustainability by reducing carbon emissions and dependence on fossil fuels. By utilizing clean, renewable energy sources, these systems help mitigate climate change and air pollution. Moreover, solar-powered lighting installations minimize habitat disruption and ecosystem degradation associated with conventional energy infrastructure.

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4. Case Studies and Projects:The "Smart Solar Tree" project in India implemented solar tree structures equipped with LED lighting for street illumination. The project aimed to enhance energy efficiency, reduce carbon emissions, and promote sustainable development in urban areas.

The "Solar Tree Project" in South Korea installed solar-powered streetlights in urban and rural areas to improve energy access and reduce environmental impact. The project demonstrated the feasibility and effectiveness of solar tree-based lighting solutions in diverse settings.

- Various municipalities and organizations worldwide have deployed solar tree installations as part of their sustainability initiatives. These projects showcase the versatility and benefits of solar-powered street lighting in reducing energy consumption and environmental footprint. Overall, solar tree-based street lighting systems offer a viable and sustainable alternative to conventional grid-connected lighting solutions. Their energy efficiency, cost savings, and environmental benefits make them a compelling option for urban and rural communities seeking to enhance public lighting while reducing their ecological footprint. Continued research and innovation in solar technology are essential to further optimize the performance and scalability of these systems for widespread adoption.

## 5. USB CABLE CHARGING

Solar trees can easily incorporate USB charging ports for mobile devices as part of their design, enhancing their functionality and usefulness in public spaces. Here's how they can integrate USB charging:

1. Strategic Placement : USB charging ports can be strategically positioned on the trunk or branches of the solar tree, ensuring easy access for users while maintaining the aesthetic appeal of the structure.
2. Multiple Ports : Solar trees can feature multiple USB charging ports to accommodate simultaneous charging of multiple devices, catering to the needs of a diverse user base.
3. Weatherproof Design : USB charging ports on solar trees should be weatherproof to withstand exposure to outdoor elements such as rain, sunlight, and temperature fluctuations, ensuring reliable operation and durability.
4. Compatibility : USB charging ports should support a wide range of devices, including smartphones, tablets, and other portable electronics, to maximize accessibility and convenience for users.
5. Integrated Lighting : Solar trees with built-in LED lighting can provide illumination at night while also serving as USB charging stations, offering added functionality and safety for nighttime use.

The accessibility and convenience of solar-powered USB charging stations in public spaces offer numerous benefits:

- Enhanced Connectivity : Solar-powered USB charging stations enable users to stay connected and powered up while on the go, enhancing their mobility and productivity.
- Promotion of Sustainable Practices : Solar-powered charging stations promote renewable energy adoption and encourage environmentally conscious behavior among the public.
- Community Engagement : Solar-powered USB charging stations in public spaces serve as focal points for community interaction and engagement, fostering social connections and collaboration.
- Emergency Preparedness : In the event of power outages or emergencies, solar-powered USB charging stations provide a reliable source of power for communication devices, enhancing public safety and resilience.

Overall, the integration of USB charging ports into solar trees enhances their accessibility and convenience, making renewable energy more accessible to the public while promoting sustainable practices and community engagement in public spaces

## 6. CONCLUSION

The review paper highlights the potential of solar systems within urban infrastructure to promote sustainable development. Key findings include:

1. Renewable Energy Integration : Solar systems offer a viable solution for integrating renewable energy sources into urban infrastructure, reducing reliance on fossil fuels and mitigating environmental impacts such as greenhouse gas emissions and air pollution.

2. Energy Efficiency : Solar technologies, including solar panels and solar trees, demonstrate high energy efficiency and can effectively harness solar radiation to generate electricity for various urban applications, including street lighting, public transportation, and building energy systems.

3. Cost-Effectiveness : Solar systems present cost-effective alternatives to traditional energy sources, with decreasing costs of solar panels and improved efficiency contributing to their economic feasibility. Additionally, the long-term savings from reduced energy bills and maintenance costs further enhance their cost-effectiveness.

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4. Environmental Benefits : The adoption of solar systems in urban infrastructure contributes to environmental sustainability by reducing carbon emissions, preserving natural resources, and mitigating climate change impacts. Solar technologies also promote ecosystem health and biodiversity conservation by minimizing habitat disruption associated with conventional energy infrastructure.

5. Resilience and Reliability : Solar systems enhance urban resilience by diversifying energy sources and decentralizing energy production, thereby reducing vulnerability to disruptions in centralized power grids and enhancing energy security during natural disasters or emergencies.

6. Community Engagement : Solar systems in urban infrastructure promote community engagement and awareness about renewable energy and sustainability, fostering public support for clean energy initiatives and encouraging individual and collective action towards sustainable development goals.

Overall, the review paper underscores the transformative potential of solar systems within urban infrastructure to promote sustainable development by enhancing energy efficiency, reducing environmental impacts, and fostering community resilience and engagement. Continued research, investment, and policy support are essential to unlocking the full benefits of solar energy in urban contexts and advancing towards a more sustainable and equitable future.

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