IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Ai-Powered Solar Energy Management System

A Prototype for Future Energy Solutions

[1] N. Navya Saahithi, [2]A. Maheshwar, [3]V. Sai Satish Chandra, [4]M. Shashidhar, [5]Dr. P. Duraipandy

[1]Student, [2]Student, [3]Student, [4]Student, [5] HOD & Dean IQAC

[1]ELECTRICAL AND ELECTRONICS ENGINEERING(EEE)Department,

[1]JB Institute of Engineering and Technology, Hyderabad, India

Abstract: Solar Energy has become a great initiative in our society which leads to new economic and technology solutions. Solar Energy and Intelligent communities increase efficiency with the use of AI algorithms for the profits and savings of inhabitants and companies. This project focuses on the development of a methodology of Energy Management, combining solar energy and storage systems. Additionally, to monitor real-time consumption a machine learning module is included in our project which generate predictions about the future energy demand by collecting data from various sources, including weather forecasts and solar panel outputs. According to the case study of Boarding School, located in Turin (Italy)given in the base paper showed an increase of 25% to 95% minimum cost of purchased energy,55% reduction in electricity bill compared to most solutions in market, with no additional costs and stabilizing effect on grid. Finally, this project kit can showcase contribution to sustainable development by optimizing energy production, reducing environmental impact and promoting renewable energy adoption. MPPT technique is used which ensures maximum energy harvesting from solar panels and raspberry pi is used for data collection and processing, sensor integration and monitoring, AI algorithm execution, Real-time control and automation & web-based interface for monitoring and control.

Index Terms - Artificial Intelligence (AI), Solar Energy Management System (SEMS), Renewable Energy, Energy Efficiency, Smart Energy Management, Machine Learning (ML), IoT (Internet of Things), Energy Storage Systems (ESS), Solar Panel Optimization, Predictive Maintenance, Energy Forecasting, Grid Management, Sustainable Energy, Energy Automation, Solar Energy Monitoring.

I. INTRODUCTION

The AI-Powered Solar Energy Management System (AI-SEMS) combines Artificial Intelligence with Battery Management Systems (BMS), inverter, and IoT technologies such as ThingSpeak and DHT11 sensors to create a comprehensive solution for optimizing solar energy utilization.

Leveraging machine learning algorithm, AI-SEMS analyses real-time data from solar panels, battery storage, and inverter performance to predict energy generation and consumption patterns. The BMS component ensures optimal battery health and performance by managing charging and discharging cycles based on predictive analytics. Inverters efficiently convert solar energy into usable power, while ThingSpeak facilitates remote monitoring and data visualization, enabling users to access critical system metrics in real time.

II. OBJECTIVES

- To store Solar energy in a rechargeable battery through a charging circuit. The Raspberry Pi controls when the charging should occur based on the SOC and SOH parameters.
- To utilize an inverter to convert the battery's DC power into AC power for supplying an AC load.

- To monitor critical parameters like voltage, current, and temperature of both the battery and solar panel, ensuring efficient power storage and usage using raspberry pi.
- To monitor continuously the Environmental data such as light intensity, temperature, and humidity and send to the ThingSpeak Cloud for remote access and analysis. This allows users to track real-time data from anywhere.
- To monitor the status of the project, including battery health, temperature, and other parameters, is displayed on an LCD screen, providing instant feedback to the user.
- To notify the user in case of any unusual conditions in the system by incorporating an abnormal alert system (Buzzer) to improve safety and reliability.

III. COMPONENTS USED

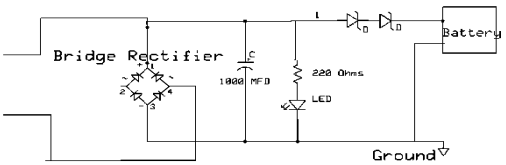
1) *Adapter(5v):*

Adapter is used to provide the power supply to the Raspberry pi zero 2w.

2) *Solar Panel (12v,10w):*

A solar cell (also called photovoltaic cell) is a solid-state device that converts the energy of sunlight directly into electricity by the photovoltaic effect. Assemblies of cells are used to make solar modules, also known as solar panels.

3) *Lithium Ion Battery*



Lithium-ion battery is a type of rechargeable battery commonly used in solar energy management systems to store excess energy generated by solar panels, the li-ion battery offers high energy density, long cycle life and relatively low self-discharge rates.

4) *Charging Circuit*

The input from solar panel i.e.12v dc is being stored into the battery with the help of rectifier and 1000MF capacitor used. We can get 12V Steady DC at the output terminal is fed to the rechargeable battery which can be indicated if the LED glows. Here we are using diodes for reverse current protection. Diodes will conduct in forward bias.

Figure 1 charging circuit

5) *Led Indicator*

LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component.

6) **Raspberry Pi (Zero 2w)**

Raspberry Pi Zero 2W does have built-in Wi-Fi connectivity, which supports the 2.4 GHz and 5 GHz IEEE 802.11b/g/n/ac wireless LAN, Bluetooth 5.0, BLE that the Raspberry Pi Zero 2W can connect to wireless networks and Bluetooth devices without requiring additional hardware.

7) *Arduino Nano (Atmega328 SMD)*

Arduino nano works as an ADC converter. Arduino Nano is based on the ATmega328 SMD chip. It has14 digital input/output pins (of which 6 can be used as PWM outputs), 8 analog inputs, 1 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, and a reset button.

8) Relay (12v)

Relay is an electromagnetic switch. When an electric current is passed through the coil, the resulting magnetic field attracts the armature and the consequent movement of the movable contact or contacts either makes or breaks a connection with a fixed contact.

9) Voltage Sensor

Voltage sensor is a device that measures the voltage levels in a solar panel or array.

10) Current Sensor (Acs712)

ACS712 Current Sensor is the sensor that can be used to measure and calculate the amount of current applied to the conductor without affecting the performance of the system.

11) Humidity Sensor (Dth11)

A **humidity sensor** senses, measures and regularly reports the relative humidity in the air. It measures both moisture and air temperature.

12) Temperature Sensor

A temperature sensor measures the temperature of the solar panels, ambient air or other system components. This data is used to monitor, protect and optimize the energy. Measurement ranges from 20 to 120 Degree Celsius.

13) Light Intensity Sensor

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light.

14) Buzzer (Piezo-Electric Type)

Piezo electric buzzer, it generates sound because of the piezoelectric effect.

15) Lcd Display

A liquid crystal display (LCD) is a thin, flat electronic visual display that uses the light modulating properties of liquid crystals. Liquid crystal display is very important device in embedded system. It offers high flexibility to user as it can display the required data on it. These are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft, cockpit displays, signage, etc.

16) MOSFET

The metal–oxide–semiconductor field-effect transistor (MOSFET, MOS-FET, or MOS FET) is a transistor used for amplifying or switching electronic signals.

17) Mono Stable Multi Vibrator (IC CD 4047)

CD 4047 is the low power Mono stable / Astable Multi vibrator that require only an external capacitor and a resistor to give the output pulses with logic techniques incorporated to permit positive or negative edge-triggered mono stable multi vibrator action with retriggering and external counting options.

18) ThingSpeak

ThingSpeak is a cloud-based platform that lets we collect, store, analyze, and visualize data from internet-connected devices. It's part of the Internet of Things (IoT). We can send data to ThingSpeak from any device using a REST API.

IV. SOFTWARE USED

SARIMAX, which stands for Seasonal Auto Regressive Integrated Moving Average with exogenous regressors. SARIMAX is a statistical model commonly used for time series forecasting, including applications in solar energy management.

In the context of machine learning-powered solar energy management systems, SARIMAX models are employed to predict solar irradiance and photovoltaic (PV) output. Accurate forecasting of solar energy production is crucial for optimizing energy storage and overall system efficiency.

For practical implementation, SARIMAX models can be developed using programming languages like Python, utilizing libraries such as stats models for time series analysis. Integrating SARIMAX with other AI techniques can further enhance forecasting accuracy and system optimization.

Language Used:

- Arduino nano for ADC value reading using C language.
- Python language for raspberry pi

V. WORKING PRINCIPLE

Solar energy is obtained stored into the rechargeable battery through charging circuit and this Battery power is uses to turn ON the AC load using Inverter. The main controlling device of the project is Raspberry pi Zero 2W which has inbuilt Wi-Fi. The Raspberry Pi measures the SOC (State-of-Charge) and SOH (State-of-Health) from voltage and current sensors and based on that it will turn ON/OFF the relay for battery charging. Here relay works as a switch to ON/OFF the charging connection. Also, it will monitor the voltage, current, temperature, light intensity of the solar panel and SOC, SOH values of BMS, and integrates this data into the ThingSpeak CLOUD. This system continuously monitors environmental parameters, including temperature and humidity, through DHT11 sensor, and integrates this data also into the ThingSpeak CLOUD. The status of the project will display on LCD. This system consists of BZEER which can gives the abnormal alert to the person.

VI. RESULT AND OBSERVATIONS

- Efficient Solar Energy Management,
- Real-Time Monitoring and Control,
- Battery Health and Longevity,
- Remote Monitoring via Cloud,
- Enhanced System Safety,
- Automation and Efficiency,
- User-Friendly Interface,
- Data Analytics for Performance Improvement,
- Sustainability and Reduced Environmental Impact,
- Scalable and Flexible System,
- Proven Concept for Renewable Energy Solutions

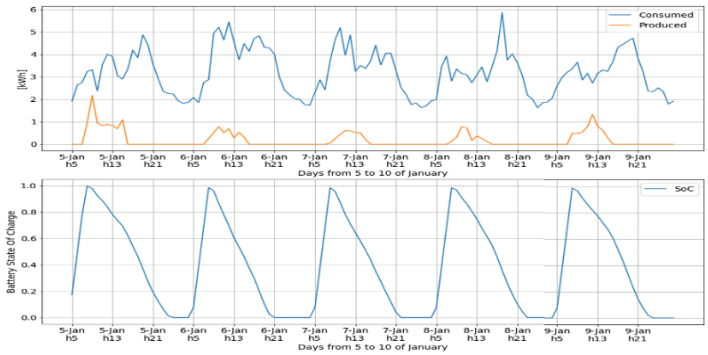


Figure 2 optimized January hourly results

VII. ADVANTAGES

- **Eco-Friendly and Sustainable**: The system uses solar energy, a renewable resource, which helps reduce reliance on traditional power sources and lowers carbon emissions**.**
- **Smart Battery Management:** It keeps track of the battery's charge level and health, ensuring it's charged correctly and lasts longer.
- **Real-Time Monitoring:** The system monitors important information like battery status, solar panel performance, and environmental conditions, and shows it on an LCD screen. You can also access this data remotely via the ThingSpeak Cloud.
- **Cloud-Based Data:** By uploading data to the cloud, users can monitor the system remotely and analyze its performance over time**.**
- **Environmental Monitoring:** The system also checks temperature and humidity, providing a full picture of the conditions that affect energy production**.**
- **Easy-to-Read Display:** The LCD screen makes it simple to see the status of the system at any time.
- **Alert System:** If something goes wrong (like a fault in the system), the BZEER alert system will notify you to take action.
- **Saves Money:** Using solar power reduces electricity bills, and the system is designed to be cost-effective in the long run**.**
- **Automatic and Convenient:** The system works automatically, managing battery charging and usage, so you don't need to constantly monitor it.
- **Flexible and Expandable:** It can be customized for different sizes of solar panels and power needs, and you can easily upgrade it in the future.

VIII. CONCLUSION

The AI-powered solar energy management system presented in this project demonstrates the potential for artificial
intelligence to revolutionize the way we harness and utilize solar energy. By integrating advanced machine learning algorithms with real-time monitoring and control systems, this project showcases a comprehensive solution for optimizing solar energy production, reducing energy waste, and promoting sustainable energy practices

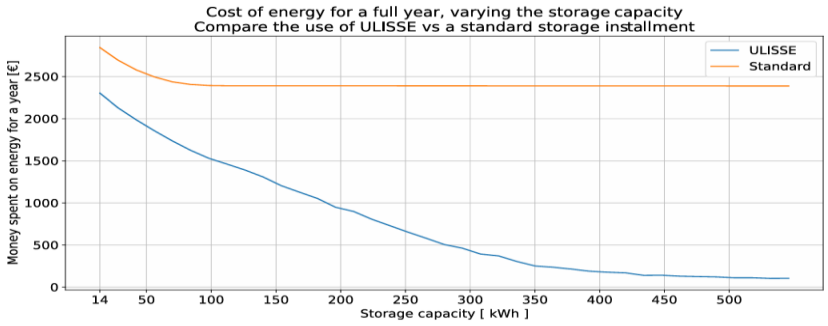


Figure 3 traditional method vs AI

REFERENCES

[1] Iyer, S. S., Kumar, S., & Kumar, R. (2023) "An Efficient Artificial Intelligence Energy Management System for Urban Building Integrating Photovoltaic and Storage," IEEE Access,11,1-13.
[2] Singh, A. K., Kumar, R., & Srivastava, S. (2023) "Impact of Artificial Intelligence on Energy Management: A Revolutionary Shift in the Power Industry," International Journal of Creative Research Thoughts (IJCRT), 11(5), 1-8.
[3] Patel, R. (2020) "AI-Driven Solar Energy Management System for Smart Homes." IEEE International Conference on Smart Energy Systems and Technologies (SEST), 1-6.