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Controlling and Optimizing Solar Energy Production Using the Internet of Things

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***Abstract*—**Solar, wind, and geothermal energy are all examples of renewable energy sources that may be used indefinitely. Solar energy is widely available and has already been put to use in a variety of contexts, such as street lighting. Solar power production monitoring and optimization may benefit substantially from the use of Internet of Things technology. Large-scale solar plant installations have been aided by the declining cost of renewable energy equipment brought on by technological progress. Most solar systems are situated in distant areas, making it impossible to keep tabs on them from a central location, necessitating the development of complex systems for automating plant monitoring through web-based interfaces. In this research, we provide a novel, low-cost approach to IoT-based solar power monitoring and optimization. This allows for real-time monitoring and optimization, as well as preventative care.

Keywords*— *Smart Home, Internet of Things, Solar Energy System, Arduino

I. Introduction

Without the need for human or computer contact, the Internet of Things (IoT) refers to the connection of digital and mechanical equipment, computing devices, items, and people with unique IDs and the possible movement of data via a network. Internet services allow for remote control of physical devices. Intelligent machines, gadgets, automobiles, houses, and urban areas are all part of the "smart world" concept. Embedded communication and information technology plays a crucial role in the IoT concept, making "smart" products indispensable. The transition toward communication networks is already seen with the proliferation of WiFi and 4G-LTE wireless Internet connectivity in the developing countries. Renewable energy sources, such as wind and solar PV, which are mature in technical potential and not costly, will be a key and expanding source of power in the future, says the International Energy Agency (IEA). One promising approach to lessening environmental damage is the widespread use of renewable energy systems. Compared to last year's report, the newest IEA Medium-Term Renewable Market Report predicts 13% more growth in renewable energy between 2015 and 2021. Over 23% of the power generated in 2015 came from renewable sources; this number is expected to climb to over 28% by 2021. The use of solar power, which is accessible everywhere, has the potential to significantly reduce the global community's reliance on foreign sources of energy. Enough sunlight reaches Earth in only 90 minutes to power every human being for an entire year. Greenhouse gas (GHG) emissions and other pollutants are not produced by solar PV during operation. Investment in additional flexible resources, including demand-side resources, electricity storage, grid infrastructure, and flexible generation, as well as system-friendly deployment, improved operating strategies, advanced renewable energy forecasting, and enhanced scheduling of power plants, are all positive outcomes.Monitoring solar power facilities is essential for maximizing their electricity production. It's useful for keeping an eye on damaged solar panels at power plants while still getting a good production of electricity.

LITURATURE SURVEY

As R. F. Gusa, I. Dinata, and W. Sunanda[1] describe, real-time monitoring systems for photovoltaic (PV) power production may be crucial and time-sensitive. Using the Atmega 2560 Arduino and associated voltage, current, and temperature sensors, a real-time monitoring system for solar panels is proposed. Through the Blynk app, the current, voltage, and power of the solar panel, as well as the ambient temps, are shown through the Arduino ATMega 2560's link with the Wifi module. For seven days, from 8:00 AM to 4:00 PM (EST), this system is put through its paces. With an error rate in monitoring results of solar panel output value below 10%, the system as designed has a high degree of accuracy. Using a microcontroller built inside a smartphone, solar panel efficiency can be tracked in real time. For bigger PV systems, a monitoring system may be designed.

To estimate the azimuth angle of the sun using a Global Positioning System (GPS) and an image sensor, K. Sujatha,R.S.Ponmagal,T. Godhavari[2] present a solar tracking system that uses ANN-based IPT techniques.In order to determine whether the current weather is sunny or overcast, a decision-making AI process is used to the characteristics retrieved utilizing IP methods. The sun tracking system validates the approximation of astronomical calculations with reference to the data obtained. The planned high-tech setup is tested, and the results of those tests are shared through a cloud service for collaborative planning.

A Solar Panel Performance Monitoring System in Sensor Node is described by Retno Tri Wahyuni and Yusmar Palapa Wijaya [3]. Since Wireless Sensor Networks (WSNs) are often deployed in inaccessible

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locations distant from the utility grid, a self-sufficient power source is an essential component of every WSN system. Since sensor nodes operate constantly in real-time, research into reliable and efficient power sources is underway. Given the large number of sensor nodes, it is essential that their power supply be as efficient and cost-effective as feasible. a WSN-based sensor node performance monitoring system for solar arrays. Temperature, radiation, current, and voltage are the variables that have been measured. Clients, servers, and the network infrastructure make up the three pillars of the system. The client includes a microcontroller, sensors, an RTC, a local display, and a backup data logger. Xbee radio frequency modules are used as the means of communication. LabView was used in the creation of the server software for personal computers..

N.Jayapandian,Dr.A.M.J.Md.Zubair[4] The use of cloud computing for the monitoring of electrical household equipment. In this case, solar energy is used to generate electricity. Data collection occurs through the internet, and the management and monitoring system uses mobile devices to govern the flow of electricity to electronics and electrical equipment in the house. One family's excess energy consumption may be leased out to a family in need. The only way to rent anything is to be part of a certain management and surveillance system. It also produces the cost report in KWH on a daily, monthly, and annual basis. Consequently, it is practical for individuals to utilize electricity, and this helps them save money. This study proposes a method to cut both costs and electrical energy consumption: monitoring all household appliances remotely, using the internet (cloud computing).Everything from a controller to a website to an app to a database to mobile devices to a solar array to a monitoring and control unit make up this system. The MCU's job is to keep tabs on the status of the home's electrical equipment and make sure the power is on. When the program is activated, the Monitoring and Control Unit begins to monitor the information sent to it by the controller, which maintains a current database of the area's energy use. This allows for an accurate accounting of energy use across the board, as well as the creation of an electric power bill.

The Internet of Things (IoT) based Solar Energy Monitoring System was suggested by Suprita M. Patil, Vijayalashmi M, and Rakesh Tapaskar [5,6].The system's focus is on figuring out how to monitor electrical appliance voltage and current use and displaying that information online.The goal of real-time current and voltage monitoring of appliances was the primary emphasis. Using current and voltage sensors, Arduino compiles data on energy use patterns.The system is composed of solar panels and batteries. Current and voltage sensors are linked to Arduino and then connected to the battery connections and the load terminals. The Arduino collects data and sends it to the RaspberryPi using a USB cable. RaspberryPi then transmits this information over the internet, where the Python-based Flask framework displays it for the system user.

PROPOSED SYSTEM

For implementation Raspberry Pi and Arduino microcontroller are used. Purpose of Arduino is to measure current & voltage consumed by appliances in real time as well as to measure battery percentage, so it acts as a monitor. Raspberry Pi acts as a controtroller, whose purpose is to facilitate interaction between Arduino & User. Algorithm for optimization is hosted on Raspberry Pi. Python programming language is used to implement Naive Bayes algorithm.

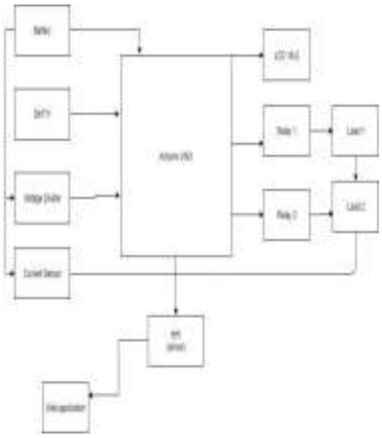

Fig 1.Proposed System

A. Measuring Current & Voltage

As analog pins on Arduino can measure voltage upto 5V, a voltage divider circuit is designed with 10kohm and 100kohmresistors. Voltage is calculated using following formula.

$$Vout = [R2/(R1+R2)*Vin]$$

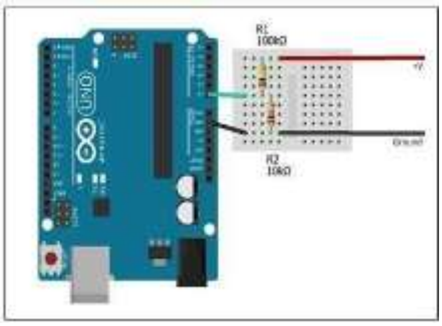

Fig 2: Voltage Divider

To measure current ACS 712 current sensor is used and current measuring circuit is designed as following.

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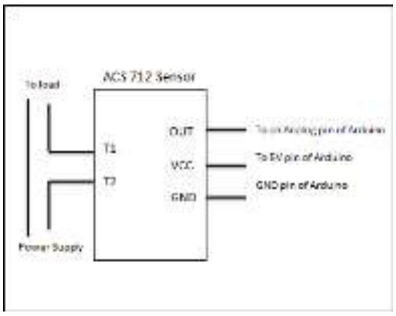

Fig 3 : Current Sensor Circuit

A. ***Controlling Appliances***.

Relay switch is used which in installed between Arduino and Appliances. Arduino gets command to either switch on or off appliance from Raspberry Pi then it performs required operation using Relay switch.

B. Server-Client Setup.

A web app is developed in PHP which have a user interface to turn appliance on/off, statistic of usage is displayed on webpage.RaspberryPi hosts a server application which saved statistics of usage in relational database or can be requested by client in real time via website. Status of currently ON appliances, their run time, wattage usage can be queried by web app as well as appliances could be turned on or off. Depending on battery level optimization is achieved by turning off high energy consuming appliances.

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A] MAPPING DIAGRAM

WHERE,

CB =PREPROCESSINGC = MONITORING. UB

=OPTIMIZATION.

B] SET THEORY

IV.I MPLEMENTATION

Q = READ SENSOR DATA.

LET S BE A SYSTEM IS USED TO TO REMOTELY MONITOR ANDOPTIMIZE SOLAR POWER FOR PERFORMANCE ASSESSMENT.

THIS FACILITATES PREVENTIVE MAINTENANCE, ENERGY FAILURE DETECTION, AS WELL AS REAL-TIME MONITORING AN D OPTIMIZATION.

1) S = {IN, P, OP,}

2) IDENTIFY INPUT IN AS

IN = {Q} WHERE,

Q = SENSOR DATA.

3) IDENTIFY PROCESS P AS

P = {CB, C}

WHERE,

CB = PREPROCESSINGC = MONITORING.

4) IDENTIFY OUTPUT OP AS

OP = {UB}WHERE,

UB = OPTIMIZATION.

= FAILURES AND SUCCESS CONDITIONS.

V. RESULTS

1. Sign in page

Fig 4 User sign in page

2. Output page:

Fig 5 : Disply the values

3. Overall system setup:

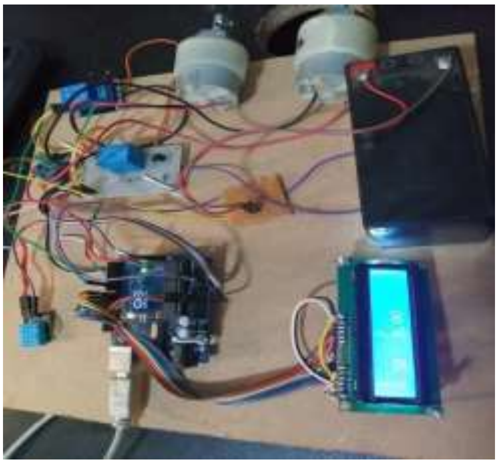

Fig 6 :Overall description

ADVANTAGES AND APPLICATIONS

i. This system has been implemented using microcontroller such as Arduino and RaspberryPi which offer computations necessary to our system at affordable price, This reduces overall cost of system.

ii. Usage of electricity can be monitored in real time as well as prediction of how much energy we are going to generate in near future can be calculated. Real time tracking includes status of on appliances with their power consumption rate and state of charge of battery.

iii. Interaction with home electric appliances can be greatly automate with this system.

iv. Solar cities, Smart villages, Micro grids and Solar Street lights are also some applications of system.

v. .Commercial Products like Solar traffic signals, solar road studs/blinkers can also bemonitored through the proposed system.

Conclusion

The objective of this paper is to implement a system for monitoring the solar energy and optimising it.It offers information about energy and optimising energy usage of your solar system.Here, we are focusing the optimization of solar electrification to charge of power with the help of Naive Bias Algorithm. By using proposed system consumption of electricity bill can be reduced substantially.Usage of clean energy along with existing electricity supply is economical as well as environmentfriendly. . Ease of interaction with day to day appliances is made efficient and effective.

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