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Novel Methods of Enhancing Solar Photovoltaic Panel Efficiency using IOT and Automation

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Abstract:- As we are observing an increase in the rate of power consumption and greenhouse problem throughout the world, many alternative renewable sources of energy have come into the picture which are clean and environment friendly. This has increased the demand for the use of solar photovoltaic devices. IoT technology receives the data from the panel, with the appliances being sent to the cloud on the internet for not only future usage but also monitors many parameters of the connected devices. IoT-based systems can be used to monitor solar panels placed in remote locations through wide area networks. In this review paper, we will discuss IoT-based devices for monitoring the efficiency of solar panels and the various key factors responsible for the decrease in their efficiency. These devices can provide real time information on the status of the battery and also provides assistance for its fault detection, maintenance and provides the user records of the complete data at regular intervals.

Keywords:- *IOT, Solar panel, Photovoltaic, Efficiency improvement.*

I. INTRODUCTION

Modest Energy Sources, for example, coal are diminishing at a disturbing pace and the overreliance on them also isn't halting. That is the place where Inexhaustible Energy sources like Solar and Wind Energy comes right into it. Sunlight based energy is a significant unlimited wellspring of energy that has been standing out enough to be noticed in the current time. Speculation being done in Solar Industry for the desire for a less reliant future on petroleum products. Energizes like flammable gas, coal, oil are restricted in amount and not natural well disposed. The peculiarities of changing over light's energy into electrical energy are known as the Photovoltaic impact. At the point when semiconductor materials are shown to light, a few photons of light beam are sucked up by semiconductor which causes a remarkable worth of free electrons inside the semiconductor. Sun powered energy innovation gives heat, light, power, for homes, organizations, and ventures. IoT connect all sensors, gadgets on a normal organization. IoT alongside has robotized controls which work on the productivity of power creation. Constant information age is a significant ace for IoT gadgets and helps in limit wastage assuming any. IoT gives astounding apparatuses to checking power utilization. Clients might manage the working of the electrical gadgets through a work area or versatile. Sensors in IoT are appended to the transmission, age, and circulation hardware. This IoT based checking framework helps the client in observing and controlling the working of the solar panels continuously. This will prompt a decrease in functional expenses and brings down our reliance on the generally expendable non-renewable energy sources. The execution of IoT will assist us proficiently using this sun-oriented energy.

II. EXISTING SYSTEM

For a really long time, we have seen client disappointment in light on-off controllers because of untimely battery failures and increasing load detaches. Sun oriented charge regulators are utilized to adjust the power running from the sun powered chargers lastly to the batteries. Overcharging batteries will enormously diminish battery life and could even damage the batteries to the degree which can make it totally futile. As the battery voltage move towards the guideline set point, the Pulse Width Modulation calculation diminishes the charging current gradually which would turn away gassing and warming in the battery, yet charging would keep on offering the most elevated benefit of energy to the battery at all time. These results in quick re-energizing, higher charge effectiveness, extending battery existence with a predominant battery at complete limit.[3]

This IoT based system would detect the battery factors like voltage, current and battery power. User's mobile will be updated by this system so we can track it anywhere around the world. This system keeps track of the status of the battery by using real-time technological advancements. We can also improve the efficiency by determining the levels of dust layer on the panels and when it exceeds the critical value, the dust will be automatically wiped off using a robotic cleaner.[3]

III. PROBLEM ASSOCIATED WITH DECREASE IN EFFICIENCY OF SOLAR PANELS

A. Temperature

Solar panel potency varies with temperature. High temperatures have a negative impact on performance. As we have a tendency to all understand, we have a tendency to use a regular daylight intensity to calibrate the nominal power of PV modules inside at 25°C. Considering that the particular outside operating temperature of the module is usually more than 25°C, and therefore the chilling conditions area unit completely different.[5][8]

B. Soiling

Material that gets collected on the outer layer of PV boards can block the light from arriving at the sunlight-based cells, subsequently reducing the produced power. The power loss because of soiling is highly inconsistent due to the type

of soiling (like residue and snow) and the recurrence of cleaning times. Dust saved on the light-receiving surface of the module will initially decrease the light conveyance of the module surface. Then, at that point, besides, it will change the occurrence point of a piece of the light, making the light spread unevenly in the glass cover. Studies have shown that under similar conditions, the resulted power of a clean sunlight-based module is basically 5% higher than that of a residue gathering module. We can say that higher the residue collection, the more prominent the lessening in the result performance of the module.[10]

Fig. 2: Various methods of soiling

C. Shading

As we knew, shading is the obstruction of irradiance due to trees, buildings, terrain, and other objects in the environment. The effect of shading on the power output of a solar installation is highly inconsistent. For example, when one solar pallet in a solar panel is shaded, all the preceding un-shaded cells can dump their corresponding energies into the first shaded cell as heat. This creates a hot spot that can potentially damage the solar panel if it lasts for a long time.[8][10]

Fig. 3: Shading of Solar Panel

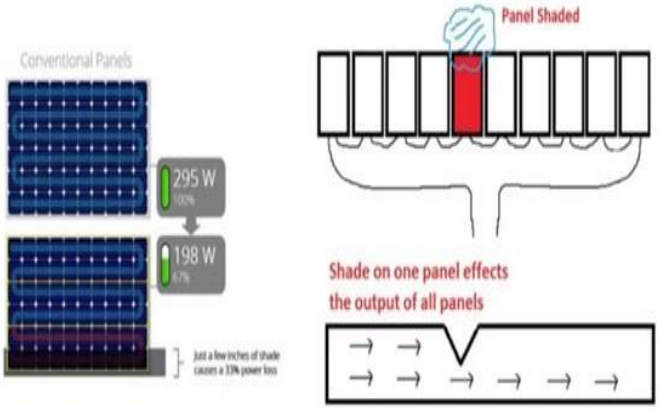

Fig. 4: Effect of shading on output

D. Mismatch

Due to manufacturing variations, modules of an equivalent type can have slightly different electrical characteristics. This mismatch between modules can lead to a performance loss and can cause impairment, if run for a longer time.[12]

E. Inverter efficiency

Conversion of DC into AC through an inverter is generally around 96-97% efficient, because inverters have higher efficiency when the DC input power is high. The conversion efficiency takes a big hit when the input power is very less than the inverter's rated power.[11]

F. Aging

Solar panels produce less energy as they get older. The decrease in their performance is seen to be around 0.5% per year.[12]

G. Design

Impairment in design or improper positioning of solar panel can also affect its efficiency because the sunlight will not be falling on the panel properly.[9]

IV. SOLUTIONS FOR IMPROVEMENT

A. Sun Tracking Solar Panel

It is dependent on Arduino controller board and coordinates the different tasks of the solar panel. It is used to harness solar energy. As a panel is directed to the sun supplies large quantity of solar energy, the panel is attached to a motor. The motor is joined to the controller board electrically. From one scope to the other, the system analyses regularly the possibility of solar energy. In the examining process, it inspects which direction has largest incident solar energy so that according to the direct sun's location the panel will go in that path. In this way a high power can be trapped from the Panel easily and efficiently.[1][3]

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Fig. 5: Sun tracking Solar Panel

B. Phase change material (PCM)

The proposed PCM cooling system is shown in figure below. Aluminum tubes were fitted into a chrome steel container. rock bottom of container was covered with wooden plank, which acts as an insulation layer. The cavities between the aluminum tubes are crammed with PCM. A layer of aluminum sheet was wont to cover PCM, which prevents direct contact between PCM and hence the back of solar array. PCM can absorb/discharge an outsized amount of energy during phase transition. The capacity of a Phase change material for temperature control depends upon its properties, heat transfer methods and the system configuration. For instance, it features a melting temperature of 48 deg – 50 deg C, while the solar array operates around 45deg C with a maximum temperature at 53 deg C. This means that PCM could also be partially melted, which ends up in little contribution of heat of transformation to heat removal from PV panel. The non-melt PCM only absorbs sensible heat. Aluminum tubes during this study were designed to extend the area of conductive heat transfer from PCM and act as ducts for natural convection by wind induced air flow.[2]

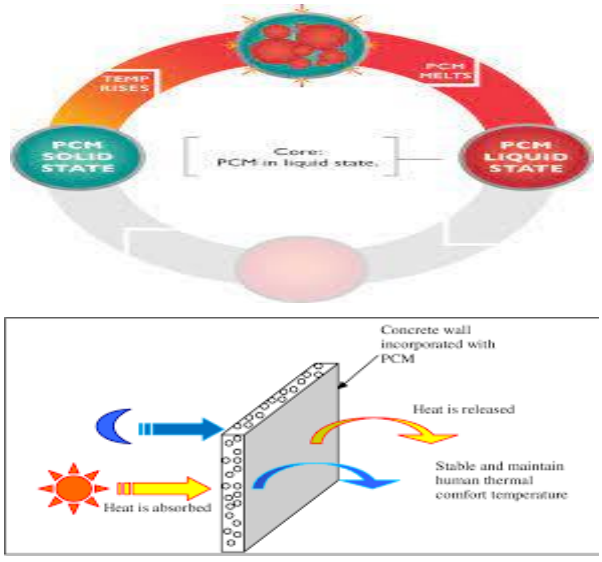

Fig. 6: Cooling by Phase Change Material

C. Rugged robot

Deserts are ideal for extracting maximum energy due to the abundance and high intensity of sunlight that falls on the surface. Hence solar panels placed here can be highly efficient. Despite the benefits, there are a lot of factors that affect the energy generation. The most common being the dust. The dust flowing in the desert can easily cover the panel, hence hindering with proper energy generation. Sending labour to clean it will be extremely hazardous, as the temperature around the panels can go upto 122 degrees Celsius. Hence, rugged robots are employed to do the same. They are placed in conjunction to the panel, and they move along the surface of the panel at regular intervals. This ensures that the panel gets cleaned of any dust that gets accumulated in between the cleaning cycle of the robot.[1]

Fig. 7: Cleaning of Solar Panels by a Rugged Robot

D. Self-Cleaning Technique

This technique makes use of an electrically sensitive material placed over the solar panels. Sensors placed over the panel measures the thickness of the dust being accumulated over the panel, and after a certain level is reached, a small charge is passed through the material, which excites the material and removing up to 90% of the dust accumulated. The energy required for this process is extracted from the energy generated by the panel itself. Since only a small amount is required, the power is supplied by the panel only. This is a cost effective method of keeping the panel clean and ensuring optimum energy generation as the overall cost of deploying the material and its usage is less compared to other methods being employed. This method can be employed largely in huge solar farms, or places where large panels are used for energy generation.

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E. Robotic Vacuum Cleaner

This framework is implemented utilizing two subsystems specifically a Robotic Vacuum Cleaner and a Docking Station. The robot uses a brush and a suction technique to clean the panel.. The brush moves in such a way that the dust is directed towards the suction pump. The motors rotate at very high speed, hence sucking the dust from the panel. This robot uses a combination of sensors to move around the panels to clean it. It is fabricated so as to work in slippery and tilted surfaces. Some feedback systems are used to decide the path that the robot must traverse.. The battery status of the robot is continuously monitored. When it goes below the minimum level, the robot is programmed to go back to a docking station, where it gets recharged and then is again sent for cleaning..[1]

Fig. 7: Cleaning of Solar Panels by Robotic Vacuum Cleaner

F. Antireflective Coating (ARC)

In the panel, when the light hits the silicon cell, the energy packets are converted into energy. Uncoated silica has a very high refractive index, a lot of incident rays are reflected away instead of getting absorbed. The reflection is diminished by finishing and by applying anti-reflective coatings (ARC) to the surface. They comprise a thin layer of dielectric material, with a proper thickness so that impedance impacts in the coating cause the wave reflected from the anti-reflection covering the top surface to be out of phase with the wave reflected from the semiconductor surfaces. These out-of-phase reflected waves damagingly interfere with each other, bringing about zero net reflected energy. The covering reduces light reflection by 75% and increases the power yield by three percent, which in isolation seems a negligible improvement, but over a long period of time can lead to significant increase in the energy generated.. To cover a solar panel, the fluid that contains silicon dioxide is applied to the sheet of glass that ensures the solar panel is protected, then is heated to room temperature which transforms it into an extremely thin layer of porous, reflection-dulling glass. This is an extremely useful method of increasing energy extraction, as the investment required is comparatively less, and over time the increase in energy generated is very high.[1][4]

V. ANALYSIS AND COMPARISON

METHODS	ADVANTAGES	DISADVANTAGES
Sun Tracking Solar Panel	• Ensures maximum utilization of solar rays. • Motor can be remotely controlled using IoT.	• Arduino motors can get glitches. • Practical applications on large solar panel are very expensive.
Phase Change Material [PCM]	• PCM material can absorb large amount of heat.	• PCM material if exposed to extreme heat can melt hence reducing solar energy utilisation.
Rugged Robot	• Can be operated using solar energy itself hence relatively inexpensive. • Can be used in remote places where regular maintenance of solar panels is not possible.	• Environmental factors can damage the robot. • Maintenance if placed in very remote locations can be a hectic procedure.
Self -Cleaning Technique	• Doesn't require any robotic or external device for cleaning purpose. • Uses energy from panel itself to work.	• Lots of parts can increase the chances of failure. • Not practical for small scale solar panels.
Robotic Vacuum Cleaning	• Consists of charging dock hence rechargeable. • Is designed to work on slant surfaces.	• Periodic cleaning of vacuum storage is required. • Costly and complicated setup.
Antireflective Coating [ARC]	• Helps in absorbing more solar energy by reducing reflection caused by uncovered silicon panels.	• Practical for bulk setups only as ARC is expensive.

Table 1

VI. CONCLUSION

IoT is an innovation that is needed to be constructed that can watch out for the battery and ensures it will work to its maximum efficiency. It is an advanced way by which an object could be recognized, observed, and monitored through a cloud server. IoT preserves time, hard work, and investment cost, efficiently. IoT is the ideal solution for giving significant data to remote spots with ease and with high productivity. IoT-based remote monitoring also saves energy and man-work and has a great extent in the future. Computerized reasoning along with different AI calculations can make smart and sensible decisions about information and performance. The process of increasing efficiency should be self-reliant and helpful to the user.

VII. FUTURE OUTCOMES

- These methods can improve the efficiency of solar energy with the help of IoT and there are other methods also which can be used to enhance the efficiency of solar panels. One such example is, the use of solar trackers or MPPT (Maximum power point tracker).[3][6]
- Combination of IoT and solar trackers with solar panels can provide the status (real time monitoring) and gives it to the user at a remote place for overcharging and undercharging.[3][6]
- Batteries can be charged without any stress by this method as user will get to know the status in advance to prevent any battery charging issues.
- In this method the system works in its fullest of capability every time and also ensures that there is no power loss.

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