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ORIGINAL

Optimization of Multi-Power Supply using Quantum Artificial Intelligence for Chemical Industries

Optimización de fuentes de alimentación múltiples mediante inteligencia artificial cuántica para industrias químicas

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ABSTRACT

Maximizing the utilization of multiple renewable energy power sources, tied to storage systems, presents an opportunity, as well as a challenge, when optimizing the system efficiency of charge and energy distribution of electric vehicles (EVs). This physics focuses on the improved design of a system whereby the power input and coordination of multiple power sources used in an electric and industrial vehicle are prime considerations. Implementing the IoT in the system ensures advanced automation and a step-down in energy waste of the ecosystems in focus. To enhance the sustainable energy practice, the system incorporates PV battery storage for the restriction of active use of grid energy. The system architecture incorporates batteries with a non-isolated multi-port DC-DC converter, which manages two distinct energy inputs and two outputs of distinct voltage levels to power multiple subsystems of the electric vehicle. The deployed IoT modems facilitate the optimization, real-time monitoring, and minimized system control of the resonator while reducing harmonic distortions and ripple torque in the motor drives. This integration of Electric vehicles with PV systems has been shown to enhance the use of energy and the life of the battery, as shown in the proposed design and systems test results. The system has a good efficiency when incorporated to Chemical Industries. The new system of a hybrid energy management system defines and augments the seamless integration of sustainable electric mobility and enables refined and efficient integration of IoT-based actuators for step-scaled real-time electric drive systems.

Keywords: Optimized Energy Sources; Internet of Things; Energy efficiency; Hybrid Energy Management; Oil and Gas Industry.

RESUMEN

Maximizar el uso de múltiples fuentes de energía renovable, vinculadas a sistemas de almacenamiento, presenta una oportunidad, así como un desafío, a la hora de optimizar la eficiencia del sistema de carga y distribución de energía de los vehículos eléctricos (VE). Este estudio de física se centra en el diseño mejorado de un sistema donde la entrada de energía y la coordinación de las múltiples fuentes de energía utilizadas en un vehículo eléctrico e industrial son consideraciones primordiales. La implementación del IoT en el sistema garantiza

una automatización avanzada y una reducción del desperdicio de energía en los ecosistemas en cuestión. Para mejorar las prácticas energéticas sostenibles, el sistema incorpora almacenamiento en baterías fotovoltaicas para restringir el uso activo de la energía de la red. La arquitectura del sistema incorpora baterías con un convertidor CC-CC multipuerto no aislado, que gestiona dos entradas de energía distintas y dos salidas con distintos niveles de voltaje para alimentar múltiples subsistemas del vehículo eléctrico. Los módems IoT implementados facilitan la optimización, la monitorización en tiempo real y la minimización del control del sistema del resonador, a la vez que reducen las distorsiones armónicas y el par de rizado en los accionamientos del motor. Se ha demostrado que esta integración de vehículos eléctricos con sistemas fotovoltaicos mejora el uso de energía y la vida útil de la batería, como se muestra en el diseño propuesto y los resultados de las pruebas de los sistemas. El sistema presenta una buena eficiencia al integrarse en la industria química. El nuevo sistema híbrido de gestión energética define y amplía la integración fluida de la movilidad eléctrica sostenible y permite una integración refinada y eficiente de actuadores basados en IoT para sistemas de accionamiento eléctrico en tiempo real y escalables.

Palabras clave: Fuentes de Energía Optimizadas; Internet de las Cosas; Eficiencia Energética; Gestión Híbrida de la Energía; Industria del Petróleo y el Gas.

INTRODUCTION

The introduction of power converter systems over the past decade has proved revolutionary to the domain of Transportation and vehicle systems. These microprocessor-controlled systems, driven by batteries or solar photovoltaic (PV) sources, aim to boost the confidence of end-to-end designers and users with respect to the efficiency and reliability with which the deployed power systems are optimized and managed. The concept of the power source/energy source diversity for hybrid vehicles is advantageous to the overall system as it mitigates the reliance on a singular energy source and augments system functionality.

The introduction of multi-port DC-DC converters supersedes the limitations of traditional power transfer systems. Integration of batteries and solar panels is one of many possibilities of energy sources coupled to a single unit flexible system. These converters are standalone systems optimized to accommodate a single load with the IoT optimization for energy systems, which allows the real-time expression of parameters and multi-system feedback control of the entire web system of distributed micro and nano grids using artificial intelligence. These IoT systems provide real-time feedback on the enclosed energy managing systems, batteries, power systems, and the rest of the load.

This document details the design of an integrated non-isolated multiport DC-DC converter with an IoT system for the management of hybrid energy sources in electric vehicles. The hybrid energy sources integrated in the system will ensure the provision of an energy solution that is eco-friendly, highly reliable, and with minimal costs. The use of sophisticated power electronics and IoT systems in the design is expected to improve the overall efficiency, performance, and sustainability of electric vehicles, and also the utilization of renewable energy sources.

Literature Review

Effective control of multiple power systems has become important over the years in most modern industries that rely on a combination of grid power, backup diesel generators, and renewable sources of power such as solar and wind. The users of such systems, ‘Edge Computing’ and ‘The Internet of Things’, have changed the dynamics of operational power

control systems and monitoring in real-time, automating grid systems and the more intelligent control of energy. This literature survey focuses on the more recent works that emphasize the use of IoT in the optimization of multi-supply power systems in industries, as is the case in [1]. IoT is making the transformation of conventional power systems faster and more efficient by superimposing optimized intelligent control systems. This study focuses on the underpinning framework, functions, and practical implementations of IoT and associated systems within energy power grids, as well as the derived values and issues that relate particularly to the sense of control. It identifies common soft spots and suggests remedial measures by illustrating how emerging solutions such as blockchain and Artificial Intelligence (AI) could enhance the robustness and dependability of IoT energy framework networksMatters such as the application of predictive maintenance techniques with fault diagnosis, along with the associated machine learning technologies on multipower systems of batteries, inverters, and generators, are the objectives of this research. The system uses slice sensor data in order to predict failures, assist in maintenance, and plan to reduce unplanned downtimes.

The results displayed that the effectiveness and dependability of industrial power systems increased quite a bit when IoT devices were integrated with machine learning algorithms. [2] Reliance on, and scheduling the power configuration from, multiple sources such as grid electricity, batteries, solar, wind, and generators, with the corresponding minimization of energy use, is truly two sides of the same coin. IoT devices here assist in producing control and monitoring in real time over energy production, load, and consumption of the system, thus enabling automated dynamic load balancing. This helps the industrial plants in minimizing their costs, optimizing system efficiency, and reducing the energy and ecological footprint of the systems. This illustrates that the IoT-based smart grids are becoming more and more critical for dependable and environmentally friendly energy management.[3]

First, the focus concerning the energy systems for an industrial application is load forecasting. Incorporation of Machine Learning and Real-time monitoring and tracking of energy consumption is done through the IoT. Analyzed data is used through Deep Learning Models to estimate prospective energy consumption. The deep learning predictive insights enable improved energy sourcing and operational effectiveness, which in turn lowers the industry cost. The insights equip predictive machine learning systems to sharpen their industrial systems' power management influence.[4] An equally significant aspect is the management of stored energy, mainly the renewable energy source. Real-time IoT systems undertake the control of monitored parameters of the batteries' discharge and charge cycles, for example, in temperature and charge depth control. The real-time control, as optimization of the stored energy, improves the efficiency in the use of available resources.[5]

Integrating IoT-monitored Distributed Energy Resources (DER) enables a real-time interface of integrated Internet monitoring systems and increases an order of magnitude in efficiency of economic systems. Predictive analytics enable process automation and improve energy efficiency, and the multi-layered cyber defense systems secure the system from a diverse degree of attacks and threats.[6] In microgrids, for example, the Internet of Things (IoT) monitors and manages primary parameters such as the demand variability in the Electrical Supply Systems (ESS), reactive power supply, and overall power quality. In the case of an alert system, the response time to the signals, which guarantees the security of supply, is significantly improved. A tested off-grid microgrid system, which illustrated strong performance in functionality and control over the web interface, customer satisfaction, and value.[7] IoT systems influence the operation behavior of microgrid systems with integrated programmable loads and Distributed Energy Resources (DER). They improve control, system reliability, and security, which is further enhanced by automation to achieve minimum outages, energy, and electricity losses, even theft. Above all, automation in the economic systems of the generator and distributor, and the system's own socio-economic advantages are highlighted.[8]

The energy decline associated with the unnoticed costs of equipment malfunctioning at idling is severe. To alleviate this issue, Remote Control of Idle Appliances Shutoff devices integrated with microcontrollers and Wi-Fi have been observed. These devices have been proven to reduce energy and power costs, while unaccounted power expenditure remains.[9] Also, automatic shut-off IoT chargers are patented and designed to minimize power waste and damage caused to batteries from overcharging. Such chargers use elementary battery level sensors, which, when triggered, deactivate those devices when the batteries reach peak energy level, thus improving system performance, which is usually lacking in modern-day systems.[10] The integrative activities at the confluence of the IoT and optimization domains seek to refine and transform the unprecedented shifts in innovative grid energy management systems. These shifts are mitigated with physical feedback and a multitude of concurrent and counterbalancing sources and sinks. The effective balancing of estimated energy demand and real-time processing with industrial cost functions renders remarkably sustainable energy efficiency in smart grids. The blended sophistication of improved unconventional systems and the disruptive attributes of frontier technology epitomize the elusive finesse of industrial energy systems described at [11].

The complex nature of energy usage in manufacturing stems from Customary Problems with diverse functions and aims of providing predicted and Adaptive Power management. Real-time cost monitoring and forecasting with changes in power supply systems and efficiently reduced robust systems end, simultaneously offer.[12] Adaptive systems with numerous power supply sources also. Multiple case studies in Industrial Power Management demonstrate that this application achieves higher reliability and efficiency at lower costs.[13] As well, relay–energy–real-time interfaces support the distribution of energy, which, typically, the IoT enhances the industry's distribution efficacy, characterized by energy loss and reduced operational costs. Increased reliability and operational costs lead to enhanced IoT-use systems' sustainability.[14]

In summary, this work aims to evaluate the inventions regarding the opportunities and the challenges of the integration of IoT systems in smart energy grids. Even in the case of industrial activity, the uninterrupted collection and valuation of the data in real-time work of the systems provides improved load balance, optimization of multiple energy sources, and reduced operational costs. On the other hand, the vertical integration of smart IoT-based grids and the complete system integration are critical barriers to the widespread acceptance of IoT-based smart grids.[15] Nonetheless, in the modern day, the management of industrial power systems is rather poorly developed, as a result of persistent energy losses, unanticipated equipment failures, insufficient load balancing, and security and scalability concerns. Relatively older systems do not succeed in enhancing operational feedback, which leads to the inability of workflows, and the subsequent planning and operational costs increase significantly. In the reactive maintenance approach, the system downtime causes and accentuates the load forecasting problems, and the result is a poorly coordinated and inefficient operation of the system. In addition, the existing smart grids with IoT technology are weak in the area of cybersecurity, which is a severe problem at a worldwide level.

Addressing the gaps in the sector disparity, IoT technology, automated processes, Predictive analytics, and advanced security systems can eliminate the gaps identified in the industry all at once. Optimizing AI in real time to monitor advanced proactive indicators balances the load, lowers costs, and minimizes energy dissipation. The combination of machine learning and predictive maintenance algorithms minimizes system failures and subsequently system downtimes. Enhanced machine learning distribution systems, in combination with blockchain technology, offer predictive cyber threat intelligence. The system also provides and demonstrates modular adaptability with reliability, which in turn offers ultimate diverse energy operational frameworks.

Problems in the Existing System

The IoT-enabled multifunctional automated charger has acquired tremendous utility in

observing and controlling parameters of charge controllers like voltage, current, and power. The management systems of power, while retaining the parameters above, do face the challenges of effectiveness and efficiency, and these have been minimized to some extent, such as:
Disregarding Principles of Control and Monitoring

Premature disconnection of the systems can lead to low efficiency, while disconnection after a delay can lead to severe damage. The use of a relay to switch a controller lacks other parameters, i.e., agility, and this is unreasonable for other real-time systems. Mechanisms left unattended for retrieving data can also be relatively weak.

Limitations of Remote Access

Remote access faces constraints due to latency and network interruptions. Severe security gaps endanger neglect, which is unaided by proper encryption and authentication.

Problems of Manual Override

Changes that are manual as opposed to automatic introduce scope for human havoc, as set imbalances or unsystematic inappropriation of energy.

Lack of Efficient Communication & Data Transmission

Standardized communication protocols that are lacking for solar, wind, and battery-powered sources are the primary sources for integration challenges. Sensors that provide information or perform real-time diagnosis that is slow, sluggish, or erroneous are detrimental to precise optimization.

Difficulty of Scalability and Maintenance

System downtime arising from the addition of new power sources or the expansion of the whole system is due to complexity and is set to be addressed. Lack of proper user training, neglect of prescribed regular maintenance, and alerts set to assume the manual are for closure.

Block Diagram

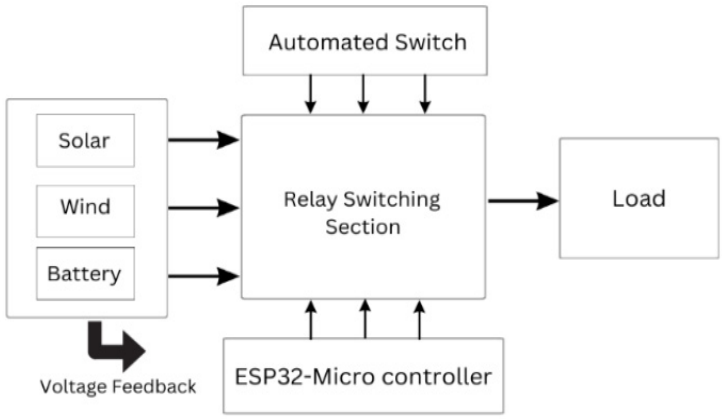


Figure 1. General Block Diagram of Power Supply

In figure 1, the consummate integration and automatic supply control of differentiated energy sources (solar, wind, and battery) is the focal point of the thesis. It incorporates IoT technologies via an ESP32 microcontroller for unattended supervision, automated decision-making, and control of the whole supply system and load. The system ensures drawing of power

from the cheapest, most available, or most efficient source of energy while optimizing the use of renewable energy and minimizing battery dependency.

Power Resources

The system can be Powered from Multiple sources namely Solar, Wind and Battery. The Solar Power is Captured by photovoltaic cells. Solar cells provide direct current (DC) electricity, which must be monitored. Voltage feedback establishes the presence and intensity of solar energy. The Wind Power is Captured by wind turbines. Wind turbines provide electricity in relation to the velocity of the wind. Voltage feedback determines the presence of wind energy. The Battery Power Provides Reserved energy used as auxiliary when solar and wind energy do not suffice. Batteries provide the load with a constant supply of power when the auxiliary sources are not available. The aim of the entire system is that these three power sources provide input supply options for the load.

Voltage Feedback

The Voltage Feedback System tracks three power sources (solar, wind, battery) and monitors and records the available voltage, which is sent to the ESP32 microcontroller. The ESP32 utilizes the feedback in order to select which power line is optimal and most readily available.

ESP32 Microcontroller is an inexpensive yet advanced IoT microcontroller that comes with Bluetooth and Wi-Fi functions. It fetches voltage feedback data of all the electrical power sources. It analyzes the data to differentiate and rank the power sources. It relays control signals to the Relay Switching Section according to the control signals. ESP32 enables automated switching between the electrical power sources and is IoT-capable.

Relay Switching Section

With the help of relays, this section works as a switch in connecting the suitable power source to the load—control signals from the ESP32 help in identifying the best power source. For Example, Relay connects the load to solar power when there is enough solar power. If solar power is not enough but wind power is, then it will switch to wind. Lastly, if the load is not sufficiently powered by solar or wind power, then it will switch to battery power. This ensures uninterrupted, smooth transitions.

Automated Switch

The Automated Switch relieves the relays of manually operating power source transitions. The load, therefore, is uninterrupted, and the power is transmitted through the efficiency and availability set defaults of the system. The automated aspect of the switch helps in reducing manual efforts and minimizing the chances of human error.

Load

The load is a term synonymous with the electrical appliances that this system powers.

Multi-Input Single-Output Converter

The proposed system is a compact, non-isolated multi-port DC-DC converter for electric vehicles (EVs) that integrates solar photovoltaic (PV) power and battery storage into a single unit. The dual-input design chassis minimizes battery use, prolongs battery life, and encourages the use of batteries and more sustainable energy. With dual output capability, it outputs high voltage for the motor and low voltage for auxiliary systems like lights and HVAC, which minimizes energy loss. Advanced harmonics in-ter processors are associated with the rest in which correlation and the in- regrate Periodic Ripple Control. These complex phenomena cross the dynamic machine models. The simplified architecture obtained with permanent and semi-

permanent implants remains dominant in terms of total weight and expense reduction. Control systems in the domain can ensure the Velocity Controlled Switch state in effect, superimposed upon the synchronization of stably controlled systems. The system optimizes savings and the mutually financed systems.

Optimizing Power

Focus on high-priority renewable energy sources (solar and wind) to minimize battery and grid dependency. Optimize the use of all available energy resources.

Automation

Reduction of manual operations through automated switching enhances dependability on a continuous power supply.

IoT Monitoring

Monitoring platforms enable remote access to real-time voltage monitoring of power sources and the status of all sources.

Uninterrupted Power Supply

The system guarantees seamless power delivery by selecting the most efficient source.

Cost-Effectiveness

Cost by reducing energy lost and improving the use of renewable sources. The Operative Principle of the system can be explained in the following phases,

Monitoring Phase

Voltage feedback monitors the power availability and the levels of power from the solar, wind, and battery sources.

Decision-Making Phase

The controller, in this case, the ESP32 microcontroller, analyzes the voltage feedback data and weighs the sources based on availability and efficiency (solar > wind > battery).

Switching Phase

Control signals are sent from the ESP32 to the Relay Switching Section to connect the assigned source to the load. The Automated Switch facilitates the transition.

IoT Integration

ESP32 sends the live data on the system status (voltage levels, power used, source switched) to an IoT Platform. Users are able to monitor the system from anywhere, its functions, and manage the power usage optimally.

Optimization Using IOT

System Initialization

The Embedded Systems engineer designs the primary components of the Microcontroller design system, comprising the voltage sensing module for every individual power source (solar, wind, battery) with an added functionality for an IoT interface for data transmission (Wi-Fi or MQTT transceivers) for all system components.

Real-Time Voltage Monitoring

Feedback loops with the voltage sensing circuits continuously calculate the active voltage

levels of: charging batteries (power storage), wind turbines (power generation), solar panels (power generation). Real-time snapshots of the monitored voltages are transmitted to the ESP32 for their primary data processing steps.

Decision-Making Process (Optimization Logic)

Based on the following conditions, the Microcontroller applies an optimization algorithm to choose which power source to utilize.

Table 1. Conditions and Power Source Priority

Condition	Power Source Priority
Solar voltage > threshold (high)	Solar power (primary source)
Solar insufficient, Wind voltage> threshold	Wind power (secondary)
Both solar and wind are insufficient.	Battery power (backup)

Example Logic:
Pseudo code
If (Solar Voltage > Threshold):
Connect Solar to Load
Else If (Wind Voltage > Threshold):
Connect Wind to Load Else:
Connect Battery to Load

The system prioritizes renewable sources (solar and wind) to optimize power efficiency. The battery is used as a last resort.

Relay Switching or MOSFET Switching

According to the relays or MOSFETs that receive the ESP32 decision, MOSFETs perform low-power switches, and their primary use is as relays and Form B connections. Primary and secondary enable disconnected power Sources. Relays close and open switches used to perform the Close the Relay Switching Section. Powers to Load Mix Assigns and selects an operating power MOSFET. Advantages of fusing Relays: More power efficient, Compact and durable, bought solution is Faster Switching Time.

Automated Switching Mechanism

The Automated Switch is capable of making the transition from one power source to another.

Example: if the system is powered by solar and the solar power source is unable to sustain operation, the system switches to wind power without delay. If both solar and wind power sources are unable to maintain operation, the system switches to battery power. This Switch is capable of removing manual operations for a continuous power supply to the load.

IoT Integration

Voltage levels of solar, wind, and battery sources, the current power source being used, user-controlled systems, and load power status and power consumption are set in real-time. These data are monitored by the ESP32 Microcontroller, and are also transmitted to IoT platforms like ThingSpeak or Blynk. Users are also capable of tracking the system due to their access to a dashboard or mobile app.

Load Power Supply

Optimum system analyzes and selects the source of power for the Load (Electrical systems,

devices, and appliances). System optimizes use of all available renewable sources (solar, wind)—practically 100 % smooth and uninterrupted power. Efficient use of the battery shall only be deployed when required.

Alerts and Data Logging

In addition to battery discharge status, the system can also communicate directly to the user about low solar and wind power via the IoT platform. Many other vital data points, like source and history of voltage levels and load performance, switching, are recorded and optimized for processing.

Advantages in the Proposed System

The innovative solutions offered in this project pilot systems within the wisdom and network of the existing structure, with features such as systems and implementation of IoT and Optimization Efficiency systems.

Real-Time IoT-Based Optimization

The systems use the features of the ESP32 board for measuring and controlling voltage, current, and power on various sources of power. Other features connect to a Remote Control, such as Moson, whereas data is embedded on multiple IoT Platforms, such as the Blynk, for the intelligent monitoring and controlling apparatus.

Solar Source Selection Enhancement

The mechanistic approach of the system is the ability to select the optimal power source, such as dynamically selecting wind, solar, or battery sources. The system is designed with mechanisms such as the MOSFET for controlling switching in a faster, reliable, and more innovative way than traditional mechanics.

Advance Energy Systems Automation

Fusion of Solar and battery sources sustains the rest of the world's systems for innovative, scaled systems. Reduction is observed in daily routines for energy exhaustion and keeping the smart gadgets on a source for monitoring with batteries.

Robust IoT Integration

Secure and scalable control systems focused on modular systems and architecture jurisdiction to the systems having additional power sources to the structure and the equipment. The systems built The Encryption Truths protected circuitry of the modules for secure transmission of data for power, as the modules of the circuitry were encrypted.

Scalable and Secure Design

Modularity enables the easy integration of additional power sources and/or peripheral devices and implements encryption and authentication for secure data transfer.

Enhanced Maintenance and Training

Audience-tailored operational systems and training documentation simplify equipment use and training. Avoidance of downtime caused by automated maintenance alerts prevents operational interruptions.

RESULTS AND DISCUSSION

The function of this simulation is to study the phenomena of multiple voltage sources with focus on their interrelationships and combined effect on the output waveform, with relevance

to load changes depicted in figure 2. The simulation environment brought to life the logic coded in MATLAB, which oversees the coordination of the circuitry and operates on the control signals sent to the primary circuit.

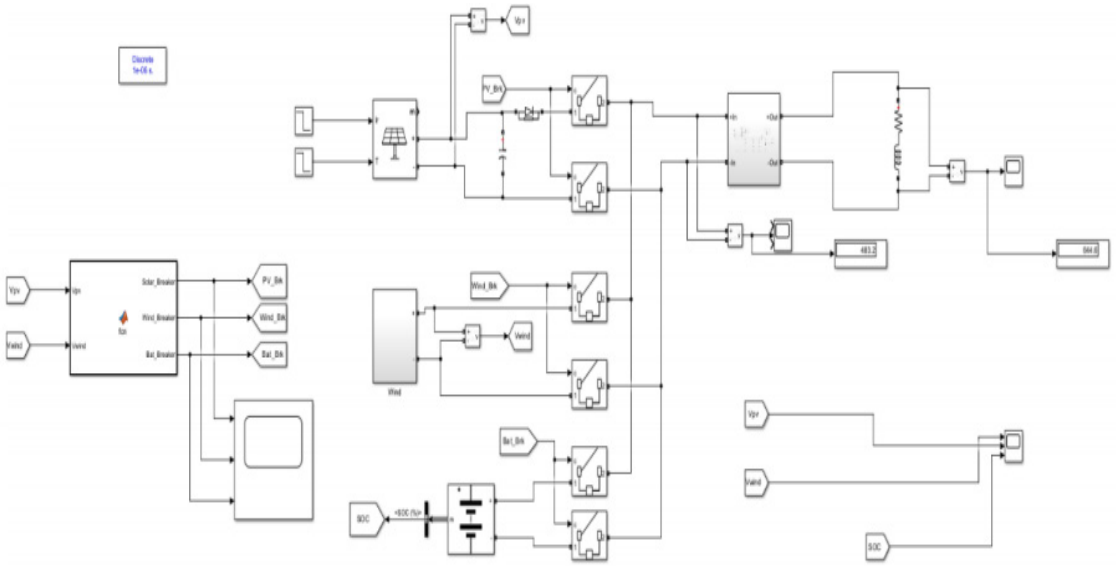


Figure 2. Multi Power Supply Functionality Simulation

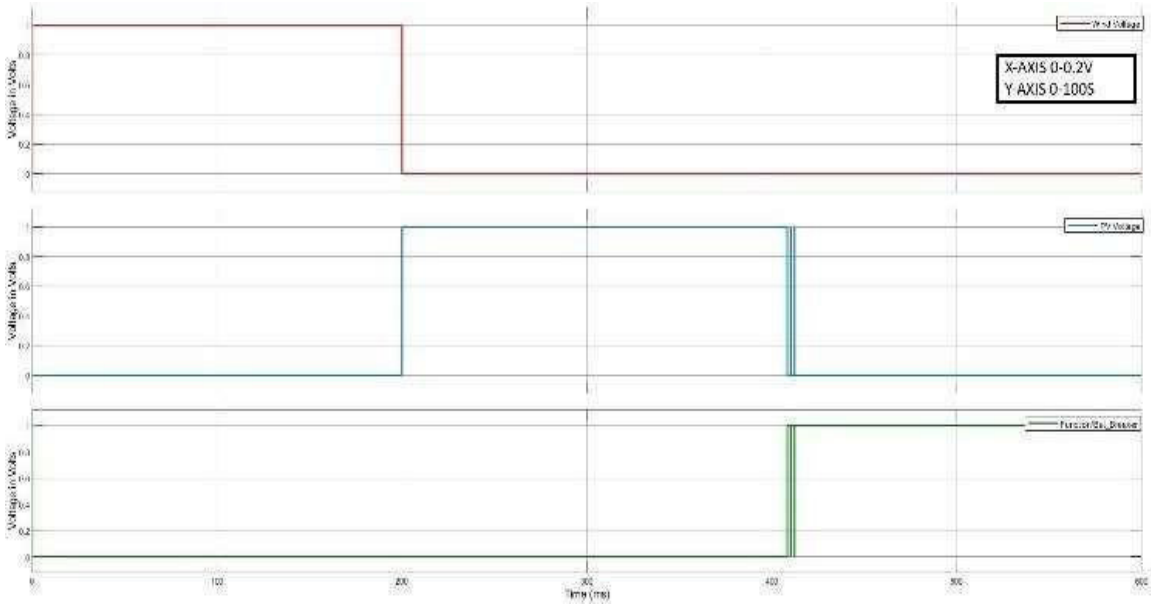


Figure 3. Voltage and Response Graph in the program section

The circuits contain three flagship energizers: Wind Energy Source: 208 volts. Solar Energy Source: 295 volts. Battery Backup: 80 percent state of charge in the beginning. The first three sources are controlled with the help of MOSFET-based automatic relay switches, which, in real time, choose the best power source based on the conditions set in the code of the simulation. The rules that are used to control power supply are.

- Use the Solar Module first if the Solar voltage exceeds the set threshold.
- Use the Wind Module if Solar power is insufficient and the Wind voltage exceeds the set threshold.
- Use the Power Module in the event of a shortage of Solar or Wind power.

The relay has no difficulty switching source from the current slot to the optimized slot. It manages this feat with no power loss. As far as the construction of the system relay and power sources is concerned, the period of sources being active is equal to the time it takes for the source condition to be assessed and the relay to switch the source. In this instance, the period is stipulated as 0,2 seconds. From the simulation results, every phase of the switch causes the source to react, with transient responses being the most dominant. They determine within which the source settles. The time it takes to switch to the optimal source from the rest is the time it takes to deliver it to the load—figure 3. The first system supplies 483 volts, and the system meets the consumer's needs by applying a voltage booster circuit that raises the voltage to 650 volts. All the system states during which source selection is prioritized, switching actions are performed, and the voltage is changed are captured and time-stamped on the interface of the simulation. Validation is performed with other data to achieve mitigation. The consumers of the system are able to exercise their strategy plan, which provides operational stability, now shielded from optimal use of energy under certain conditions.

The graph depicts and models the voltage assigned in the wind solar battery system at the… in the very first stage of the simulation, in which the rectangular profile is configured for the system to work. The red profile is the voltage of the wind source, the blue one is the solar source, and the green one is the output of the battery. For simulation purposes, the simulation is set with a 0,2 V scale on the vertical Y axis and 0,1s for the horizontal X axis as depicted in figure 4. The circuit optimizes and switches to the preferred energy source every 0,2 seconds, maintaining a steady voltage output. This system of dynamic optimization of wind, solar, and battery sources improves the real-time performance and the entire system stability and reliability.

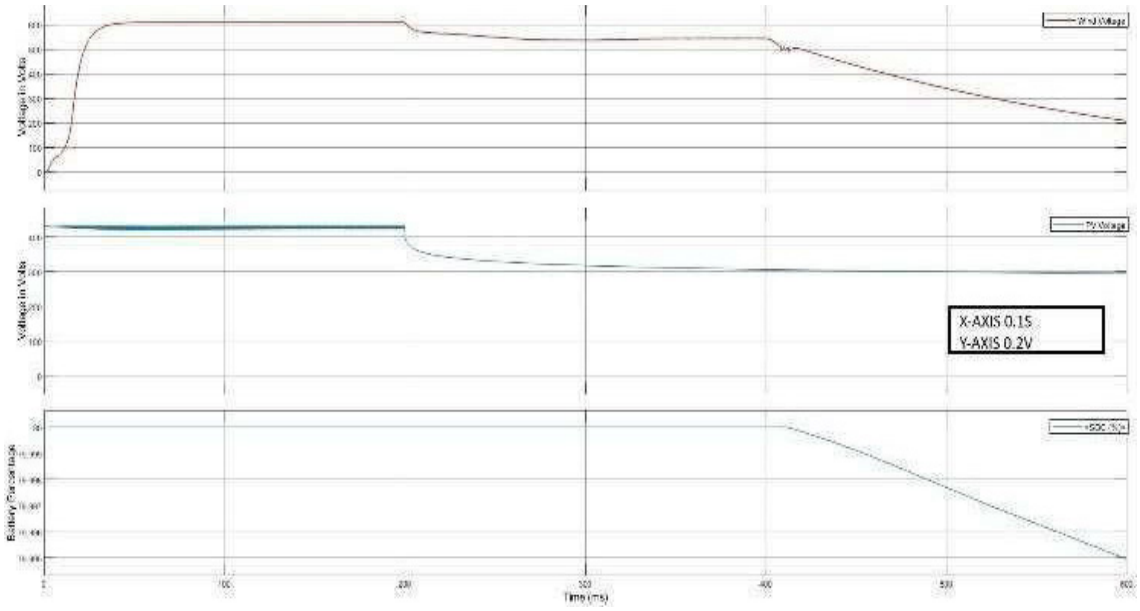


Figure 4. Three Voltage Source Graphs Right Before Addition of Relay Unit

The voltages of each of the sources were monitored independently by setting a dedicated display at each source and observing the raw stability of the monitoring tools, which displayed solar voltage of roughly 208V, wind voltage of approximately 295V, and a battery at a constant 80 % capacity, as in figure 5. These sources are fed to the relay units directly. The Y axis is in volts, ranging from 0V to 100V, and the solar battery and wind are in percentages.

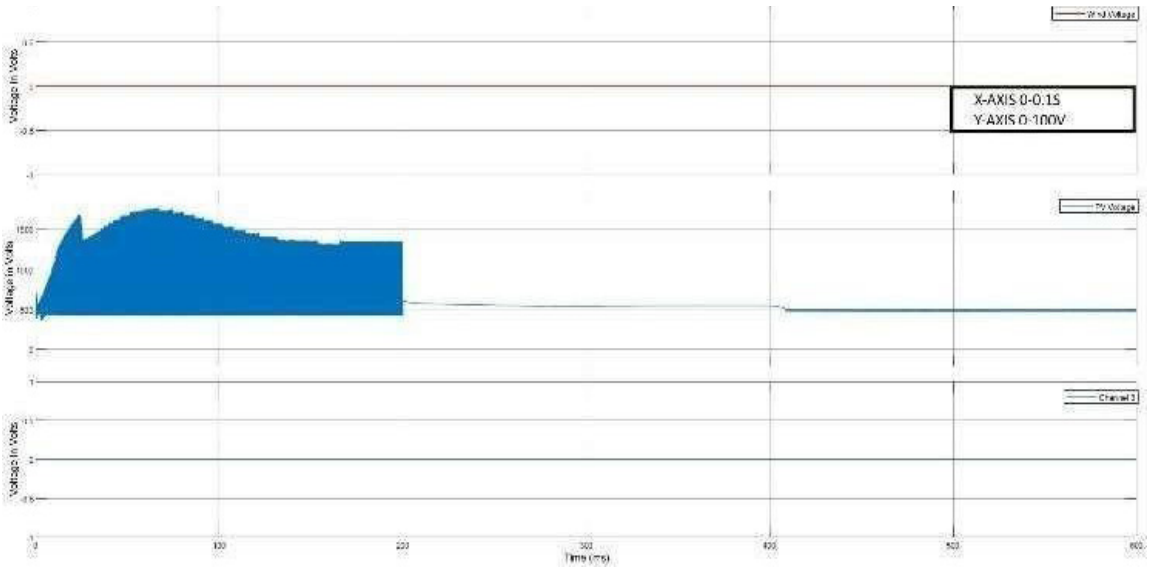


Figure 5. Voltage Behavior Before Load Unit

The X axis is the time, tt, from 0s to 0,1s. The time interval on the X axis is from 0,2s to 0,2s. The wind graph peaks at 600V, while the solar climbs to 420V. The battery is constant at 80 %. The graded drops in voltage are known at the 0,2s step value, and at this instant, the system switches to the relay and transitions to the most stable source for remaining operation.

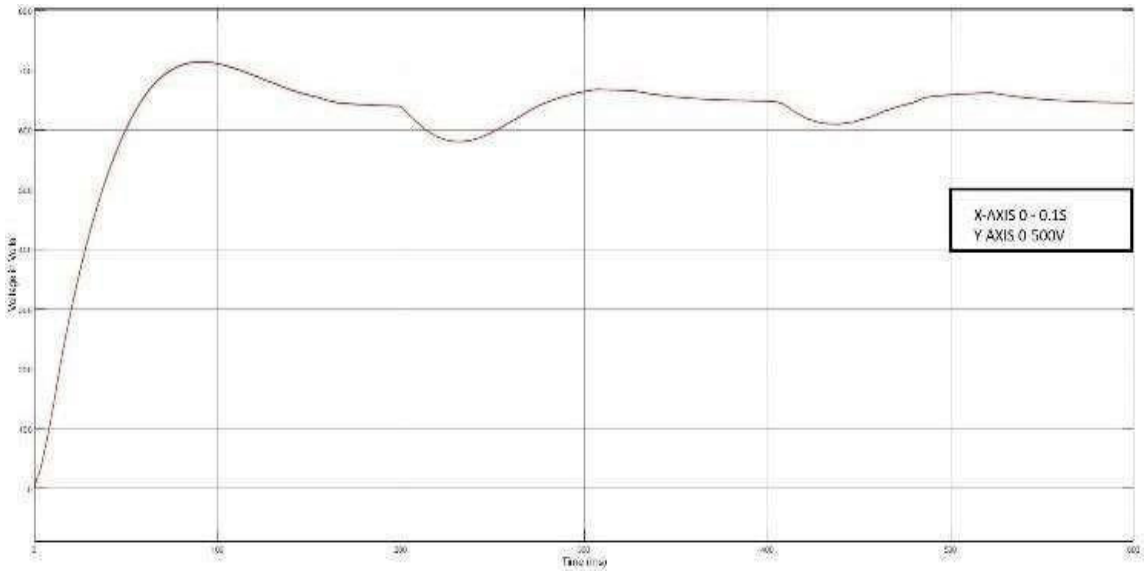


Figure 6. Behavior of Voltage after applying the Load unit

Upon crossing the relay switching, the relay unit identifies and selects the best source, then stabilizes the output voltage to about 483,2 V figure 6 shows this. The figure has voltage on the y-axis in 0-500V intervals and time on the x-axis from 0 to 0,1s, showing the selection and stabilization of the best source.Consumers with varied requirements support the use of the relay circuit for its versatility, with a voltage range of 482 to 644. The graph exhibits a sharp inclination at the beginning to the value of 710 V at t=0, followed by a decrement to 630 V by t=0,2, before constantly maintaining the value of 645 V from t=0,4 to the very end. The voltage remains stable after the output is elevated. Stable voltage reduces the chances of overshoot of the output voltage for the fluctuating sine wave that the system receives as the primary input.

Where the data in the graphs elucidate the different scenarios of voltage achieved in individual as well as combined manner of 3 primary sources of energy (solar, wind, battery) in the overall system, the waveforms represent the answer to how the system interacts before and after a load is applied. The waveforms also embody the system's source switching and voltage stabilization, enabling it to respond with versatility and reliability in power supply.

The system has distinct transient cycles and steady states integrated into one system behavior. After loading the application, the system's integrated output, which includes solar, wind, and battery inputs, remains stable and predictable. The system's adaptive and stable control features are demonstrated during the transition from 'before load' to 'after load.' The system proves its reliability, robustness, and efficiency in handling varying dynamic power loads through the stabilization of voltage and the control of the waveform during and after load application in the steady state.

Hardware Implementation

S. No	Components	Quantity	Rating / Load / Voltage
1	12V 2A Adapter	1	12V, 2A
2	Bridge Rectifier	1	12V Input
3	12V Transformer	1	230V to 12V
4	ESP32 Microcontroller	1	3.3V Operating Voltage
5	Voltage Regulator	1	5V, 12V
6	Voltage Divider	1	Adjusts voltage levels
7	12V Relay	2	12V Switching Relay
8	12V Load	1	12V
9	LCD Display	1	16x2 or 20x4, 5V
10	12V Solar Panel	1	12V, 10W (Example)
11	12V Battery	1	12V, 7Ah (Example)
12	Capacitors	2	1000µF, 25V
13	Resistors	Multiple	1kΩ, 10kΩ, etc.
14	Diodes	2	IN4007, 12V
15	Temperature Sensor	1	LM35, -55°C to 150°C
16	Wi-Fi Module (ESP32)	1	Built-in Wi-Fi

Figure 7. Components List

The system is designed to intelligently manage and monitor multiple energy sources for chemical, oil or gas industry while dynamically distributing power to the load for optimal efficiency. Figure 8 shows the Hardware Working Model of the entire Work.

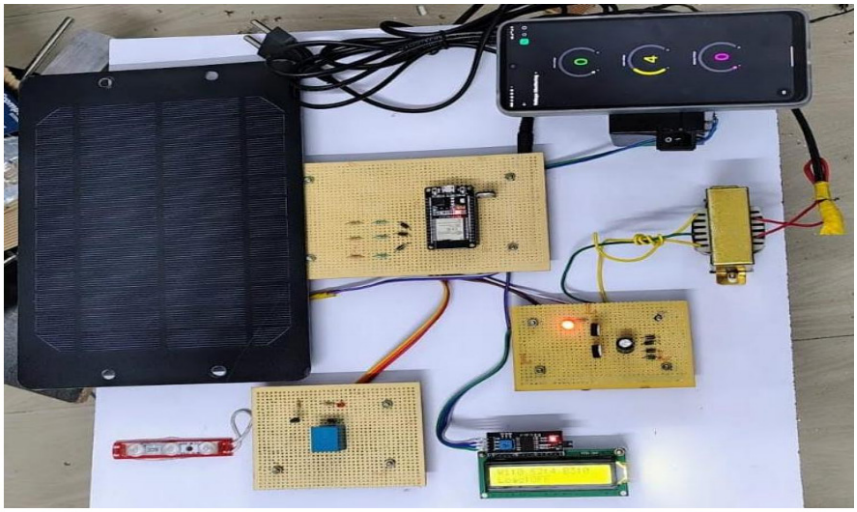


Figure 8. Hardware Simulation

At the start, all three energy sources—wind, solar, and battery—are activated to ensure a seamless and uninterrupted power supply. The wind power source, which is initially connected, operates by converting AC to DC through a transformer, ensuring compatibility with the system's DC-based components. Critical components such as the ESP32 microcontroller, voltage regulator, voltage divider, and relay circuit work in synchronization to monitor, regulate, and dynamically control the power distribution process. Figure 9 shows the LCD Display connection with the Microcontroller.

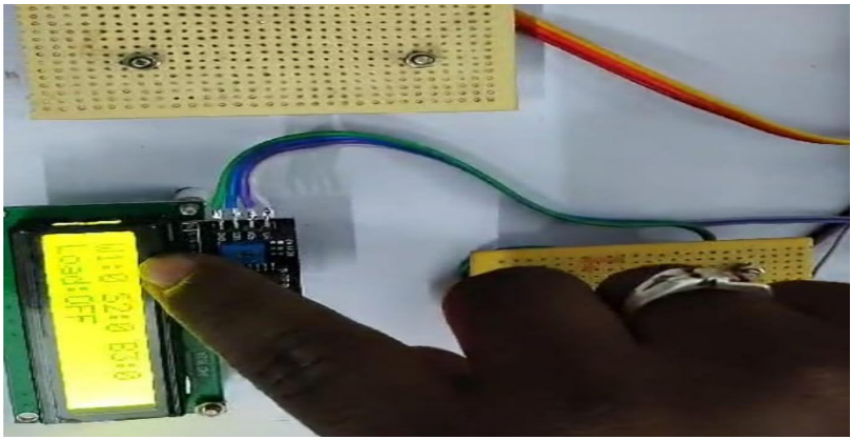


Figure 9. LCD Display Connected With ESP32

The current from the wind source flows through the transformer, where it is rectified and stabilized before being sent to the ESP32 microcontroller. The voltage divider and regulator play a crucial role in adjusting and maintaining the voltage within safe operational limits. The processed power is then directed to the relay unit, which actively monitors the voltage

levels. If the wind power meets the required threshold, the relay prioritizes it as the primary energy source, activating the load accordingly. On the LCD display, real-time system status is shown, indicating the active power source and voltage output. For instance, when wind power is supplying the load, the display reads "W1 ON 12V," with voltage variations ranging from 11V to 12V, reflecting the natural fluctuations in wind energy generation. The system continuously evaluates the wind power output, and if voltage levels drop below the acceptable range, the relay intelligently switches to an alternative energy source—solar or battery—to maintain a stable power supply. This dynamic power management ensures efficient utilization of renewable energy sources while preventing power disruptions. Figure 10 and 11 shows the Blynk app connection and the Output on the Loaded Condition.

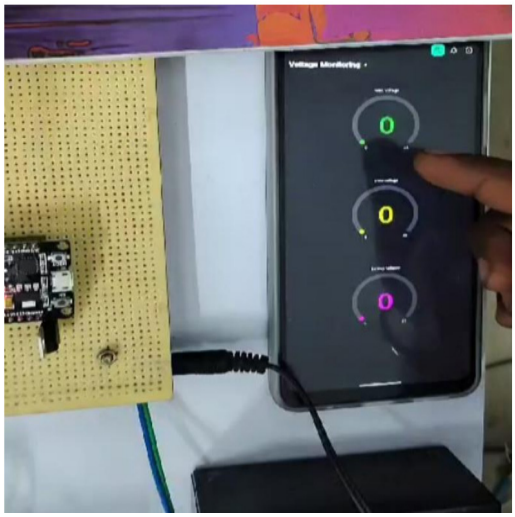


Figure 10. IOT Connection With Blynk App

The integration of ESP32 with precise control mechanisms enables real-time monitoring and automated source switching, enhancing system reliability. Through optimized hardware coordination and intelligent decision-making, the system ensures a smooth transition between energy sources, mitigating fluctuations and delivering consistent power to the load.

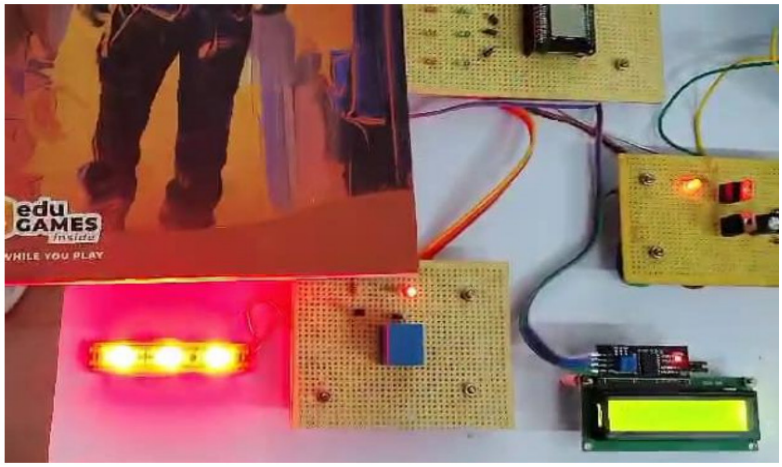


Figure 11. Load on State Condition

CONCLUSIONS

The work presented sheds light on the integration of battery storage systems with renewables and their use in electric vehicles (EVs). The system employs solar energy with batteries, which makes the EV solar-powered. The use of the IoT system optimizes the total energy system, which improves overall battery performance and reduces the use of conventional energy sources. The performance of the battery improves, and the use of classical sources of energy reduces due to the incorporated IoT functionalities in the system. Apart from the above advantages, the Mult-Port DC-DC Motor IoT Controller design is advantageous from an economic standpoint, as the criteria of geo-economics and geo-assemblage are met. Hence, the performance is augmented due to structural simplicity and the minimized number of components in the design. The tests prove energy use optimization, evidencing a penetrating impact on cleaner technology use in transportation. Future work may incorporate other renewables, such as wind energy, and machine-learning-driven predictive maintenance to manage energy use more intelligently. The offered solution, besides EVs, may also find application in areas such as industrial automation, where optimization of energy use with constant supervision is needed.

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CONFLICT OF INTEREST

None.

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