Use of Solar Energy for IOT Based Street Lights and For Charging of Electric Vehicles (EV)

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Abstract: ***Today's cities are constantly balancing the need to provide valuable services to their communities, while at the same time face the demand to reduce the cost of operations and maintenance of their infrastructure. The future of the smart city is explicitly tied to having a community based, economically extendable network. These networks are critical for expanding safety and security solutions, enabling other community services as well as leveraging existing infrastructure to support energy efficiency initiatives. The combination of solar energy and electric vehicle (EV) charging is the key in drastically reducing our dependence on fossil fuels. Electricity comes from a variety of sources and it's crucial that electric vehicles will be powered by renewables. Electric cars are becoming immensely popular and coming years we expect nearly anyone who owns a solar energy system will install a solar charging station at its home This paper discusses the value of a Smart City Solutions platform and the capabilities of such an integrated platform in achieving: (1) Energy efficient, sustainable, net zero energy streetlight networks. (2) Self-fund smart city projects. (3) Enhance public safety. (4) Strengthen municipal resilience. (5) Electric vehicle (EV) Charging.***

Keywords: Solar Energy, Electric Vehicles, Smart City, Public Safety, Energy Efficient, Integrated Platform

1. Introduction

By 2050, 70 percent of the global population will live in urban areas. Fortunately, the digital revolution holds great promise for responding to many of the challenges created by inexorable urbanization. IoT in particular offers far-reaching opportunities to change the trajectory of asset and resource management and usage to help cities become more efficient and sustainable as demands increase. A key goal of a smart city is to enhance the use of public resources, increasing the quality of services offered to its citizens while reducing operational costs. While this objective cannot be achieved with technology alone, leveraging the deployment of IoT within a city can go a long way to reaching this goal.

With advances in web-based monitoring, real-time data analytics and connectivity, street poles are a resource for tangible use beyond lighting assets that cities can measure and manage. As many towns and cities are retrofitting their streetlights with efficient lighting, a seamless integration of solar energy generation can turn the energy savings initiative into energy generation and a platform for grid-aware technologies -- that monitor and report their own usage and increase or decrease their electricity usage by remote command. This bundling solution can drive down acquisition costs. The developed Smart City Solutions platform connects streetlight, energy generation, surveillance and data and communication networks to a city's public work department. The Smart City Solutions improves municipal energy efficiency, increases distributed renewable energy production, and adds surveillance data and communication networks to allow cities to provide additional valuable services to its citizens at little to no additional cost.

As streetlights continue to be operated and maintained manually by local municipalities in India, power consumption and transmission losses are getting too high to ignore. While some are making a shift to LED lights to save power, automation is the surest way to real savings EV Charging

Most people believe we need to be able to charge our plug-in electric vehicle (PEV) or plug-in hybrid electric vehicle (PHEV) within 2-4 minutes, similar to pulling over at a gas station and filling up your car with gas. Even though Tesla's super chargers are trying to do exactly that, electric charging is going to be different from what people are used to. From now on most people will charge their electric cars with their home solar charging station while they sleep or while they're at work.

Solar charging stations will be used for "topping off" an electric car, giving the owner enough battery charge to return home where she can fully recharge the EV.

Fact: Just 10 solar panels should provide roughly enough electricity to power 21,000 kilometers of electric driving each year

2. Related Work

The need for automation: -Different municipalities have different budgets and vendors for street lighting, raw materials and installation. Of the millions of streetlights currently installed, only a small percentage use LED lights, while others might be CFLs, metal halide or sodium vapor. Thus an automation solution must work with the current infrastructure, without needing major overhaul.

Automation considerations: -Remote monitoring: A street lighting automation system must allow supervisors to view streetlight statuses from the Internet. Important data such as operational hours, energy consumption, and faulty equipment must be made available at the click of a button.

Integration with existing infrastructure: It's not feasible to change the millions of existing streetlights to suit an automation system. Instead, it is essential for any automation system to work with the existing infrastructure.

Fail-safe nature*:* Automation systems must be designed to work without a continuous Internet connection, and in all weather. It is imperative that streetlights are not affected, even if the solution itself fails.

Schedule: What's the use of an automation system that still requires human intervention? An automation system must have schedules to operate lights according to the time of day. Going a step further, the schedules must be flexible enough to account for changing sunrise and sunset timings throughout the year.

Manual override: While the system should run without human intervention, of course the final authority to switch a streetlight on or off must rest with a human being. Under certain circumstances, it may be important for supervisors to control the lights—for example, switching off streetlights when under maintenance, or switching them on when the schedule is faulty.

Sensor integration: Automation systems would be more efficient if they could sense the intensity of surrounding light. For example, in foggy, stormy or smoggy conditions, it would be essential for the streetlights to activate, regardless of the time of day. Thus, automation systems should include sensor integration.

Wireless nature: An automated street lighting solution should avoid extra wiring, digging and re-paving of roads to enable monitoring and control. Instead, the solution must be wireless, plug and play, and low cost in nature.

Automation models and solutions using IoT: -

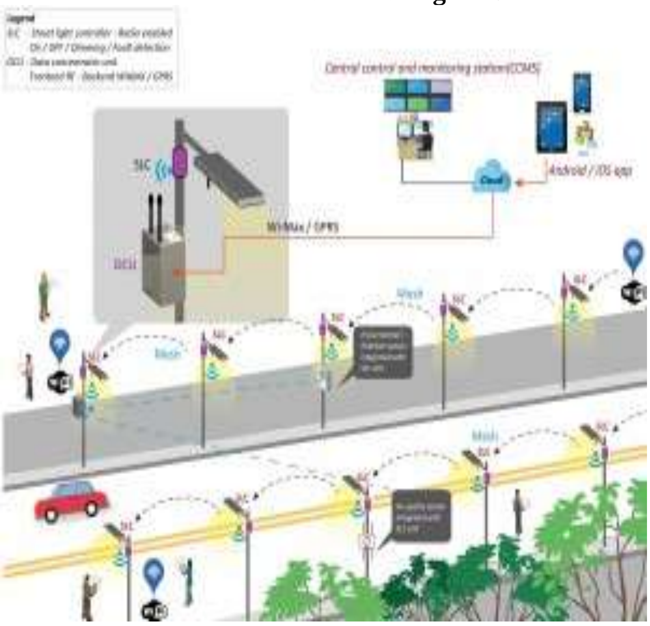

Figure 1: Automation models and solutions using IoT

Automation systems for streetlights cannot have a one-size-fits-all model. Existing hardware, budgets and installation efforts must be considered before moving forward. So let's talk about two broad categories of the automation system: phase wise control and individual light control.

Phase wise control

This solution would control streetlights based on phases. A feeder panel (switching point), along with a gateway device and possibly an energy meter, would work perfectly in this situation. The energy meter would be used to find the phase consumption, and the gateway would upload it to the Internet. The gateway would also be responsible for implementing the schedule for phase operation. While the solution controls the three phases individually, it would not be able to control lights individually. As a result, pinpointing faulty equipment wouldn't be possible with such a solution.

On the other hand, the solution would costs less than the alternative. Street lighting modifications would only be necessary where the streetlights are not LED-based and are not going to be replaced.

Individual light control

This solution would control each light individually. Each streetlight will have circuit board installed to control the light, read the consumption, and transmit all data wirelessly. In order to successfully control the light, the board must be integrated with the LED driver. For the high range of data transmission, the chip must use a far-reach technology and a mesh protocol to maintain robust connectivity. A gateway device would be needed to collect data from and control streetlights, upload the data to the Internet, and control the lights based on either the schedule, if-then rules or manual control. The solution would be able to pinpoint faulty lights and track energy consumption by individual light. However, this solution costs more than phase wise control and should be considered if LED lights are replacing the existing lamps or if new streetlights are being installed.

Optimization in real world: -

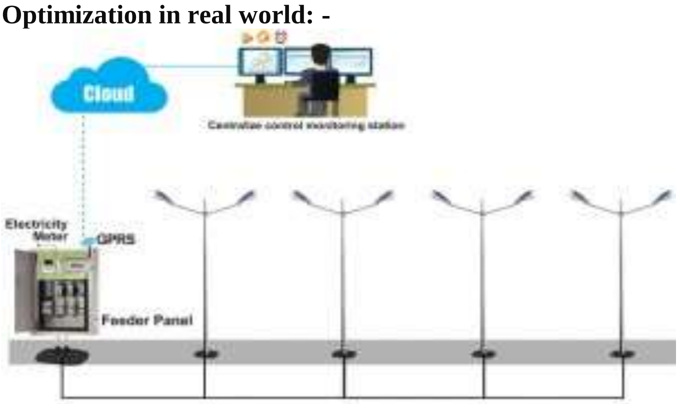

Figure 2: Automation systems

Automation systems, combined with certain policies, will help lower the operating costs of streetlights without leaving anyone in the dark.

Dimming in high traffic: Cities face the highest concentration of traffic between 5 PM and 11 PM, and streets are illuminated with headlights and streetlights during that time. We can guess that if lights are programmed to work on

60% to 80% of their capacity at this time of the day, we can save on operational costs.

Integration with light sensor: Light sensors would help to automatically switch OFF the streetlights during daytime, and switch them ON in the evenings. Streetlights switched ON during the daytime would soon become a thing of the past, saving a lot of money.

Special schedules: Individual control of lights gives us great flexibility in their operations. Schedules that would allow one in two, or one in three, to be switched OFF or dimmed would save energy. These schedules would usually work best post-midnight—say after 3 AM, when traffic is minimal.

Ready-to-use infrastructure: The existing light control infrastructure could be used for additional data collection. Since the existing mesh network is already connected to the Internet, the infrastructure could be used for pollution monitoring, fire alarms and Wi-Fi hotspots, amongst other things. With minimal additional cost and some planning, the lighting infrastructure could be turned into a multi-purpose smart initiative platform.

Smart city Economic Capabilities: To help power economically sound smart city projects, the platform is capable of: Energy efficient, sustainable, net zero energy streetlight networks, which reduce municipal street lighting costs up to 70% by using dim able smart controls. For example, each solar PV panel generator powers four streetlights daily, and a network of 10,000 poles eliminates 7 million pounds of carbon emissions a year, the equivalent of taking 790 vehicles off the road. Secondly, the platform enables self-fund smart city projects, since such a platform establishes a distributed data and communications network for enhanced security and extended service at little to no cost. It also allows cities to self-fund smart city technologies including surveillance, public and private Wi-Fi, electric vehicle charging, emergency response and grid performance monitoring. Thirdly, the platform enhances public safety as it provides public safety personnel with access to real-time information to enhance the quality and speed of their response and customizes cameras, sensors and other metering and communication devices to meet the necessary needs. Finally, the platform strengthens municipal resilience by introducing grid-independent communications, a critical asset for responding to emergencies such as earthquakes and extreme weather events in addition to the fact that a robust and resilient communications and lighting remain active during grid disturbances

Smart City Solutions Building Blocks: -

Figure 3: The Smart City Solution Street lighting

The Smart City Solutions improves municipal energy efficiency, increases distributed renewable energy production, and adds surveillance data and communication networks to allow cities to provide additional valuable services to its citizens at little to no additional cost.

As shown in Figure 3.

The Smart City Solution is built with:
1) Smart light controller comprised of smart transceivers that control individual streetlight ballasts.
2) Wireless networking capabilities with multiple bandwidth options.
3) Streetlight network gateways.
4) Surveillance and sensor networks for security and traffic monitoring.
5) A grid-connected solar power generator that leverages the industry's most mature and proven microinverter technology.
6) Battery backup to manage operations during grid interruption.

3. Components used in Smart Street lighting

A. Smart Lighting Control System

The Smart Lighting Control system is a fully integrated solution that includes:
1) Intelligent light controllers comprised of smart transceivers that control individual streetlight ballasts: ON/OFF streetlight control, dimming control and sunrise/sunset timing.
2) two-way mesh network communications and streetlight network gateways,
3) Surveillance and sensor networks for security and traffic monitoring.

B. Wireless System

The wireless system achieves complete visibility, command and control of all assets via the Internet to obtain real-time analytics and data collection through an advanced user interface (UI). The company's open architecture creates a single communication platform and allows for simplified integration across the entire network.

Figure 4 shows the pole- to-pole mesh communication architecture and how the signal gets communicated from the pole to the Network Operations Centre (NOC).

C. Surveillance and Sensor Network

The Surveillance and Sensor Network module relies on the Wi-Fi network architecture to support virtually all Wi-Fi devices including camera, recording, sensor and communication devices and can be customized to meet your specific needs. Built on adaptive system architecture, the Surveillance and Sensor Network module can be configured to include a light sensor, video surveillance, emergency response, weather stations and traffic monitoring.

D. Intelligent Power Generator

The Intelligent Power Generator includes a high-efficiency solar energy system composed of a PV solar panel, a microinverter, and fully integrated racking and cabling for simplified and secure pole attachment. The Generator communicates with the communications bridge through the AC line by means of a Power Line Communications protocol or PLC, which then connects to the wireless backhaul through a Wi-Fi connection. Managers can view all obtain complete visibility, management and control over the entire distributed solar power plant. Such a system comes with added benefits such as Safety – the system is inherently safe with no high voltage DC currents, and automatic shut-off per PV module, Performance – Maximize the perforce per PV module, Reliability – No single-point of failure, Diagnostics – monitoring, reporting, and control at the PV module level and Adaptability – highly flexible and scalable architecture.

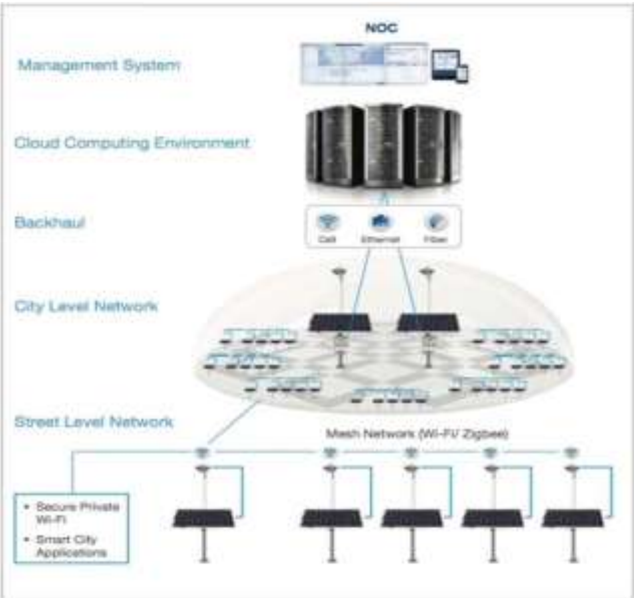

Figure 4: The pole- to-pole mesh communication architecture

E. Battery Backup Module

The Battery Backup module enables uninterrupted power for devices installed on the same pole. It maintains critical services like emergency lighting and network connectivity by powering the access points.The Battery Backup option is a highly scalable and configurable solution component, allowing you to accurately match storage capacity with your needs in the most cost effective manner. The company's Smart City Solutions is engineered to support a wide array of energy storage solutions ideal for safety, and security, and system backup. The Battery Backup Module is composed of a battery, a charge Controller, a PLC /Controller and an AC Connection Relay.

4. Electric Vehicle Charging

Most people believe we need to be able to charge our plug-in electric vehicle (PEV) or plug-in hybrid electric vehicle (PHEV) within 2-4 minutes, similar to pulling over at a gas station and filling up your car with gas. Even though Tesla's super chargers are trying to do exactly that, electric charging is going to be different from what people are used to.

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Fact: Just 10 solar panels should provide roughly enough electricity to power 21,000 kilometers of electric driving each year. How's that?

Solar energy charging for electric vehicles

a) On-Grid solar charging stations

A grid-tied solar energy system is the most straight forward way to charge your electric car with solar energy. A grid-tied solar energy system will feed the power to the grid, regardless of whether your home needs the power at that moment or not. So when your solar energy system is feeding to the grid, and you are at your office, the electric power generated at home is sold to the utility company. You'll get that power back from the utility company in the form of a credit. When you come back from work and park your car at home, you can use that credit to re-charge your car at home.

A conventional electric vehicle charger that is connected to the grid "will almost always be cheaper" than an Off-Grid charger that stores the power in batteries.

b) Off-Grid Solar charging station

An Off-Grid electrical car charger can also be named "Electric Vehicle Autonomous Renewable Charger" There's no connection to local utilities required. The solar panel array will feed the battery energy storage system and the entire power needs are drawn from this storage system.

Off-grid electrical car chargers can be placed virtually anywhere, as there's no need for a connection to the electrical grid. The independent solar array canopy catches quite some wind, and for that reason a solid foundation is required.

Some off-grid solar energy chargers have a heavy steel base plate that functions as ballast. Those are extremely easy and quick to install, as no foundation or digging is required.

Most electric car owners will completely charge their EV batteries at night at their homes. Therefore for most solar charging stations, the objective is not to fully charge an electric car, but to allow several cars to "top off" their batteries.

c) Components needed for a solar charging station

1) EV charger
2) Solar panel array, installed on roof, ground or canopy
3) Battery energy storage system (ESS, in case of an Off-Grid Solar energy charging station)
4) Solid foundation, in case of a stand-alone solar charging canopy (Often used: a steel base plate that functions as ballast, so no foundation is required, simplifying the installation).
5) Intelligent software

5. Conclusion

Streetlights can now be transformed from simple roadway illumination devices into one of the most valuable smart city assets in a community. The paper describes the Smart City Solutions, which improves municipal energy efficiency, increases distributed renewable energy production, and adds surveillance data and communication networks to allow cities to provide additional valuable services to its citizens at little to no additional cost. Building blocks behind the Smart City Solutions are based on technology from the University of Central Florida, NASA, & the U.S. Air Force. The implementation of GEC supports a design philosophy based on pushing intelligence to the periphery of the power system. It empowers distributed devices on the distribution network to take real-time decisions and shape local transients in a favourable and predictable fashion. Rules or profiles can then be used to grant supervisory control to a more-centralized controller. This philosophy dramatically reduces communications requirements and relieves the need for massive centralized data processing and decision-making operations. It allows sections of the grid to isolate and form intentional islands during contingencies.

If we envision smart cities initiatives being launched around the globe, smart streetlights should be a part. Internet of Things automation systems are still in their early days. But smart streetlights will bring a number of benefits to communities and their governments. They will provide baseline data to help governments make informed policy decisions. They help reduce energy consumption and eliminate the need for staff dedicated to streetlight operation. And, as the technology matures, there will be solutions for periphery lighting, especially college and university campuses, gated communities and townships.

If you are still driving a conventional car using 100 years old technology (gas), **sell that thing** and be part of the future with an EV! As you know electricity comes from a variety of sources, including dirty fossil fuels, and now is the time to push for renewables to take its place. Solar charging stations for home and commercial use will play a major role in powering electric vehicles with renewable energy.

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