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A Hybrid Artificial Intelligence Based Iot Model for Generation of Renewable Energy Sources

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Abstract

A noticeable raise has been in the use of different renewable energy technologies worldwide. The installed capacity of renewable energy sources (RES) including solar PV and wind power has grown quickly as a result of attractive investment opportunities in many nations. At the global level, 27.3% of all energy sources were produced by these variable renewable power energy sources. The usage of internet of things (IoT) in the energy output of solar PV systems can enable smart cities fulfill their energy demands more effectively. Recent improvements in IoT systems have been aided by a diverse set of artificial intelligence (AI)-based sensors. This paper aims to create a solar PV energy measuring using Arduino Board technology. A light dependent resistor (LDR) sensor was used to detect the intensity of the light. Because the voltage generated by the solar panel is too high for the Arduino to function as a receiver, the voltage was measured using a voltage divider. The energy production data from the solar PV system is wirelessly sent over the internet to the Arduino UNO module, which manages the energy sources. The IoT is utilized to manage the sent data remotely.

***Keywords** – Renewable Energy, IoT, Arduino.*

Introduction

A growing understanding of the damaging pollutants and greenhouse gases linked to the production and burning of fossil fuels for power generation has led to a significant demand for renewable energy technologies. The increasing demand reduced the cost of renewable energy, making it more affordable. Between 2015 and 2025, it is planned to cut the cost of solar photovoltaic (PV) systems by 65%. Renewable energy generation is expanding, while established technologies such as wind turbines and solar panels are becoming more efficient. The general reduction in reliance on fossil fuels is increasing the use of other, more established renewable energy sources like geothermal and hydropower [1].

Renewable energy modeling involves the use of mathematical and computational models to analyze and optimize the use of renewable energy sources. These models can help in designing, planning, and operating renewable energy systems in a cost-effective and efficient manner. Solar panel modules use the photoelectric effect to convert light energy (photons) from the Sun into electrical energy. The majority of modules make use of plate-based crystalline silicon blocks or thin film blocks. The top or rear layer of the module might be the structural (bearing) element. For modeling, we used Proteus's existing SP module [2].

One commonly used approach is the system-level modeling, which involves the creation of a model that represents the entire renewable energy system, including the energy source, storage, conversion, and distribution. This model can be used to simulate the performance of the system under different conditions, such as changes in weather patterns or energy demand.

Another approach is the techno-economic modeling, which considers both the technical and economic aspects of renewable energy systems. This type of modeling can help to identify the optimal mix of renewable energy sources based on factors such as cost, energy efficiency, and environmental impact. There are also modeling tools that can be used to assess the potential of renewable energy resources in a given area. For example, a geographic information system (GIS) can be used to map the availability of solar, wind, or hydro resources in a particular region, and to analyze their potential for electricity generation.

Overall, renewable energy modeling plays an important role in the transition towards a sustainable and low-carbon energy future, by providing insights into the optimal use of renewable resources and helping to designand optimize renewable energy systems [3].

AI could possibly be applied to renewable energy to increase the efficacy, dependability, and affordability of renewable energy systems. AI has the potential to significantly improve the efficiency and effectiveness of renewable energy systems, helping to accelerate the changeover to a sustainable, low-carbon energy outlook. AI based sensors greatly boost new architectures in IoT and its applications, where centralized control and data processing are replaced by local intelligence and distributed data cycles [4].

The IoT is a term used to describe the connection of everyday devices and appliances to the internet. Thiscovers anything from wearable like fitness trackers to industrial machinery and sensors to smart home gadgets like thermostats and lighting systems. The idea behind IoT is to create a network of interconnected devices that can communicate with each other and with users, sharing data and performing tasks automatically. This has the potential to improve efficiency and convenience in many areas of life, from home automation to transportation to healthcare. Sensors, processors, and communication technologies are commonly found in IoT devices, enabling them to gather and send data over the internet. This data can be used to monitor and control the device, as well as to provide insights and analytics that can inform decision-making. One of the challenges of IoT is ensuring the security and privacy of the data that is collected and transmitted. As more devices become connected to the internet, Data breaches and cyberattacks are more likely now. Consequently, it's critical to install strong security measures to safeguard IoT devices and the data they produce [5].

IoT can be used to monitor and manage renewable energy sources like solar panels and wind turbines. Sensors can be placed on these devices to track energy production and usage, and this data can be analyzed using AI to optimize energy generation and consumption. For example, AI algorithms can adjust the angle of solar panels to maximize energy production based on weather conditions [6].

Overall, organizing renewable energy requires a holistic approach that considers the energy needs of thesystem, the renewable energy sources that are available, and the technologies and infrastructure required to capture and distribute the energy. By taking these factors into account, it is possible to create efficient, sustainable, and cost-effective systems that can help reduce our dependence on fossil fuels and promote a more sustainable future[7].

1. Photovoltaic System And Thermo Electric Plentinum

According to the consumption and pollution of fossil fuels, RES has to be included into the power systemin order to meet up future needs. Small scale off grid system is built in distant areas rather than building transmission lines to transmit power from producing units to loads. A modest system that typically relies on solarand wind is known as a microgrid. Due to instability, interruption, and the high cost of solar and wind power systems, additional nonrenewable energy sources and energy storage have also developed in order to ensure a permanent and reliable power supply. Hybrid renewable energy systems are created when RESs are combined

with other energy sources. Energy demand from consumers is frequently not distributed evenly throughout time, which causes problems with how quickly energy is produced and used. The balance between output and use determines grid stability. [8]. Many modules are utilized in the fabrication of wafer crystalline silicon cells or thin film cells. The data for solar irradiation for the year in India is illustrated in Fig: 1.

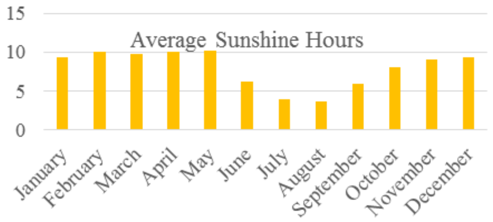


Fig: 1. Monthly solar irradiation in India.

Modeling Of Hybrid System

The hybrid energy system incorporated smart grid is illustrated by Fig. 2, there are three primary components that can be identified: the hybrid energy sources, which are made up of temperature, solar energy, and the BSSs linked to the DC-link through their respective controllers.

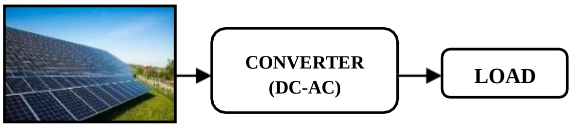


Fig: 2 Solar power system model.

Solar power system model

The PV panel is linked to the DC-link to form the solar conversion system (SCS). The SCS mathematical model is represented by the equations below 1-4:

$$\frac{dV_{PV}}{dt} = \frac{I_{PV}}{C_{PV}} - \frac{I_{PV}}{C_{PV}} \quad (1)$$

$$\frac{dI_{PV}}{dt} = \frac{V_{PV}}{L_{PV}} - (1-U_2)\frac{V_{dc}}{L_{PV}} + D_3 \quad (2)$$

$$\frac{dV_{DC}}{dt} = (1-U_2)\frac{I_{LPV}}{C_{dc}} - \frac{I_{OPV}}{C_{dc}} + D_4 \quad (3)$$

Where, I_{PV} denotes current in the PV, L_{PV} inductance, V_{PV} voltage of the PV panel, I_{LPV} current of the inductor, U2 stage parameters.

$$V_{PV}^{ref} = \frac{P_L}{I_{PV}} \quad (4)$$

Where P_{PV} denotes the PV panel power. Maximum power point can be observed on nonlinear P vs V and I vs V characteristics in fig: 4 [9].

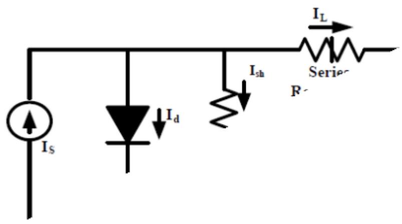


Fig: 3. Solar cell model

Table: 1. Parameters and ratings of PV system

S. No	Different parameters	Ratings
1	Cells in series placed (N_p)	72
2	Cells in parallel placed (N_s)	1.0
3	Short circuit current in panel (I_{SC})	10 A
4	Open circuit voltage in panel (I_{oc})	90 V
5	Voltage at maximum power in PV (V_{mp})	82 V
6	Current at PV maximum power (I_{mp})	9 A
7	Output voltage from PV (V_{out})	230V

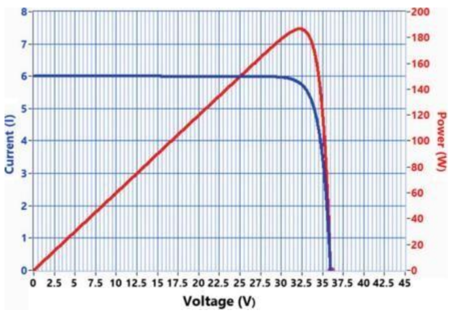


Fig: 4. P vs V and I vs V characteristics of a typical PV system

Modeling Of Hybrid Power System

Load is divided across solar PV, thermal, and battery storage power plants in our model. In this case, a load with a larger capacity than the PV system is used so that the initial light energy is fully consumed and then the thermal system supplies the additional required quantity of power. As an energy source, the model includes a solar thermal power plant. The modeling and simulation of purposed model is performed on Arduino v 1.8.19.

Getting the most electricity possible from a PV-WIND hybrid system under a variety of climatic circumstances is crucial to improving performance. The maximum power point(MPP) must be monitored using the proper control techniques. The MPP is continually tracked in this suggested system under continuously changing environmental circumstances. [10]-[11]. PV system energy is now regarded as an excellent prospective form of renewable energy due to its numerous advantages: inexpensive operating costs, no need to relocate, and no pollution. However, a barrier to its adoption might be the solar panel's poor efficiency and the expensive cost of installing one. [12]

2. Ai-Based Arduino

The groundbreaking concept known as IoT has determined the future of the Internet. This attempts to render everything around us capable of communicating with one another. A great deal of study has been conducted in to investigate the possibilities of IoT and to focus on its growth in various categories based on various works taken into account and focusing on different instances where the various potential of IoT are explored. There is currently no set paradigm through which an IoT model may be deployed, and the operation is mostly dependent on applications. It's possible that the best approach for deploying IoT to solve one IoT challenge will also work to resolve another [13].

To maintain optimal energy production efficiency, AI and IoT technologies used to distantly manage andmanage these tracking systems. The movement of the sun and solar radiation is recorded using analytics solutions,which is utilized to automatically alter the angle of solar panels. In addition, AI and IoT technologies are employedin wind power plants to monitor operating factors that impact electricity generation.

The use of AI and IoT technology in PV system will also radically cut the cost of developing and maintaining solar power plants. AI and IoT systems real-time monitoring & predictive analytics capabilities are utilized to monitor characteristics that may impact power station efficiency or result in unexpected breakdowns. therefore, Facilities will reduce auditing and upkeep expenses while improving performance [14].

Most Internet of Things (IoT) applications demand minimal latency. Cloud computing affects the way they operate in terms of latency. In order to solve this problem, fog computing was developed, allowing for the delivery of amenities outside of the cloud while lowering latency and congestion in the network. Fig.5 depicts the 4-level structure 1. Generation, 2. Transmission 3. Distribution and 4. Consumption.

In order to ensure sure broadband information is consistently given in a dynamic and timely manner, improving IoT device functioning & applications requires significant management capabilities for energy and datastorage. IoT and distributed computer integration are necessary for IoT based applications. Storage on the cloud is a full option based on necessary quality of service and a subscription-based pricing structure. It contains a lot of storage capacity as well as computing abilities.

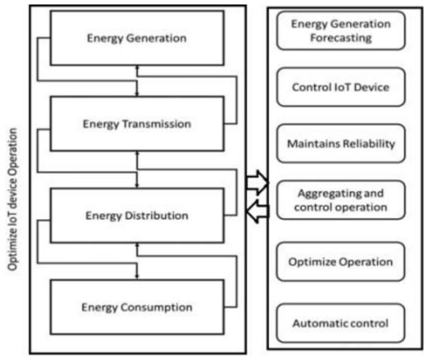


Fig.5: The energy value chain

3.2 The Role Of Iot In Renewable Energy Sources

The IoT is expanding the use of renewable energy. The growth of smart grids enabled by IoT has accelerated the emergence of RES. They propose significant benefits in real-time notifications and energy usage monitoring, enable power utilities to contain RES. The following are a few of these advantages:

The use of RES by the power sector to guarantee a steady flow of electricity to their loads has significantly expanded as a result of the IoT. Already, the IoT has increased the use of solar and wind power. Weshould look at its application in geothermal, biogas, and hydropower plants. The future belongs to renewable energy there can be no ambiguity about it. They will definitely and gradually satisfy our growing electricity need.

3.3. Role Of Ai In Renewable Energy Resources

The bottleneck challenges to AI implementation in the smart energy sector comprise quality and lack ofdata, AI network parameter tuning, technical infrastructure challenges, a lack of proficient experts, interface

challenges, risks, or regulations, and legal concerns. Finding and analyzing of faults are also complex challenges for building energy systems. Numerous studies have identified data security issues and imprecise information as two of the major troubles confronting energy systems. The reliability and performance of the system are impacted by the poor quality of the controllers, sensors, and controlled devices used to operate and estimate the data for the energy system. Photovoltaic (PV) panels are powered by solar irradiation. Methods based on data make forecasts using statistical and machine learning models to discover the link between model outputs and historical data inputs. In the literature, three major groups of parameter identification strategies have been used: analytical, deterministic, and heuristic approaches. The first lesson involves analyzing the electrical properties of solar cells in relation to model parameters. The last two categories are focused on minimizing discrepancies between practical and theoretical solar cell model properties, however these two groups apply different optimization techniques [15].

Arduino As Microcontroller

This work is based on microcontroller designs, produced by many suppliers, employing a variety of microcontrollers. These devices feature sets of analog and digital Input-Output pins that can be used to interact with various expansion boards (referred to as shields) as well as additional circuits. For loading applications from personal computers, the boards provide serial connection ports, notably Universal Serial Bus (USB) on some variants. The arduino provides an IDE based on a language used for programming microcontrollers. The Arduino UNO, seen in Fig: 6, is a multi-purpose ATmega328P microcontroller.

Fig: 6 Arduino UNO

The Arduino UNO microcontroller has a six-channel analog-digital converter. The converter features a 10bit resolution and outputs data ranging from 0 to 1023. The analog pins in this work are mostly used for readingthe ASC712 sensors and voltage divider. The pins that are digital are general purpose input-output (GPIO) pins that are utilized to control the LCD display.

Voltage Regulator

Analog inputs on the Arduino UNO may be used to measure DC voltage up to 5v. The range of voltagesthat the Arduino can calculate is expanded by employing two resistors to form a voltage divider. The voltage to be measured is denoted by Vin, and the divider voltage output, Vout, will be linked to the input pin, is denoted by. The voltage divider reduces the observed voltage near to the range of the Arduino analog inputs.

Controller Design

By reading the stated variables and pins, the Arduino begins configuring the hybrid MPPT controller. It converts digital pins 0 through 6, 7, 8, and 11 to outputs. These pins output a signal, which can be either High or Low. Because pins 0, 7, and 8 are utilized as High/Low, they are originally set to Low (off) to prevent flow from the output. The duty cycle has been chosen to prevent either energy flow from the output or charging of the bootstrap gate capacitor. To the IR2104 half bridge drivers, the Arduino UNO delivers a 62.5 kHz signal from pin- 6 and a 31.25 kHz signal from pin- 11. If the system has been turned off, the Arduino will continually check to see whether it can be turned back on.

3.4.3. Arduino Integrated Development Environment (IDE):

The Arduino IDE is the programming environment for the application code needed to construct the hybrid controller's control settings. Setting up the IDE involved selecting the "Arduino/Genuino UNO" board under the Tools Menu and selecting the COM to which the UNO is present. After receiving power from the UNO, a controller analyzes the input and output source variables. It begins developing the controller by selecting the pins that will supply an output and setting the modes. After setting up the controller, a welcome screen appears before the infinite loop begins. The first of the loop's three stages reads the values at both the input and the output [16]. The sun and wind updates then initiate; the Arduino regulates the amount of duty specified through every pin in order to correct the voltage that is output and input current. The Development Board and Serial Port are displayed in the bottom right corner of the window [17].

3. Arduino Based Iot Model

An open-source hardware and software platform called Arduino was created for the construction of interactive electronics projects. It is built around a microcontroller board that can be programmed to manage a wide range of electronic parts, including sensors, motors, lights, and displays. Since then, it has developed into a well-liked platform utilized by both experts and amateurs. The Arduino board, which includes a microcontroller chip, input/output pins, and other parts required to communicate with other electrical components, is the foundation of the Arduino platform. The Arduino IDE is a free, open-source software tool for writing and uploading code to the Arduino board. The IDE is straightforward to use, with a basic interface and a library of pre-written code samples known as sketches [18].

The Arduino platform's versatility allows it to be utilized for a broad range of projects, from basic LED lights to complicated robotics and automation systems. The block diagram representation of the proposed work shown in Fig: 7.

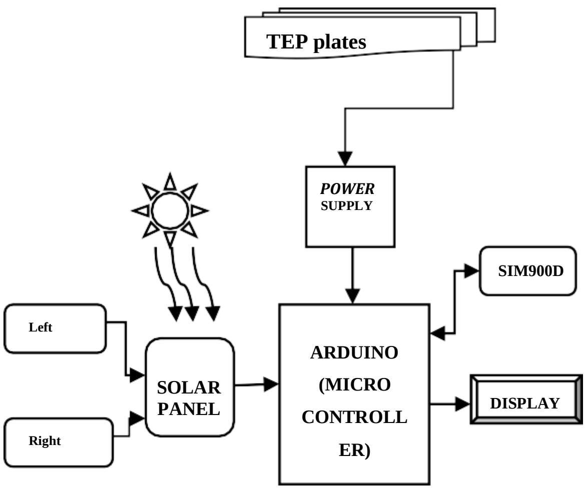


Fig: 7. Block diagram of Arduino based IoT hybrid system.

Simulation Of Hybrid Ai Based Iot Model

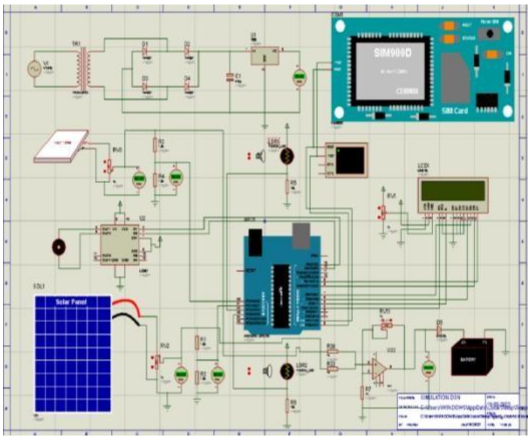


Fig: 8. HYBRID AI BASED Iot MODEL

Simulink, on the other hand, is a simulation and modeling environment provided by Arduino v 1.8.19, which is widely used in the fields of engineering and science. It provides a graphical programming interface to build block diagrams and models of dynamic systems and control algorithms. The combination of Arduino and Simulink provides an efficient and user-friendly platform for designing, testing, and implementing control algorithms and systems. Simulink models can be easily generated for Arduino, enabling the creation of real-time control systems.

The Simulink model for Arduino can be created using the Simulink Support Package for Arduino Hardware, which provides blocks for the Arduino hardware, including digital and analog input/output, communication protocols, and motor control. These blocks can be used to design various kinds of control algorithms and systems, such as PID controllers, state machines and filters.

Solar Panel get yield us the output as per the intensity sunlight fall in the solar panel.

TEP will absorb the temperature, Solar Panel up to certain temperature it will generate voltage beyond temperature if the solar panel getting heated up the voltage will get attenuated. As, we have dual source of power generation. Motor is mounted on behind the Solar panel. So that base in which they are accept intensity is more in it will rotate to grab the more power. In order to compensate the laws, obtain by the thermo electric co efficient. We are using this TEP. This Solar panel voltage generates from TEP two voltages is combined together with the help of two summing amplifiers and these two voltages power source combined together and it is used for charging the battery. IoT through the terminal what source will generate the solar panel.

LDR -LIGHT DEPENDENT RESISTOR

LDR (shown in Fig: 9) sensors, also known as photo resistors, are electronic components that change their resistance based on the amount of light they receive. They are widely used in various applications, includinglight meters, camera exposure controls, and street lights. The working principle of LDR sensors is based on the photoconductivity effect, which is the ability of some materials to conduct electricity more efficiently when exposed to light. LDR sensors are made of a semiconductor material that has high resistance in the dark and low resistance in the light. When an LDR sensor is exposed to light, photons from the light source excite the electrons in the semiconductor material, which causes an increase in the number of free electrons, and hence, a decrease inthe resistance of the LDR sensor.

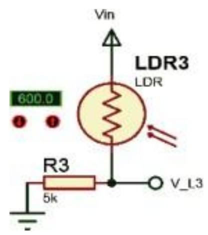


Fig: 9 LDR

Conversely, in the absence of light, the electrons in the semiconductor material do not have sufficient energy to conduct electricity, resulting in a high resistance of the LDR sensor. The resistance of an LDR sensor is measured in ohms, and it varies with the intensity of the light. Therefore, LDR sensors are commonly used as voltage dividers in electronic circuits to measure the amount of light present in the environment. In summary, LDR sensors work by varying their resistance based on the quantity of light they receive. The increase in the number of free electrons in the semiconductor material of the LDR sensor when exposed to light results in a decrease in the resistance of the sensor [19].

The Hybrid Ai-Iot Model

The generation of non conventional resource of energy refers to a system that combines artificial intelligence, IoT, and renewable energy sources to generate electricity. The algorithm of AI technique is shown in Fig: 10.

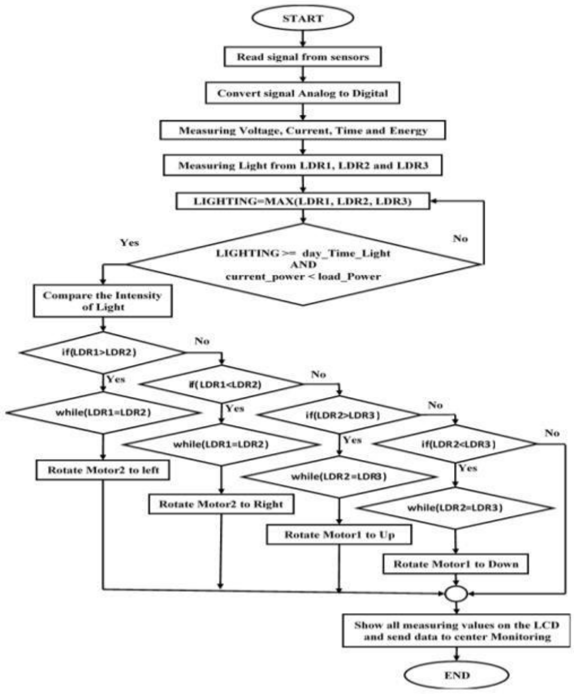


Fig: 10. Algorithm for Operation of AI based IoT.

The operation and working principle of this model involve the following steps:

In summary, the hybrid AI-based IoT model of generation of non-conventional resource of energy combines the power of artificial intelligence, internet of things, and renewable energy sources to create a smart and efficient energy generation and distribution system [20].

Thermo Electric Peltier Plate:

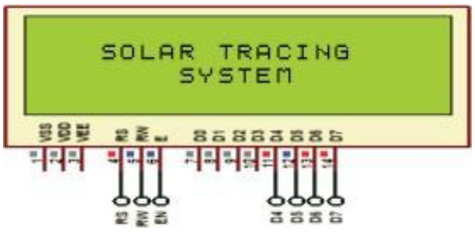
The Thermo Electric Peltier (TEP) Plate measures temperature using platinum. It operates on the premisethat the permeability of platinum varies with temperature. The thermometer measures temperatures ranging from200°C to 1200°C. Platinum is a dull metal that may be easily fashioned into tiny wires. Platinum is utilized as a sensing element in thermometers because to its characteristics. Platinum's resistance increases linearly with temperature, and this feature of the metal is used to measure temperature. Platinum resistance is evaluated by putting an alternating or direct current through it. The voltage induces across the metal due to the current, which is measured by the voltmeter. The measurement equation is used to translate the voltage data into the temperature.

Pv Solar Panel

The majority of modules employ thin film or plate-based crystalline silicon blocks. The top or rear layerof the module may serve as the structural (bearing) component. For modeling, we made advantage of Proteus's already-existing SP module [12]. One commonly used approach is the system-level modeling, which involves the creation of a model that represents the entire renewable energy system, including the energy source, storage, conversion, and distribution. This model can be used to simulate the performance of the system under different conditions, such as changes in weather patterns or energy demand. Another approach is the techno-economic modeling, which considers both the technical and economic aspects of renewable energy systems. This type of modeling can help to identify the optimal mix of renewable energy sources based on factors such as cost, energy efficiency, and environmental impact.

There are also modeling tools that can be used to assess the potential of renewable energy resources in agiven area. For example, a geographic information system (GIS) can be used to map the availability of solar, wind,or hydro resources in a particular region, and to analyze their potential for electricity generation. Overall, renewable energy modeling plays an important role in the transition towards a sustainable and low-carbon energy future, by providing insights into the optimal use of renewable resources and helping to design and optimize renewable energy systems.

Fig: 11 LCD display



Battery:

Battery is a device that transforms chemical energy to electrical energy. Battery chemical reactions include the transfer of electrons from one substance to another via an external circuit.

Sim-Subscriber Identity Module

The SIM card connector is made up of a body with a slot for placing a SIM card and several connected-through receptacles for holding conducting terminals. An electrical signalling contact with the SIM card can be created through the conducting terminals. Wireless communication techniques are rapidly evolving, and this has led to the production of a wide range of portable electronic items. The mobile device for communication is amongthe most popular and adaptable technological goods. A mobile phone number often correlates to a SIM card in a mobile telephone communication system.

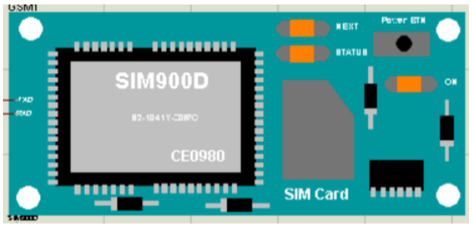


Fig: 12. SIM900D model.

When a mobile phone user inserts the SIM card into the phone, the system immediately recognizes the user and provides the necessary transmission and data collection services for billing reasons.

Result Analysis

A hybrid AI-based IoT system for the generation of renewable energy can provide a comprehensive analysis of energy production, consumption, and storage. Such a system could use a combination of AI algorithms and IoT devices to optimize renewable energy generation and utilization.

The IoT devices can be used to gather real-time data from renewable energy sources. This data can be analyzed using machine learning algorithms to identify patterns and make predictions about energy production and consumption. The AI-based IoT system can also be used to monitor and control energy storage systems such as batteries and capacitors, ensuring that energy is stored and used efficiently. This can help to reduce energy waste and optimize the use of RES. The analysis of the data collected by the hybrid AI-based IoT system can provide valuable insights into the efficiency of renewable energy systems and identify areas for improvement. The results of Arduino based hybrid generating system run in Arduino v1.8.19for different case studies are explained in following sections.

Maximum Radiation To Solar Pv System:

In this study both LDRs are nearer to solar panel, solar panel is generating maximum power and it is shown in simulation display. Fig: 13 show the maximum power tracking from solar PV plate.

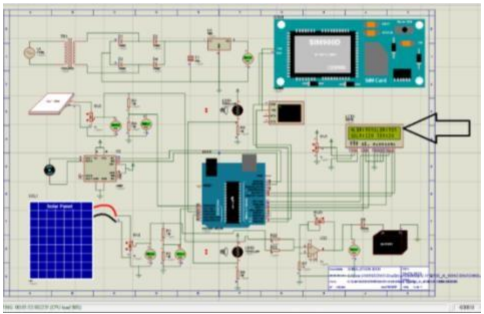


Fig: 13 High efficiency in PV system.

Light Radiation In South Side

In this case considering the evening time, such as south side more radiation is occurring. South LDR is nearer to solar PV system, North LDR is far from Solar PV system. Display shows the 95% of solar radiation on PV system shown in Fig. 14

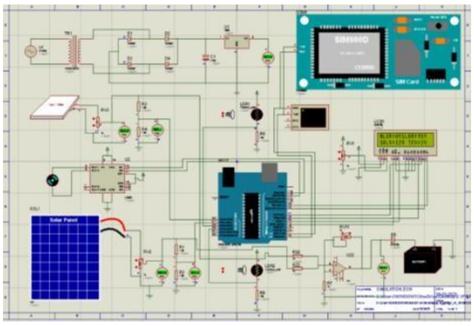


Fig: 14. South LDR active at solar PV system.

Light Radiation In North Side

In this case considering the morning time, such as north side more radiation is taking place. North LDR is nearer to solar PV system, South LDR is far from Solar PV system. Display shows the 95% of solar radiation on PV system shown in Fig.15.

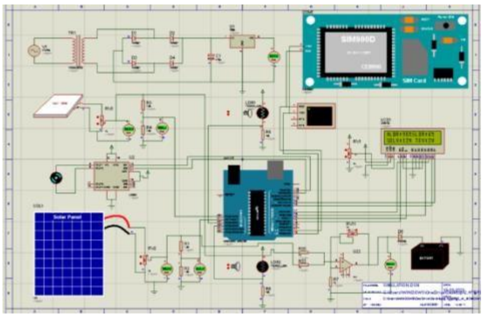


Fig: 15 North LDR active at Solar PV system.

No Light Radiation

In this case considering the night time, South LDR and North LDR is far from Solar PV system. Display shows the 0% of solar radiation on PV system shown in Fig.16.

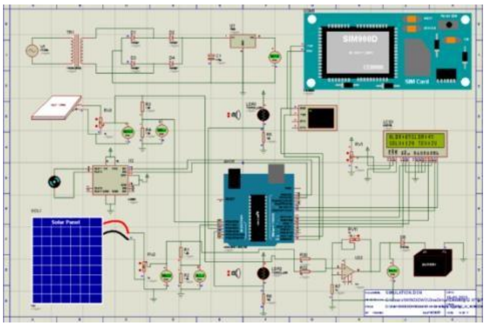


Fig: 16 Low light radiation.

Thermo Electric Peltier (Tep)

In this TEP depends on heat for entire day it is same such that power generation in TEP is 2v. Absence of solar power this TEP will send the power to the battery and this operation shown in Fig.17.

Fig: 17 TEP power generation.

Conclusion

This study discussed the design and functioning of a flexible and wireless hybrid energy control strategy. Data about solar PV system characteristics such as temperature, light intensity, voltage, and current are communicated. The temperature sensor that measures changes in ambient temperature, the LDR sensor for measuring light intensity, and the voltage divider technique for measuring voltage were used to reduce the maximum value of the solar panel to a voltage value acceptable for the Arduino of power supply. This hybrid system is totally automated and can monitor all parameters under the supervision of an IoT-driven controller. In order to produce electrical energy from solar and thermal platinum for domestic appliances and industrial sectors, we created a novel IoT-based system. We evaluated the renewable sources using AI models.

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