A Review on

IoT Platform to augment Solar tree as Smart Highway Street Light with Ambient Monitoring Capability

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***Abstract*— *The presented work describes an interconnected multi-server IoT network for monitoring and control of smart solar tree. The IoT enabled solar tree is introduced as a smart street light with air quality monitoring capability and has been implemented in the Central Electronics Engineering Research Institute, Pilani. The presented network is a three-layer architecture with a sensor node at the lowermost layer for collecting the sensor data. The solar tree server above it performs the sampling of the data by triggering the software for sensor node. Upon successful data collection, the tree server communicates the same to the central server which is responsible for aggregation, visualization, storage, analysis and control of all the connected solar trees. The paper also discusses the implementation aspect of the network and presents the collected data from the solar tree. The presented IoT network aims for enhancing the capabilities of the solar tree beyond just a power generation device to an application such as security, surveillance, pollution monitoring and many more. At present, the work discussed is towards self-sustained street light with ambient monitoring capability.***

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

1.INTRODUCTION

Today much debate has been going on in scientific circles about how real the phenomenon of global warming is and what would be mankind’s response in averting the consequence of it. Realizing this, steps have been taken to reduce the use of fossil-based energy and substituting the same with renewable sources such as solar and wind energy etc. Till now we are producing the electrical energy with the means of either windmills (only the effect of wind) or solar panels (only the effect of solar energy) so far but all the two forms of these energies we are not using in same system. If we will do so then surely, we can get the more efficient system than ever we had. So here in this paper we will demonstrate how an artificial tree will produce the electrical energy by using both (wind as well as solar) energies.

For constructing the artificial tree, the first step is to construct the nano tree. The Nano leaf will consist of two transparent conducting layers one at the top and other one at the bottom. Between these two layers we are placing thin film photo voltaic layer to convert the sunlight into electrical energy and thin film thermo voltaic layer to convert the thermal radiation into electricity. The Nano tree then connected to twigs and branches using tiny piezoelectric elements that convert the movements of the tree caused by wind and rain into more electricity. It will be interesting to know that one tree depending on the size and location, can produce between 2000 and 12000 kHz per year plus the trees provide shade and function as a windbreak.

In this project we mainly concentrate on saving the power in streetlights. The heart of the project is Arduino. This controller will control the all the streetlights and all the processes. In our project we are doing automatic control of streetlights by sensing the vehicles. If is there any vehicles entre at that time the IR sensor will sense the vehicle and send the information to controller at that time the controller will on the streetlight by using relays. Once the vehicle pass from the streetlight automatically previous streetlight will going to be OFF, and next streetlight will ON. Also, we are using LDR sensor to indicate day and night conditions. Day time all the streetlight will off automatically, and nighttime turn on with more intensity and we are checking fault detection in all the streetlights by using LDR.

The other one application what we are adding to this project is Coin based mobile charging. Because nowadays the usage of mobile will gradually increase, and charging is very important matter so we can introduce that concept in society like coin based mobile charging. If we insert a coin our mobile will start charging. The main important message in our project is to save energy, here we are using solar panels, sun light is naturally available to us. So, we can generate the power from sun by using solar panels. And that generated power is stored in rechargeable battery. From this battery we can supply the power to streetlights as well as 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.
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.

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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