ARDUINO BASED EFFICIENT ENERGY STORAGE SYSTEM USING SOLAR AND WIND POWER

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ABSTRACT

This project describes an Arduino-based hybrid energy storage system that stores solar and wind energy in batteries for reuse. The system is particularly suited for off-grid locations, and provides optimized energy collection and management. An Arduino micro controller keeps track of energy production, battery status, and weather conditions. For both the solar panels as well as the wind turbine MPPT, or Maximum Power Point Tracking, is used to obtain maximum output from the system. When wind or solar power is not available, the stored energy can be used to power devices. It is an inexpensive, scalable, clean way of storing energy that has been proven to work. It encourages renewable resources via smart control and real-time monitoring.

KEYWORDS: Arduino Based Efficient Energy Storage System, Solar and Wind Power, Efficient Energy Storage, Efficient Energy Storage System Using Solar and Wind Power, Energy Storage System.

1. INTRODUCTION

Solar and wind: Renewable energy sources are an important tool for sustainable generation. Yet the efficient storage of this power for when we need it is a daunting task. We work on Arduino based energy storage system which store the energy generated from solar panels and wind turbine and also manage automatically. Using sensors and controllers, it collects, stores, and distributes energy effectively while maximizing energy efficiency. The cost-effective and easy-to-use design based on Arduino ensures the reliability and accessibility of renewable energy for the most applications.

The followings are the key features of the Arduino Based Efficient Storage System Using Solar And Wind Power.

1.1 KEY FEATURES:

1. **Hybrid Renewable Energy**

Combines solar panels and a wind turbine to generate electricity irrespective of the weather, giving a stable source of power.

2. **Arduino-Based Smart Control**
   Arduino keeps track of voltage, current, battery life, and manages the system for power control and automation efficiently.
3. **Smart Energy Storage**
   Stores surplus energy in batteries with overcharge and deep discharge to prolong the life of the battery and stabilize.
4. **Charge Controller Integration**
   Equipped with PWM or MPPT charge controllers for maximizing solar and wind energy to battery storage energy conversion.
5. **Real-Time Monitoring & Display**
   Live system data (such as battery level, input voltage) display on LCD/OLED displays or are retrieved using a serial monitor.
6. **Eco-Friendly & Expandable**
   Promotes clean energy, reduces grid reliance, and can be added in the future in a modular fashion.

2. OBJECTIVE OF THE PROJECT

The primary objective of this project is to design and develop a Low-Cost Arduino Based Efficient Energy Storage System. It facilitates efficient energy management at low cost. The primary objective of this project is to make the system easy to use, and also control this system with very little knowledge. Renewable energy systems are a perfect example. These systems have come a long way from mere energy harvesters to advanced systems with autonomous energy management, communication, and environmental adaptation. Even though they have come a long way, their relatively high cost ensures that most advanced energy storage solutions are beyond the reach of the masses. This project is intended to break the limitations of commercially available systems by being a part of the design and development of a Low-cost Arduino Based Efficient Energy Storage System Using Solar and Wind Power.

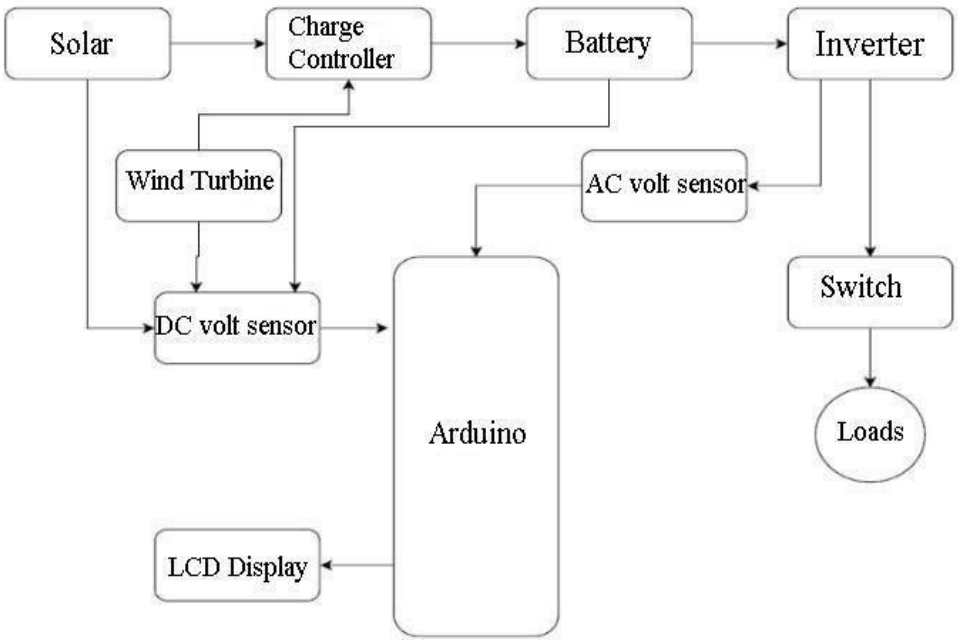

Fig.1 Block Diagram

The Arduino-based efficient energy storage system using solar and wind power block diagram is shown fig. This block diagram consists of Arduino UNO ,Solar panel, Battery, AC voltage sensors, DC voltage sensors, Buck Boost module, Solar Charge Controller, LCD display, Dynamo motor, Inverter module .The key component of Arduino based efficient energy storage system is voltage sensors to measure the voltage .Solar and Dynamo is to generate the power supply .A Dynamo motor is attached to a stand which is equipped with the propeller. The power supply is given to the Arduino UNO board the entire system is run by battery. Arduino will display the respective reading in the LCD display.

3. MAJOR COMPONENTS USED

3.1 MAJOR COMPONENTS

The following components are the major components to construct this project.

3.1.1 Arduino UNO – A micro-controller board utilized to sense and regulate all the devices plugged in with the help of programming in the Arduino IDE.

3.1.2 Solar Charge Controller – Controls power from the solar panel to the battery to prevent overcharging and over discharging.

3.1.3 Battery – To store electrical power obtained from the dynamo or solar panel for later use.

3.1.4 ZMPT101B AC Voltage Sensor –Safely measures AC voltage levels and gives feedback to Arduino to be read or controlled.

3.1.5 DC Voltage Sensor Module – Measures DC voltage levels (e.g., battery or solar) and transmits it to the Arduino for monitoring.

3.1.6 Buck Boost Converter –Controls voltage levels in both directions to meet the needs of attached components.

3.1.7 Solar Panel – It converts solar power to DC (electric) power to charge the battery and drive machinery.

3.1.8 Dynamo Motor – Converts mechanical energy (e.g., from motion) into electrical energy as a secondary power source.

3.1.9 LCD Display – Shows real-time information like voltage, current, and system status collected by the Arduino.

3.1.10 Arduino IDE – Software used for programming to write, compile, and upload code onto the Arduino UNO to manage system behavior.

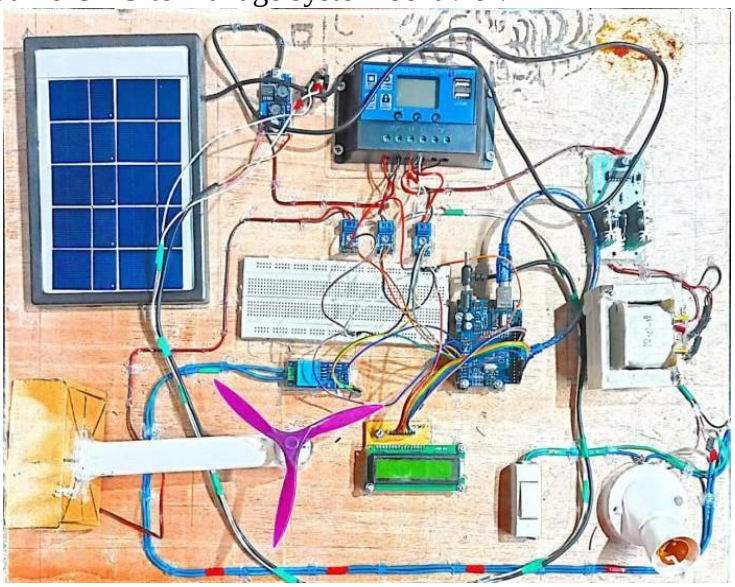

Fig.2 Arduino Based Efficient Energy Storage System Using Solar and Wind Power.

By using 3 main components in this Arduino Based Efficient Energy Storage System Using Solar and Wind Power they are

1. SOLAR PANEL
2. BATTERY
3. SOLAR CHARGE CONTROLLE

3.2 SOLAR PANEL

Solar panels utilize photovoltaic (PV) cells to convert sunlight into electricity, and they are hence a clean and renewable source of energy. Solar panels are utilized widely in residential, commercial, and industrial applications, as well as in space stations and satellites. Solar energy minimizes the use of fossil fuels and global warming. However, since sunlight is not persistent, energy is stored in batteries. Buck-boost converters play an important role in solar systems because they regulate variable voltage from panels, giving a constant output and efficient battery charging, hence making the system more efficient and reliable in general.

Fig:.3 SOLAR PANNEL

3.2.1WORKING PRINCIPLE OF THE SOLAR PANNEL:

The functioning of a solar panel is based on the photovoltaic effect. Sunlight that strikes the surface of a solar panel travels through the photovoltaic (PV) cells that are made of semiconductor materials like silicon. The energy of the sun energizes the electrons in the materials, and they begin to move, generating a current of direct current (DC) electricity. The electricity can be used directly, stored in batteries, or converted to alternating current (AC) by an inverter for the powering of domestic and business appliances.

3.2.2ADVANTAGES OF SOLAR PANEL

1. Eco-friendly and reduces carbon emissions.
2. Lowers electricity bills over time.
3. Requires minimal maintenance.
4. Suitable for remote or off-grid areas.
5. Long lifespan with reliable performance.

3.3 LEAD-ACID BATTERIES

Fig.4 Lead Acid Battery

Lead-acid battery is a strong, familiar rechargeable battery that employs a chemical reaction involving lead plates and lead dioxide plates in a sulfuric acid electrolyte. It is capable of storing and supplying electrical energy at high efficiency and is appropriate for use in transport (SLI), back-up, and solar storage. On smart appliances like vacuum cleaners, it offers a reliable source of power, meeting cost, capacity, and heavy current output.

3.3.1 WORKING PRINCIPLE OF BATTERIES:

During discharge, lead at the anode combines with sulfuric acid to form lead sulfate releasing electrons. Lead dioxide at the cathode combines with sulfuric acid and electrons to form lead sulfate again. The electrons move through an external circuit, powering the device to which the battery is connected. The sulfuric acid electrolyte is consumed in doing this and gets diluted. During charging, the process is reversed. An external electric current forces the lead sulfate at both the anode and cathode to revert back into lead and lead dioxide, respectively, and the sulfuric acid electrolyte is replenished.

3.4 SOLAR CHARGE CONTROLLER

A solar charge controller manages power from solar panels to batteries, preventing overcharging and reverse current. Two varieties are available: PWM, simple and low-cost for small systems, and MPPT, more efficient for large systems. More recent controllers may include temperature compensation and multi-stage charging. Choosing the correct controller is key to battery life, system efficiency, and general reliability.

3.4.1 TYPES OF SOLAR CHARGE CONTROLLER

3.4.1.1 PWM (Pulse Width Modulation):

Fig5. Solar Charge Controller

PWM (Pulse Width Modulation) is an easy method used in certain solar charge controllers. PWM charges by pulsing the solar panel to the battery and modulating the pulse width to control the level of charge passed. PWM controllers are best for small installations when panel and battery voltages are nearly identical. PWM controllers are cheap and will stop overcharging but are not as efficient as MPPT controllers when voltages are widely variable.

3.4.1.2 MPPT (Maximum Power Point Tracking)

Fig.6 MPPT Solar Charge Controller

MPPT controllers are smart and effective, moving more voltage from the solar panels to the battery's lower voltage with less loss. They utilize clever algorithms to deliver maximum energy output typically gaining 10–30% efficiency or more when it is cold. Though expensive, they yield better performance and installed in 12V, 24V, 48V, multi-voltage systems.

4. COST ESTIMATION

The provided Table summarizes the specifications of the Low-Cost Arduino Based Smart Vacuum Cleaner Robot serves as a starting point for estimating the total cost.

S.NO	EQUIPMENT	QUANTITY	COST PER UNIT	TOTAL COST
1	Arduino UNO	1	375	375
2	Solar Charge Controller	1	770	770
3	Battery	1	1800	1800
4	AC voltage Sensor	1	120	120
5	DC Voltage Sensor	3	45	135
6	Charging pin	1	160	160
7	Buck Boost Module	1	240	240
8	Jumper Wires	60	7	420
9	Card Board	1	800	800
10	Solar Pannel	1	900	900
11	Dynamo Motor	1	450	450
12	LCD Display	1	340	340
13	Inverter	1	200	200
14	Transformer	1	300	300
15	Nylone wire	10	7	70
16	Bulb and Bulb Holder	1	180	180
17	Bread Board	1	160	160
18	Charger	1	650	650
19	Switches	3	35	105
20	Arduino to USB Connecting Cable	1	110	110
21	5v Charge Pin connector	1	160	160
22	Tools	1	1400	1400
23	Others	1	1000	1000
	Total			**10,825**

5. CONCLUSION

In conclusion, these are some ideas on how to design an energy storage system based on Arduino to make sure you use the renewable energy in the best way possible! With the addition of integral components like solar panels, wind turbines, and clever battery management systems. Arduino-based instruments are not only versatile, but they can also be modified, depending on an individual's energy needs and the environmental specifications of a particular region. This ensures that you can always improve on what you have and scale up whether whether you have just small automated systems installed in your apartment or large industrial automated production lines installed in factories.

6. SCOPE OF THE PROJECT

There are some improvements possible by modifying Arduino Based Energy Storage System. Harvesting more energy in cities by employing better solar panels and more efficient wind turbines. Integrating advanced sensors and weather information can enhance monitoring and control. The modular design would make it easy to scale for various energy requirements. Connectivity with IOT platforms provides for remote supervision and smart energy management. Emerging battery technologies, such as solid-state or lithium-sulfur, can ensure more efficient and safer energy storage. Furthermore, machine learning based predictive energy management, and smart grid-compatibility features can help in further refining energy usage and system performance.

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