IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 5, April 2024

IOT Based Solar and Wind Water Heater System

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Abstract: *The IoT-based Solar and Wind Water Heater System offers a sustainable and efficient solution for water heating by harnessing renewable energy sources such as solar and wind power. By integrating IoT technology, the system optimizes energy usage, enables remote monitoring and control, and reduces carbon emissions, contributing to a cleaner and more sustainable environment. With its ability to adapt to various applications and provide cost savings through free renewable energy, this innovative system promises to play a crucial role in mitigating climate change and promoting a greener future.*

Keywords: Renewable, IoT, Efficiency, Sustainability, Optimization

I. INTRODUCTION

1.1 Overview

In the realm of water heating, the landscape has been traditionally dominated by gas and electric systems, driven by the imperative to meet the demands of modern living. However, in recent years, a shift towards more sustainable and energy-efficient solutions has gained momentum. This shift has been catalyzed by growing environmental concerns and the escalating costs of conventional energy sources. In response, technologies such as solar water heaters have emerged, capitalizing on the abundant and renewable energy provided by the sun. Yet, the march towards sustainability doesn't halt there.

Enter the IoT-based solar and wind water heater system—an innovative fusion of renewable energy and smart technology. This concept represents a natural progression in the evolution of water heating solutions, leveraging advancements in both renewable energy and connectivity. By integrating solar and wind energy sources with IoT technology, this system offers a holistic approach to water heating that is both efficient and intelligent.

At its core, this system embodies the convergence of two key trends: the proliferation of renewable energy sources and the rise of IoT connectivity. It harnesses the inexhaustible power of the sun and wind, tapping into nature's bounty to fulfill our energy needs. Furthermore, it leverages IoT technology to optimize energy production and consumption, providing users with unprecedented control and efficiency in their water heating operations.

As society navigates the intersection of sustainability and technological innovation, the IoT-based solar and wind water heater system stands as a beacon of progress. It represents a paradigm shift in how we approach energy consumption, offering a glimpse into a future where sustainability and efficiency go hand in hand. In this era of heightened environmental consciousness, this system offers a tangible solution—a bridge between our aspirations for a cleaner planet and the realities of modern living.

1.2 Motivation

Our motivation stems from the urgent need to address the escalating challenges posed by climate change and dwindling fossil fuel reserves. Fueled by this imperative, we are driven to design a system that seamlessly integrates renewable energy sources such as solar panels and wind turbines. By maximizing energy capture and conversion efficiency, we endeavor to usher in a new era of sustainable energy utilization. Furthermore, our dedication to leveraging IoT technology aims to empower users with real-time monitoring, remote control capabilities, and predictive maintenance algorithms. Through these endeavors, we aspire to ensure a consistent and reliable energy supply for water heating, irrespective of varying weather conditions. Ultimately, our goal is to contribute towards a cleaner, more resilient future, where renewable energy solutions play a central role in mitigating climate change and securing energy sustainability for generations to come.

1.3 Problem Definition and Objectives

The problem at hand revolves around the inefficiencies and challenges inherent in traditional water heating methods, exacerbated by environmental concerns and the finite nature of fossil fuel resources. To address this, our focus is on developing an innovative solution that seamlessly integrates renewable energy sources, namely solar and wind, into a cohesive system for water heating. By doing so, we aim to tackle the pressing issues of energy sustainability, carbon emissions, and reliance on non-renewable energy sources. Our goal is to design a system that optimizes energy capture, distribution, and utilization while ensuring reliability and resilience, even in the face of fluctuating weather conditions. Through this endeavor, we seek to pave the way towards a more sustainable and environmentally conscious approach to water heating, thereby contributing to the broader effort of combating climate change and securing a cleaner future for generations to come.

- To design a system that seamlessly integrates solar panels and wind turbines to maximize energy capture and conversion efficiency.
- To develop an IoT-based control system that enables real-time monitoring, remote control, and data analysis for optimized energy distribution and water heating.
- To ensure the system can provide a consistent and reliable energy supply for water heating, even during varying weather conditions and fluctuations in energy generation.
- To implement predictive maintenance algorithms using IoT data to detect and address system malfunctions or inefficiencies before they lead to downtime.

1.4.Project Scope and Limitations

The scope of this project encompasses the design, development, and implementation of an integrated system that combines solar panels and wind turbines for water heating purposes. This includes the creation of an IoT-based control system for real-time monitoring, remote control, and data analysis to optimize energy distribution and maximize efficiency. Additionally, the project will involve testing the system's performance under various weather conditions to ensure reliability and consistency in energy supply for water heating applications.

Limitations As follows:

- Geographic Limitation: The effectiveness of solar panels and wind turbines may vary based on geographical location and local weather patterns, which could impact the system's overall performance.
- Initial Investment: The implementation of renewable energy systems often requires a significant initial investment, which may pose financial constraints for certain users or applications.
- Maintenance Requirements: While predictive maintenance algorithms can help detect and address issues proactively, ongoing maintenance and servicing of the system are essential to ensure long-term reliability and efficiency, which may require additional resources and expertise.

II. LITERATURE REVIEW

Development of IoT based solar water controller (Jan 2023):

This paper focuses on analyzing and enhancing the efficiency of a solar water heating (SWH) system using IoT technology. It utilizes IoT data to gain insights into the system's performance and environmental conditions, aiming to identify areas for improvement in individual SWH components. Additionally, it designs control strategies to ensure the smooth operation of the system.

IoT-enabled smart solar water heater system using real-time ThingSpeakIoT platform (Jun 2023):

This paper introduces an IoT-enabled solar water heater system aimed at reducing water wastage compared to conventional systems. The IoT system continuously monitors parameters such as tank level, temperature, and pH level. Data collected by IoT nodes are uploaded to the ThingSpeak platform in real-time for analysis and management.

IoT-based performance analysis of hybrid solar heater-double slope solar still (Dec 2021):

The article describes a monitoring system integrated with a hybrid solar heater-double slope solar still. IoT techniques are employed to post parameters like air temperatures and relative humidity on a webpage. The study demonstrates the system's effectiveness in desalinating water, achieving chemical parameter values similar to mineral water. Additionally, the addition of a solar preheater is shown to accelerate the evaporation process, improving the prototype's efficiency.

Design and Implementation of IoT Based Smart Water Heating System (Jun 2020):

This research aims to develop a flexible, economical, and portable IoT-based smart water heating system. The system's objective is to prevent water wastage and analyze water usage effectively. It offers features such as analyzing water temperature to ensure it meets user requirements. The system's applicability extends to various industries like oil and automotive.

Deep Learning-Based Smart Hybrid Solar Water Heater Erection Model to Extract Maximum Energy (Oct 2022):

This paper proposes a deep learning-based model for optimizing the operation of a smart hybrid solar water heater. It discusses the challenges of using a heat exchanger when the main heat source is switched off in the summer. The paper describes the operation of the system, including the roles of heat pumps, solar collectors, and heat exchangers in heating water efficiently.

III. REQUIREMENT AND ANALYSIS

12V Wind Generator:

A 12V wind generator, also known as a wind turbine, harnesses the kinetic energy from wind and converts it into electrical energy, commonly stored in a 12-volt battery system. Primarily used in off-grid or remote locations, these generators power small electrical devices or appliances. Key features include a rated power of 200W, rated voltage of 12V, and a start-up wind speed of 2m/s.

PWM Charge Controller:

A PWM (Pulse Width Modulation) charge controller is crucial in solar power systems for regulating battery charging from solar panels. Specifically designed for lead-acid batteries, it controls voltage by rapidly switching solar panel output on and off. Noteworthy features include operating temperature ranging from -20°C to 55°C, charging mode using PWM, and a maximum charge current and discharge current of 20A.

NodeMCU (IoT):

NodeMCU is an open-source firmware and development board based on the ESP8266 WiFi module, facilitating IoT application development. With features like a 32-bit Tensilica microcontroller, Wi-Fi connectivity, and various I/O pins, it's suitable for DIY IoT projects. Operating voltage is 3.3V, with digital I/O pins numbering 16, UARTs, SPIs, and I2Cs available.

Temperature Sensor:

Temperature sensors measure temperature electronically and are commonly used across industrial, scientific, and consumer electronics applications. The DS18B20 digital temperature sensor, for instance, operates within a voltage range of 3V to 5V, offers a temperature range from -55°C to 125°C, and features a conversion time of 750ms at 12-bit resolution.

DHT-11:

The DHT11 is a low-cost, popular digital temperature and humidity sensor module commonly used in DIY and small-scale electronics projects. It provides digital output for both temperature and humidity values and operates at voltages between 3.5V to 5.5V. With an accuracy of 1°C and 1% humidity, it's suitable for various applications.

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12V Lithium Battery:
A 12-volt lithium battery is rechargeable and provides a voltage output of 12 volts. Commonly used in portable electronics, electric vehicles, and solar power storage, these batteries have specific temperature ranges for optimal performance. Key features include a capacity of 12AH, dimensions of 151mm x 98mm x 94mm, and a weight of 4.20kg.

Inverter Circuit:
An inverter circuit converts direct current (DC) power into alternating current (AC) power. Specifications may include input voltage range, peak power output, AC output voltage and frequency, and maximum efficiency. For example, a typical inverter circuit may have a DC input voltage range of 38V to 62V, peak power output of 9 kW, and an AC output voltage of 230V.

Heating Coil & LED Bulb:
A heating coil generates heat when an electric current passes through it, commonly used in various heating applications. LED bulbs produce light using LED technology and are energy-efficient alternatives to traditional bulbs. Features may include power ratings, maximum temperature, and power supply requirements.

Display:
Display specifications refer to the technical characteristics of visual display devices, including size, resolution, and technology used. For example, a display may have a viewing area of 77.00mm x 25.20mm, an active area of 70.40mm x 20.80mm, and support for various display technologies such as IPS or OLED.

SSR Relay:
A Solid-State Relay (SSR) is an electronic switch used to control electrical current without moving parts. Features may include operational ratings, frequency range, maximum voltage, and current ratings. SSRs offer advantages over traditional relays and are commonly used in various applications.

Wires:
Wire specifications include parameters such as conductor material, gauge size, and maximum current capacity. For example, copper wires are commonly used for their excellent conductivity, while aluminum wires may be used in high-voltage transmission lines. Wire specifications ensure that the wire meets the requirements of the application and operates safely within specified temperature ranges.

DC Voltage Sensor:
A DC voltage sensor measures and monitors direct current (DC) voltage levels in various applications. Features may include input voltage range, analog voltage output, and resolution. DC voltage sensors are used in power monitoring, control systems, and battery voltage monitoring applications.

Push to ON Switch:
A "Push to ON" switch, also known as a momentary push-button switch, temporarily completes an electrical circuit when pressed. Features may include operational ratings, such as voltage and current, and switch type, such as normally open (NO) or normally closed (NC). These switches are commonly used in applications requiring temporary or momentary control.

IV. SYSTEM DESIGN

4.1 System Architecture
The below figure specified the system architecture of our project.

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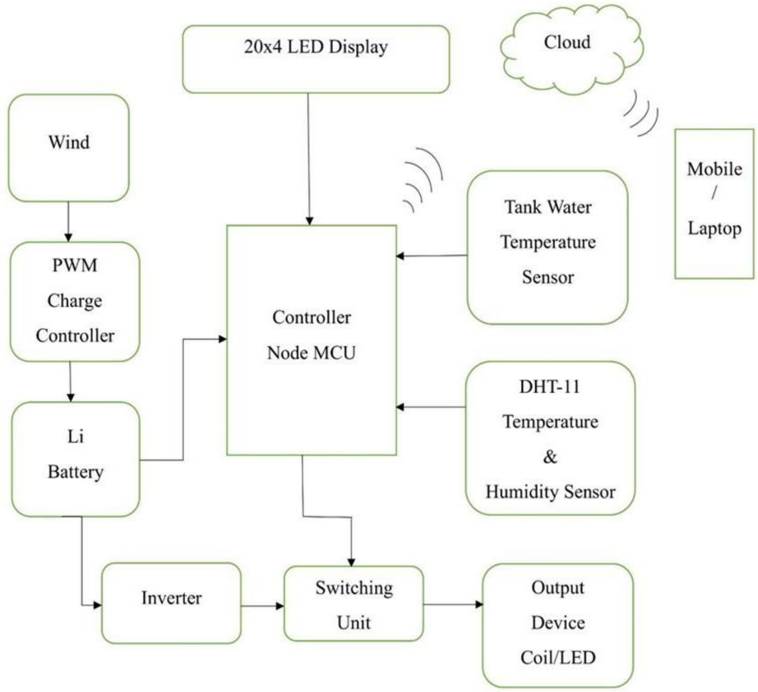

Figure 4.1: System Architecture

4.2 Working of the Proposed System

The proposed system operates by harnessing the kinetic energy of wind through wind turbines, which are commonly referred to as wind energy generators. As the wind interacts with the turbine blades, kinetic energy is converted into electrical energy. This generated energy undergoes modulation through a Pulse Width Modulation (PWM) charge controller, which ensures a constant output voltage suitable for charging the battery.

For efficient and rapid charging, lithium batteries are employed due to their high capacity and fast-charging capabilities compared to traditional liquid or gel batteries. The charged battery acts as an energy reservoir for subsequent use in powering various devices or appliances.

To convert the stored DC energy into AC power, an inverter is utilized. The inverter serves a dual purpose – activating the heating coil for water heating and providing AC supply to output devices such as LEDs and fans. The switching unit, controlled by a microcontroller or NODEMCU, regulates the ON/OFF status of output devices based on predefined conditions.

The microcontroller plays a central role in the system's operation. It employs temperature sensors to monitor the water tank temperature, atmospheric temperature, and humidity levels. When the water temperature falls below a specified threshold, and the atmospheric conditions warrant heating, the microcontroller triggers the activation of the Solid State Relay (SSR), thereby turning on the heating coil for water heating. These temperature and environmental parameters, along with the battery level, are displayed on an LED display for real-time monitoring and user convenience.

The microcontroller or NODEMCU integrates a built-in WIFI module, facilitating connectivity to the internet for IoT functionality. This connectivity enables users to monitor and control the system remotely via mobile devices or laptops through cloud-based platforms. Through these interfaces, users can access detailed information about the system's operation, make adjustments, and receive notifications, enhancing overall system management and user experience.

4.3 Circuit Diagram

The below figure specified the circuit diagram of our project.

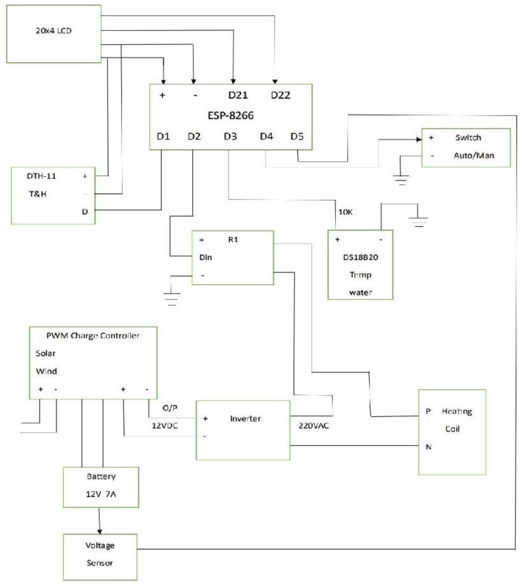

Figure 4.2: Circuit Diagram

4.4 Result

Figure 4.5: Output of Project

The IoT-Based Solar and Wind Water Heater System successfully integrates renewable energy sources, such as solar and wind power, with advanced IoT technology to efficiently heat water in off-grid or remote locations. By harnessing the kinetic energy of wind through a 12V wind generator and converting solar energy into electrical power with a PWM charge controller, the system ensures reliable energy generation. Additionally, the inclusion of components like temperature sensors, a NodeMCU for IoT connectivity, and SSR relays for control enhances system monitoring and automation. With this innovative solution, users can enjoy consistent hot water supply while reducing reliance on conventional energy sources, contributing to sustainability efforts and environmental preservation.

V. CONCLUSION

Conclusion

The systems ability to harness renewable energy sources can lead to long term cost savings on energy bills. It reduces green house gas emission and lower carbon footprint are positive outcomes of using renewable energy source.

In conclusion, an IoT based solar and wind water heater represents a promising solution for sustainable efficient and remotly manageable water heating. Its environmental and economical benefits make it valuable choice for home owners and businesses looking to reduce their energy footprint.

Future Work

In future iterations, the IoT-based solar and wind water heater system could explore enhancements such as integrating machine learning algorithms to optimize energy distribution based on predictive weather patterns and user behavior. Additionally, advancements in battery technology could enable the incorporation of higher-capacity and longer-lasting energy storage solutions, further enhancing system efficiency and reliability. Moreover, research into improving the integration of renewable energy sources with the grid infrastructure could lead to the development of more robust and scalable solutions, ultimately contributing to a more sustainable and resilient energy ecosystem.

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