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ORIGINAL CONTRIBUTION

A Survey on minimizing use of solar energy with the help of IoT devices

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ABSTRACT

Internet of Things has been at the forefront of technical domain for the last few years. With new advancements being made and developments being reported each passing day, IoT [10] is all set to capture the imagination of the most prolific minds who run the industry. This paper however aims at providing **an overview** of how IoT can be merged with the use of renewable energy to facilitate the maximization of energy usage efficiency. While the discussions for the use of solar energy to power IoT devices has been in for quite some time, now this paper tries to explain and understand how the process can be reversed and reaped to revolutionize the way renewable sources of energy (solar in particular for this paper) are used. IoT can be at the control of how energy is channelized and the data gathered can be used to prioritize the requirements of the different devices requesting energy. The use of IoT to control and manage renewable energy consumption is what forms the basis of this paper.

Key words: *IoT: Solar Energy; Elon Musk; Solar City; Rajasthan Solar Park; Machine to machine interaction; smart grid; artificial intelligence*

1. INTRODUCTION

The current state of affairs leaves us facing a gaping problem of energy crisis. As the world population continues to increase exponentially, it comes as no surprise that we face a crunch of energy resources. Our dependency on non-renewable depletable sources adds to the problem. The exploitation of renewable energy sources as an alternative to solve this problem has for long been an alluring prospect and much work has been done in this direction. But the efficient and feasible production and management of unconventional sources of energy has stood out as an issue.

The availability of resources as well as the ease of harnessing them has been a challenge due to the lack of efficient technologies. Even the most efficient of technologies can't guarantee 100 % efficiency. Under such circumstances, it is important that the renewable energy produced is properly managed and judiciously channelized to maximize efficiency. This is where IoT comes to play. With constant monitoring through IoT backed devices, the requirement, usage and availability of power generated by a solar powered home system can be constantly checked and manipulated.

The IoT powered home running on power generated by solar energy where the distribution of power is carried out by IoT devices or terminals. The data would be constantly monitored and fetched by the IoT servers and the necessary communications will be communicated to the devices. The power distribution will be done on the basis of prioritization of requirements, using Artificial Intelligence Module. If need arises, power could be cut off from a device not needing it and can be redirected to a device that requires more.

2. DATA COLLECTION

According to a survey conducted in various fields on the use of solar technology, we have come across various examples such as:

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2.1. Elon Musk Solar City

Solar city [2][3] was founded in 2006 by brothers Peter and Lyndon Rive based on a suggestion for a solar company concept by their cousin, Elon Musk, who is the chairman and helped start the company. By 2009, the solar panels which had been installed were generating 440 megawatts (MW) of power. Presently the company generates 9370 MW of power which can be used to light 1.5 million houses in America including the White House. [5][6]

In 2006, the company merged with Tesla.Inc and offers energy storage services through Tesla, which includes a turnkey residential battery backup services that incorporate Tesla's Powerwall [1][4].

The company is also planning to manufacture Tesla solar roof products in partnership with Panasonic.

Figure 1: - Elon Musk's Solar City

2.2. Rajasthan Solar Park

Bhadla village on the fringes of the Thar Desert about 200 km from Rajasthan's famed Jodhpur city wasn't on the tourist map and nobody ever went there. It only made headlines for extreme heat, temperatures that went up to 52 degrees in the summer. But the sun's bounty is now helping change the lives of the people. It is the heart of India's clean energy push, home to the Bhadla Solar Park. A recent auction of solar power to be generated at a new 250-megawatt plant was recently auctioned for just about Rs.2.62 for every unit, or kilowatt-hour. This would be among India's cheapest sources of power, certainly a lot cheaper than the average tariff of Rs.3.2 per unit for coal-fired thermal units.[7]

Once the solar park is fully operational, the project spread across 10,000 acres, or 40 sq. kilometers of wasteland will be a power gold mine, designed to generate 2,255 megawatts of power. That is a little more than one-third of the peak daily demand in the national capital of 6,000 MW, or for that matter, Rajasthan total demand for power.

Figure 2: -Rajasthan Solar Park

With these advances being made in the field of solar energy, IoT can really come handy in managing the resources and consumption. With more installations to produce energy, higher levels of monitoring of terminals are required. Machine to machine interaction can result in low costs of production and time saving.

3. IOT AND SOLAR ENERGY: RELEVANCE AND RELATION

IoT or Internet of Things is an ecosystem of connected physical objects that are accessible through the internet. The thing in IoT could be a person with a heart monitor, or an automobile with built in sensors i.e. Objects that have been assigned an IP address and have the ability to collect and transfer data over a network without manual assistance or intervention.

As the solar energy industry grows to new heights, some firms are presented with an entirely new challenge: sprawl. More installations means more endpoints to monitor and guarantee. For example, a California-based PV firm is now just as likely to have installations in states such as Massachusetts and New Jersey as it is to operate sites located down the road from corporate headquarters. While solar energy firms could previously have relied upon manual processes to keep tabs on everything, this

approach is no longer feasible due to the sector's scale and spread.

To address this issue, solar energy companies can embrace the Internet of Things, also known as the Internet of Everything. Loosely defined as the creation of more Internet-connected endpoints designed with machine-to-machine interactivity, IoT has the potential to dramatically transform energy companies, according to Cisco. For example, a solar energy company can install sensors on panels to monitor their performance and provide real-time insight to site management teams. [8]

3.1 STRUCTURE OF IOT

The Internet of Things has transformed the physical world to an intertwined physical system of its own. The devices are fitted with sensors and actuators which are fitted to various physical objects, either wired or in wireless connection with the network. These networks help in fetching the data which are analyzed and then transmitted to the servers for further actions based on the programming structure.

IOT is spreading like wildfire in different fields, be it Smart trafficking, Smart homes, Smart School, Smart grids (in respect to Energy Systems).

1) **3.1.1 Smart Grid.**

Smart grids is the integration of 20th century traditional electric power grid with the 21st century information technologies which enables efficient resource utilization to optimize energy consumption, install and manage distributed energy sources as well as to exchange the generated power.

The IoT based sensing and measurement technologies helps in evaluating the health of the equipment's and the integrity of the grid.

IOT based smart grid system is basically used for smart meters and smart power consumption, energy efficiency monitoring and management, power demand side management. It is deployed for transmission line monitoring and controlling, equipment, management, distribution automation and intelligent substation. [11] [12]

3.2 PROCESS OF IOT

The IoT is basically a network which connects smart devices to the internet based on protocols. There are three main concepts that are realized in IoT:

1. Things Oriented: It involves smart devices, RFID tags, sensors, actuators, cameras, laser scanners, GPS, NFC etc.
2. Internet Oriented: This concept enables communication among smart devices through communication technologies like ZigBee, Wi-Fi, Bluetooth, and cellular communication and connect them to the internet.
3. Semantic Oriented: This concept realizes a variety of applications with the help of smart devices.

The Internet of Things integrates the above three approaches to bring out the most advanced technical wonders in the field of automation.

3.3 Integration: IoT and Smart Grids

IoT can be very efficiently used for controlling the SG through application interfaces. The information sensing in a smart grid can be highly supported and improved by IoT technology. The IoT also plays an essential and pivotal role in the infrastructure deployment of data sensing and transmission for SG, assisting in network construction, operation, safety management, maintenance, security monitoring, information collection measurement, user interaction, etc.

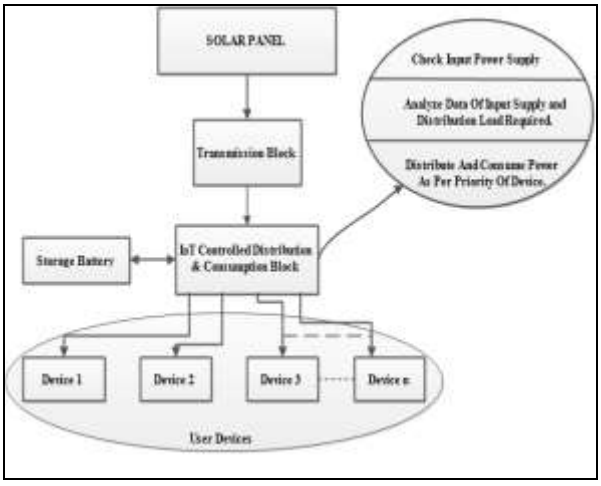

Figure 3: -Structure based on working of IoT device in Energy Process.

The House Model

Figure 4: -Smart house design

4. WORKING

The solar panels absorb solar energy and the total energy generated per minute is calculated by an IoT device (smart console) which in turn sends the calculated data to the server. All our appliances are connected through IoT and are sharing the energy generated. The console distributes and manages the energy to the devices on priority basis.

This working mechanism can be used to manage the efficient distribution of energy in case of a crunch. Suppose, on a cloudy day, not much energy could be produced. The battery sends a signal to the server telling it that the stored reserve is not enough to run all devices. The server sends this message to the console. The console detects the devices in an urgent need of energy. It also sees which devices are in need of no energy currently. Artificial Intelligence(AI) [9] analyses the requirements of various devices and cuts off the power supply from devices not being used currently to redirect it to devices in need.

Similarly, on a brilliantly sunny day when sunlight is available in abundance the excess energy produced can be stored in the smart battery and can be used in the future when the need arises.

4.1. Pseudo Code:

```
class solar_energy:
 refference_voltage_solar;
 refference_voltage_battery;

 def solar_status():
   lp=lower_priority();
   hp=higher_priority();
   bp=power_saving_to_battery();
   while (1):
   while(solar_voltage==True):#Solar Power Available
          if(solar_voltage>=refference_voltage):
                 bp.battery_charge_on();#battery charging
                 lp.lower_priority_on();
                 hp.higher_priority_on();
          if(solar_voltage<refference_voltage):
             bp.battery_charge_off();#battery not charging
             lp.lower_priority_off();
             hp.higher_priority_on();
   while(solar_voltage==False):#Solar Power Not Available
       if(battery_voltage>=refference_voltage_battery):
                    lp.lower_priority_off;
                    hp.higher_priority_on();
       if(battery_voltage<refference_voltage_battery:
                                          #Battery Low
                    lp.lower_priority_off();
                    hp.higher_priority_off();
                    hp.higher_priority_emergeny();
```

The system is backed by an artificial intelligence (AI) model. If the need arises the IoT functions can be triggered by a remote control accessible by a human being. The AI module installed in the IoT console will activate the power saving modules and monitor the proper distribution of powers in various modules connected to different devices.

5. IOT AND SOLAR ENERGY: VISION FOR FUTURE

The topology in India is diverse in its own unique ways and disparity in the availability of sunlight is thus inevitable. The use of IoT thus, if done judiciously and tactfully could result in making things even.

The use of IoT to control the distribution of energy can be particularly helpful in cloudy areas where the availability of sunlight is dubious and uncertain. The use of smart batteries and IoT monitored devices can prove instrumental in storage and utilization of energy on days of crisis.

The areas like **Mawsynram** and **Cherrapunji** in **Meghalaya** and which are rain prone and remain covered in cloud cover almost perennially might go low on energy reserves while the sun does not come out for many days. IoT devices can monitor the consumption of energy in these days and plan the usage accordingly using the data available.

The excess energy stored on sunny days can be stored in the battery. When the energy is scarce, the server can send the data to the battery to save energy by turning off unnecessary devices and the saved energy can be redirected to the needy devices. When the energy levels are restored, the switched off devices can be turned on.

6. CONCLUSION

During the bright sunny days when the solar panels generates the maximum energy from sunrays, the fully generated energy are not needed by us, so with the help of IoT devices we can monitor it and store the excess energy for future use.

Now by seeing the daily forecast if we see that the coming 10days are to be cloudy, hence solar panels can't generate energy to its full, with the help of IoT devices we can lower our reference voltage and minimize the use of stored energy in days of need.

With ever changing technical dynamics in today's world, even the most competent of technologies need to constantly evolve and adapt to changes, incorporating improvements wherever possible. This paper endeavors the possibility of merging of two leading technologies today and how it can help solve real time problems in the real world. We saw how human interaction can be minimized to optimize the use of limited energy and in the meantime also cut costs and save power.

The idea is intriguing and further work in this domain can revolutionize the usage of non-conventional energy sources adding yet another feather to the hat of things made possible with the amazing Internet of Everything.

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