e-ISSN: 2278-8875
p-ISSN: 2320-3765

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

Volume 15, Issue 3, March 2026

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.807

9940 572 462 | 6381 907 438 | ijareeie@gmail.com | www.ijareeie.com

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

Intelligent Renewable Energy Exchange Between Grid, Home and Electric Vehicle for Optimal Demand and Cost Management

J. Harikrishna[1], B. Logesh[1], B. Pradhap[1], S. Srikanth[1], Dr. V. P. Sakthivel[2]

UG Final Year Students, Department of EEE, Government College of Engineering, Dharmapuri, Tamil Nadu, India[1]

Assistant Professor, Department of EEE, Government College of Engineering, Dharmapuri, Tamil Nadu, India[2]

ABSTRACT: Due to the rapid growth of renewable energy systems, electric vehicles (EVs), and smart grid technologies has created the need for an intelligent energy management system. This paper proposes an IoT-based renewable energy exchange framework that integrates solar photovoltaic (PV) systems, home loads, EV batteries, and the utility grid. The enables system bidirectional energy flow and real-time monitoring using IoT sensors and cloud platforms. An intelligent control algorithm optimizes energy usage by prioritizing renewable sources and shifting loads based on tariff conditions. The EV acts as both a load and an energy storage system through Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H) operations. Experimental analysis shows improved energy efficiency, reduced electricity cost, enhanced renewable utilization, and better grid stability. The proposed system is scalable and suitable for smart homes and future smart grid applications.

KEYWORDS: IoT, Electric Vehicle (EV), Smart Grid, Renewable Energy, V2G, V2H, Energy Management, ESP32

I. INTRODUCTION

The global transition towards sustainable energy systems has accelerated the adoption of renewable energy sources and electric vehicles (EVs), fundamentally transforming the structure and operation of modern power grids. Solar photovoltaic (PV) systems, in particular, have emerged as a prominent clean energy solution due to their scalability and environmental benefits. Simultaneously, the increasing penetration of EVs has introduced new dynamics in energy consumption patterns, placing additional demand on existing grid infrastructure. While these advancements contribute to reducing carbon emissions, they also present significant challenges related to energy management, load balancing, and grid stability. Traditional power systems are primarily designed for centralized and unidirectional energy flow, making them inadequate for handling the variability of renewable energy generation and the bidirectional nature of modern energy systems. The intermittent nature of solar power, combined with unpredictable EV charging demands, often leads to inefficient energy utilization, increased peak load stress, and higher electricity costs. These limitations highlight the urgent need for an intelligent and integrated energy management framework capable of coordinating multiple energy sources and loads in real time.

In response to these challenges, this paper proposes an innovative and intelligent renewable energy exchange system that integrates solar PV generation, residential loads, electric vehicles, and the utility grid into a unified platform. The proposed system leverages Internet of Things (IoT) technology to enable continuous monitoring, real-time data acquisition, and remote control of energy flow. Key electrical parameters such as voltage, current, power consumption, and battery state of charge are monitored using sensors and processed through a microcontroller-based control unit. A distinguishing feature of the system is its ability to support bidirectional energy flow, allowing the electric vehicle to function not only as a load but also as a distributed energy storage unit. Through advanced operational modes such as Vehicle-to-Grid (V2G) and Vehicle-to-Home (V2H), excess energy generated from renewable sources can be stored in the EV battery and later supplied back to the home or grid during peak demand periods. This capability enhances energy flexibility, reduces dependency on the grid, and contributes to improved load management.

Furthermore, the system incorporates intelligent control strategies to optimize energy distribution by prioritizing renewable energy usage and minimizing reliance on conventional grid power. By dynamically managing energy exchange between the grid, home, and EV, the system reduces electricity costs, improves overall energy efficiency, and supports sustainable energy consumption practices. In addition to its technical advantages, the proposed system is scalable and adaptable, making it suitable for integration into future smart grid environments and smart city infrastructures. The combination of IoT-enabled monitoring, intelligent control, and bidirectional energy exchange

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

positions this system as a forward-looking solution for modern energy challenges. Ultimately, this work contributes to the development of a resilient, efficient, and environmentally sustainable energy ecosystem.

II. LITERATURE REVIEW

The rapid growth of electric vehicles (EVs) and their integration with modern power systems has attracted significant research attention. Early studies focused on the concept of Vehicle-to-Grid (V2G) technology and its impact on power systems. It was observed that V2G improves grid stability, voltage regulation, and load balancing by allowing bidirectional power flow between EVs and the grid [1]. Further work demonstrated that EVs can function as distributed energy storage systems, capable of supplying power back to the grid and generating economic benefits [2]. Research on EV charging strategies highlighted their impact on grid performance. It was found that uncontrolled charging increases peak demand and may lead to system instability, whereas controlled and optimized charging improves efficiency and reliability [3]. The integration of EVs with renewable energy sources and smart grids enhances sustainability and reduces dependence on conventional energy sources [4]. In addition, spatial–temporal models were developed to analyze EV charging demand, showing that coordinated charging is essential for maintaining grid stability [5]. With advancements in intelligent systems, modern charging techniques have been introduced. Machine learning-based scheduling methods improve charging efficiency and reduce operational costs [6]. Optimal charging strategies help in minimizing peak load demand and enhancing grid performance [7]. The use of Internet of Things (IoT) technology enables real-time monitoring and control of energy systems, improving overall system reliability [8]. The integration of renewable energy and storage systems has further improved EV infrastructure. Energy storage systems combined with renewable sources increase grid flexibility and efficiency [9]. EVs can also operate as distributed energy resources, supporting grid operations and improving reliability [10]. Stochastic energy management techniques address uncertainties in renewable generation and EV usage [11]. Additionally, the development of standardized charging technologies ensures compatibility and efficient operation of EV charging systems [12].

Artificial intelligence has become a key component in EV energy management. AI-based load forecasting techniques enable accurate prediction of energy demand for EV charging stations [13]. Coordinated charging strategies support load balancing and efficient energy utilization [14]. Demand response techniques using EV energy storage contribute to peak load reduction and improved grid stability [15]. Optimization and scheduling methods have been widely applied to EV charging systems. Efficient charging control strategies for parking infrastructures improve system performance and reduce energy wastage [16]. Admission control and scheduling techniques ensure proper allocation of charging resources under system constraints [17], [18] In addition to EV-focused studies, optimization techniques from other domains provide useful insights. Heuristic and metaheuristic approaches used in complex scheduling problems demonstrate high efficiency in resource allocation and optimization [19]–[24]. These methods can be adapted for EV charging systems to improve scheduling and energy management. Recent developments focus on integrating advanced technologies such as artificial intelligence, IoT, and renewable energy systems. AI-based smart charging strategies enable real-time decision-making and improve system efficiency [25]. IoT-enabled charging infrastructure supports real-time monitoring and automated control [26]. Solar-integrated EV charging systems reduce dependency on conventional grid power and promote sustainable energy usage [27]. Advanced AI-based load balancing techniques further enhance charging efficiency [28]. IoT-based energy management systems improve system performance and scalability [29], while cloud-based solutions enable real- time energy management and data processing [30].

Overall, the literature indicates that the integration of V2G technology, artificial intelligence, IoT, and renewable energy sources plays a crucial role in the development of efficient and sustainable EV energy systems. Despite significant advancements, challenges such as real-time coordination, communication reliability, and optimal energy utilization remain . These challenges highlight the need for advanced intelligent energy exchange systems, which form the basis of the proposed work.

III. PROPOSED SYSTEM

The proposed system consists of several interconnected components that work together to achieve intelligent energy management between the solar source, home, electric vehicle (EV), and the utility grid. The block diagram of proposed system fig 3.1 shown in given below. The main blocks include the solar photovoltaic (PV) system, power converters, EV battery, home load, grid connection, sensors, microcontroller, and IoT platform. The solar PV system acts as the primary energy source, converting sunlight into electrical energy. This energy is regulated using a DC-DC converter to maintain a suitable voltage level for charging the EV battery and supplying power to home loads. The EV battery serves as an energy storage unit, storing excess solar energy and supplying power when required. It supports bidirectional energy flow, enabling Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G) operations. The home load represents the

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |
|| Volume 15, Issue 3, March 2026 ||
| DOI:10.15662/IJAREEIE.2026.1503015 |

electrical appliances that consume energy. The system prioritizes supplying power from the solar source, followed by the EV battery, and finally the grid when necessary. The grid connection acts as a backup source and ensures uninterrupted power supply. Sensors are used to measure key parameters such as voltage and current, providing real-time data to the microcontroller. The microcontroller (ESP32) processes this data and controls the switching operations through relays. It ensures optimal energy flow based on demand and availability. The IoT platform enables real-time monitoring and remote access to system data, allowing users to track energy usage and system performance. Overall, the system ensures efficient energy utilization, cost reduction, and improved reliability through intelligent control and seamless integration of all components.

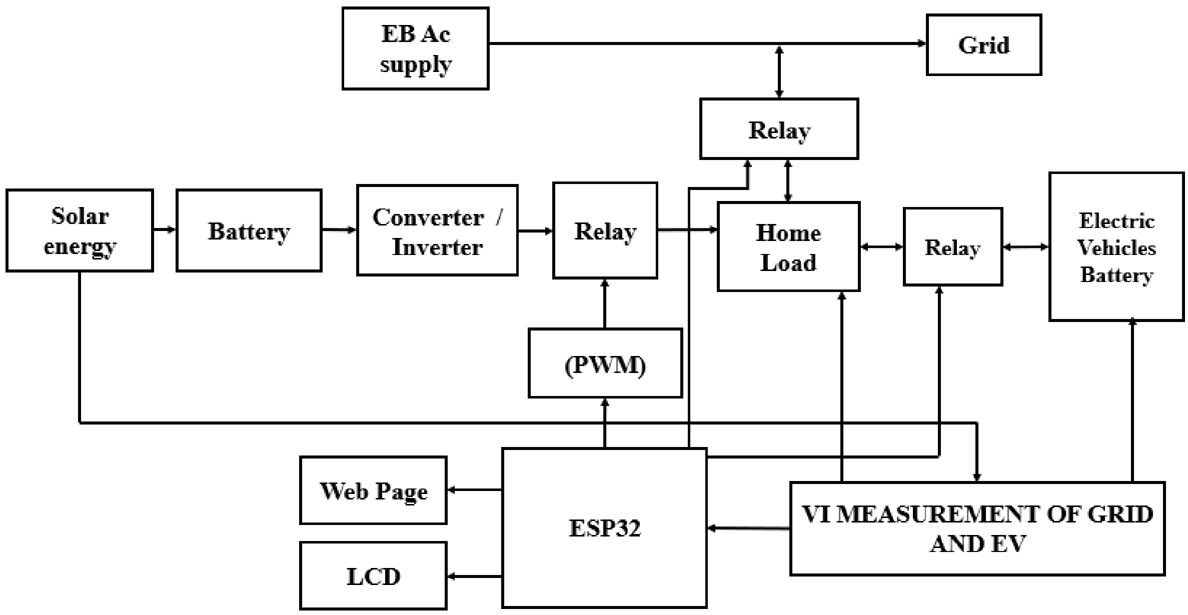


Fig.3.1 Block Diagram of the Proposed System

The proposed system is strongly based on Internet of Things (IoT) technology, as it involves real-time monitoring, data communication, and intelligent control of energy systems. In this paper, sensors are used to measure important electrical parameters such as voltage, current, and battery state of charge. These values are collected by a microcontroller (such as ESP32) and transmitted to a cloud platform through IoT communication protocols. Using IoT, the system enables remote monitoring and control of energy flow between the solar panel, home loads, electric vehicle (EV), and the grid. This allows users to track energy usage in real time and make efficient decisions. IoT also supports automation, where the system can intelligently switch between different energy sources based on demand, availability, and cost. Thus, IoT plays a key role in enhancing system efficiency, enabling smart energy management, reducing power wastage, and supporting the development of smart grid infrastructure.

A renewable energy system uses natural energy sources such as solar, wind, and hydro to generate electricity in a sustainable and eco-friendly manner. In this paper, solar photovoltaic (PV) energy is used as the primary renewable source to supply power to home loads and charge the electric vehicle (EV). The integration of renewable energy helps reduce dependence on conventional fossil fuels and lowers carbon emissions. However, since renewable sources like solar are intermittent in nature, efficient energy management is required. To address this, the system combines renewable energy with energy storage (EV battery) and grid support. By prioritizing solar energy usage and intelligently managing power flow through IoT-based monitoring, the system ensures optimal energy utilization, cost reduction, and improved efficiency. Thus, renewable energy plays a key role in achieving a sustainable and smart energy management system.

IV. HARDWARE SETUP OF INTELLIGENT ENERGY SHARING BETWEEN HOME, EV AND GIRD

The proposed system of fig 4.1 Hardware Setup of Intelligent Energy Sharing between Home, Ev and Gird shown in given below. The hardware implementation of the proposed system includes a solar photovoltaic (PV) panel, power converters, sensors, a microcontroller, a battery, and a relay module. The solar panel acts as the primary energy source, generating electrical power from sunlight. A DC-DC converter is used to regulate the voltage and ensure efficient battery charging, while an AC-DC converter is used to convert grid power into DC when additional energy is required. An

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

ESP32 microcontroller serves as the central control unit, collecting real-time data from voltage and current sensors and controlling the overall system operation.

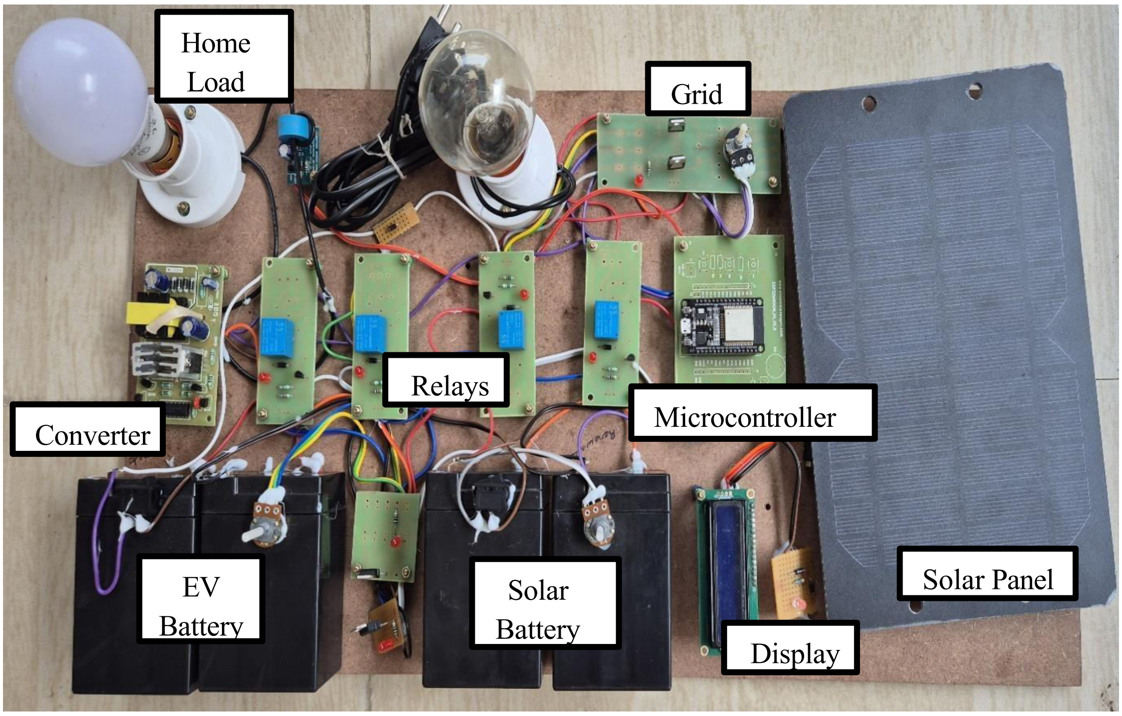


Fig.4.1 Hardware Setup of Intelligent Energy Sharing between Home, EV and Gird

The battery, representing the electric vehicle (EV), functions as an energy storage unit that stores excess energy and supplies power during low generation periods. A relay module is used for automatic switching between different power sources such as solar, battery, and grid. The system also supports bidirectional power flow, enabling Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G) operations. Additionally, IoT technology is integrated to enable real-time monitoring and remote control of the system. Overall, the hardware setup ensures efficient energy utilization, reliable performance, and reduced dependency on the grid.

A. Solar Photovoltaic (PV) System

The solar panel acts as the primary energy source in the system. It converts sunlight into electrical energy. This generated power is used to supply home loads and charge the electric vehicle battery. Since solar output is variable, proper control and storage are required.

B. Power Converters

Power converters play a crucial role in regulating and converting electrical energy:
DC-DC converter adjusts the voltage level from the solar panel for battery charging.
AC-DC converter converts grid AC power into DC when additional power is required.
DC-AC converter converts DC power from solar and battery into AC for home Loads. These converters ensure stable and efficient energy transfer between different components.

C. Battery / Electric Vehicle (EV)

The EV battery acts as an energy storage system. It stores excess solar energy and supplies power when needed. It supports:
Vehicle-to-Home (V2H): EV supplies power to home loads
Vehicle-to-Grid (V2G): EV supplies power back to the grid This bidirectional capability improves energy utilization and reliability.

D. Home Load

The home load represents electrical appliances that consume power. The system prioritizes supplying power from solar energy first, followed by the EV battery, and finally the grid if needed.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

E. Grid Connection
The utility grid acts as a backup power source. When renewable energy and battery storage are insufficient, power is drawn from the grid. In some cases, excess energy can also be fed back to the grid.

F. Sensors (Voltage & Current)
Sensors are used to continuously monitor key electrical parameters such as voltage, current, and power. This real- time data is essential for system control and optimization.

G. Microcontroller (ESP32)
The **ESP32** acts as the brain of the system. It collects data from sensors, processes it, and controls the switching operations of relays and converters. It ensures proper energy flow based on system conditions.

H. IoT Cloud Platform
The IoT platform enables real-time monitoring and remote control. Users can view system performance, energy usage, and battery status through a mobile or web interface.

I. Relay / Switching Unit
Relays are used for automatic switching between different power sources (solar, battery, grid). The microcontroller controls these relays to ensure optimal energy management.

V. HARDWARE IMPLEMENTATION OF INTELLIGENT ENERGY SHARING BETWEEN HOME, EV AND GIRD

The hardware implementation of the proposed system integrates renewable energy generation, energy storage, sensing, control, and communication modules. A solar photovoltaic (PV) panel is used as the primary energy source, converting sunlight into electrical energy. The output from the solar panel is regulated using a DC-DC converter to ensure a stable voltage suitable for charging the battery and supplying the load. An ESP32 microcontroller serves as the central control unit. It collects real-time data from voltage and current sensors placed at different points in the system. These sensors continuously monitor parameters such as voltage level, current flow, and power consumption, enabling accurate system analysis and control. A rechargeable battery, representing the electric vehicle (EV), is used as an energy storage unit. It stores excess solar energy and supplies power during low generation or peak demand conditions. The system supports bidirectional energy flow, allowing the battery to power the home load when required. A relay module is used for automatic switching between energy sources such as solar, battery, and grid. The ESP32 controls these relays based on real-time conditions and predefined logic. Power converters, including AC-DC and DC-DC, are used to ensure proper voltage conversion and efficient energy transfer. Additionally, the system is connected to an IoT platform through the ESP32, enabling real-time monitoring and remote access to system data. This hardware setup ensures efficient energy utilization, reliable operation, and intelligent control of the overall system.

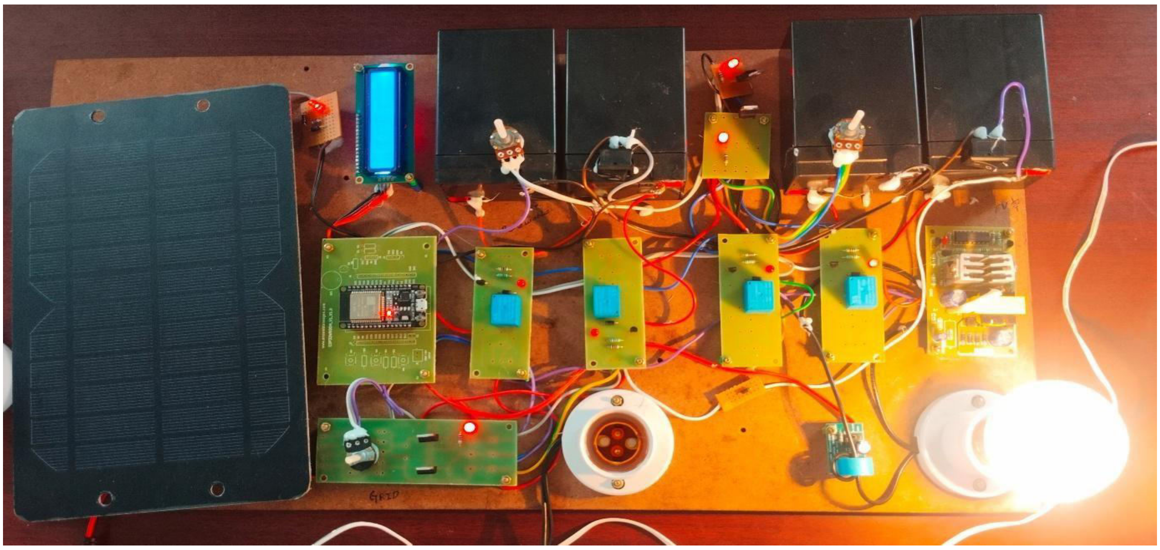


Fig.5.1 Hardware Implementation of Intelligent Energy Sharing between Home, Ev and Gird

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

A. Working Mode

- **Renewable Priority Mode**

When renewable energy is sufficient, the system powers the home and charges the EV battery. This mode reduces grid dependency and electricity cost.

- **EV Sharing Mode**

When renewable energy is low, the EV battery supplies power to the home. This helps in utilizing stored energy and reducing peak-hour grid usage.

- **Grid Support Mode**

When both renewable energy and EV battery are insufficient, the grid supplies power to ensure uninterrupted electricity.

- **EV Charging Mode**

When renewable energy and Grid supply exceeds demand and the EV battery gets charged, and excess power is exported to the grid.

B. Algorithm of the Proposed System

STEP 1: Start
STEP 2: Initialize system (LCD, Wi-Fi, relays, variables) STEP 3: Read sensor values (renewable, grid, EV, current)
STEP 4: Convert sensor data to voltage and current
STEP 5: Calculate load power
STEP 6: Apply decision logic to select mode (Renewable mode, Grid mode, EV sharing & charging mode)
STEP 7: Activate corresponding relay based on selected mode STEP 8: Calculate energy consumption (units)
STEP 9: Compute electricity cost based on selected source
STEP 10: Perform trend analysis (average and peak power) STEP 11: Detect faults (overload and low voltage)
STEP 12: Calculate efficiency and sustainability STEP 13: Predict future load
STEP 14: Display data on LCD and web server STEP 15: Repeat continuously
STEP 16: End

VI. RESULT AND DISCUSSION

The proposed Intelligent Renewable Energy Exchange System was successfully designed and tested under various operating conditions to evaluate its performance in managing energy flow between the solar source, electric vehicle (EV), home load, and the utility grid. The system demonstrated efficient operation in all four working modes, including renewable-to-load, renewable-to-battery, battery-to-load (V2H), and grid-supported operation. During testing, it was observed that the system effectively prioritized renewable energy usage. When sufficient solar power was available, the home load was supplied directly from the solar source, and excess energy was stored in the EV battery. This significantly reduced dependency on the grid and improved overall energy utilization. The DC-DC converter ensured stable voltage levels during battery charging, minimizing losses and improving efficiency. In conditions of low or no solar generation, the system successfully switched to battery mode, where the EV supplied power to the home load. This Vehicle-to-Home (V2H) operation ensured uninterrupted power supply and demonstrated the effectiveness of the EV as a distributed energy storage unit. When both solar and battery energy were insufficient, the system automatically switched to grid supply, maintaining continuous operation without interruption. The relay-based switching mechanism provided smooth and reliable transitions between different power sources. No significant delay or instability was observed during switching, indicating proper coordination by the ESP32 controller. The system also demonstrated bidirectional energy capability, where excess energy stored in the battery could be supplied back to the grid (Vehicle-to-Grid mode), contributing to grid support and improved energy flexibility. The integration of IoT technology enabled real-time monitoring of system parameters such as voltage, current, power flow direction, and battery status. The data collected through the IoT platform helped in analyzing system performance and ensured accurate decision- making. The monitoring system also improved transparency and allowed remote control of operations.

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

- Renewable Voltage: 230 V
- Grid Voltage: 25 V
- EV Battery Voltage: 12 V
- Load Current: 48.76 mA
- Load Power: 1219.00 W
- Units Consumed: 0.63158 kWh
- EB Bill: â,¹0.65
- Mode: **RENEWABLE MODE**

Fig.6.1 Output Display For Renewable Energy Mode

- Renewable Voltage: 115 V
- Grid Voltage: 230 V
- EV Battery Voltage: 12 V
- Load Current: 49.04 mA
- Load Power: 11279.20 W
- Units Consumed: 0.64680 kWh
- EB Bill: â,¹0.76
- Mode: **GRID MODE**

Fig.6.2 Output Display For Grid Mode

- Renewable Voltage: 0 V
- Grid Voltage: 0 V
- EV Battery Voltage: 0 V
- Load Current: 0.00 mA
- Load Power: 0.00 W
- Units Consumed: 0.63001 kWh
- EB Bill: â,¹0.65
- Mode: **EV SHARING MODE**

Fig.6.3 Output Display For EV Sharing Mode

- Renewable Voltage: 230 V
- Grid Voltage: 230 V
- EV Battery Voltage: 3 V
- Load Current: 102.36 mA
- Load Power: 23542.80 W
- Units Consumed: 0.30694 kWhh
- EB Bill: â,¹.09
- Mode: **EV CHARGING MODE**

Fig.6.4 Output Display For EV Charging Mode

VII. CONCLUSION

This paper presents an intelligent renewable energy exchange system that integrates solar energy, electric vehicles (EVs), home loads, and the utility grid into a unified platform. The system effectively utilizes IoT technology and an ESP32-based control unit to monitor and manage energy flow in real time. By enabling bidirectional energy transfer, the EV functions not only as a load but also as an energy storage system, supporting Vehicle-to-Home (V2H) and Vehicle-to-Grid (V2G) operations. The implementation demonstrates that the system can efficiently prioritize renewable energy usage, reduce dependency on the grid, and ensure uninterrupted power supply under different operating conditions. The relay-based switching mechanism provides smooth and automatic control between solar, battery, and grid sources. Overall, the proposed system improves energy efficiency, reduces electricity costs, and promotes sustainable energy

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

utilization. It also provides a scalable and reliable solution for future smart grid and smart home applications. The integration of IoT further enhances system performance through real-time monitoring and intelligent control, making it a promising approach for modern energy management systems.

REFERENCES

[1] M. Yilmaz and P. T. Krein, “Review of the Impact of Vehicle-to-Grid Technologies on Distribution Systems and Utility Interfaces,” IEEE Transactions on Power Electronics, vol. 28, no. 12, pp. 5673–5689, 2013.
[2] W. Kempton and J. Tomic, “Vehicle-to-grid power fundamentals: Calculating capacity and net revenue,” Journal of Power Sources, vol. 144, pp. 268–279, 2005.
[3] S. Habib, M. Kamran, and U. Rashid, “Impact Analysis of Vehicle-to-Grid Technology and Charging Strategies,” Renewable and Sustainable Energy Reviews, vol. 54, pp. 169–178, 2016.
[4] A. Mwasilu, J. J. Justo, E.-K. Kim, T. D. Do, and J. Woo, “Electric Vehicles and Smart Grid Interaction: A Review on the Vehicle-to-Grid and Renewable Energy Sources Integration,” Renewable and Sustainable Energy Reviews, vol. 34, pp. 501–516, 2014.
[5] Y. Mu, J. Wu, J. Ekanayake, N. Jenkins, and H. Jia, “A Spatial–Temporal Model for Grid Impact Analysis of Plug-in Electric Vehicles,” Applied Energy, vol. 114, pp. 456–465, 2014.
[6] S. L. Arun and J. Selvan, “Intelligent Scheduling of Electric Vehicle Charging Using Machine Learning Techniques,” Energy Reports, vol. 6, pp. 2664–2674, 2020.
[7] E. Sortomme and M. A. El-Sharkawi, “Optimal Charging Strategies for Unidirectional Vehicle-to-Grid,” IEEE Transactions on Smart Grid, vol. 2, no. 1, pp. 131–138, 2011.
[8] G. Rigas, N. Hatziargyriou, and D. Roga, “IoT-enabled Smart Grid Systems for Energy Management and Real- Time Monitoring,” Electric Power Systems Research, vol. 189, 2020.
[9] Z. Shao, C. Wang, and M. Shahidehpour, “Impact of Energy Storage and Renewable Integration on Smart Grid Operation,” IEEE Transactions on Smart Grid, vol. 7, no. 3, pp. 1335–1345, 2016.
[10] P. T. Babatunde, A. M. Moghaddam, and M. R. Haghifam, “Optimal Operation of Electric Vehicles as Distributed Energy Resources in Smart Grids,” IET Generation, Transmission & Distribution, vol. 12, no. 6, pp. 1439–1447, 2018.
[11] X. Wu, X. Hu, and S. Moura, “Stochastic Energy Management for Electric Vehicles in Microgrids with Renewable Integration,” Applied Energy, vol. 210, pp. 936–948, 2018.
[12] M. Brenna, F. Foiadelli, and D. Zaninelli, “Electric Vehicles Charging Technologies and Standards,” IEEE Transactions on Industry Applications, vol. 52, no. 1, pp. 168–179, 2016.
[13] A. B. Arif, S. Z. Islam, and M. A. Mahmud, “AI-Based Load Forecasting for Electric Vehicle Charging Stations,” IEEE Access, vol. 9, pp. 99868–99879, 2021.
[14] L. Jian, K. Zhang, and Z. Song, “Coordinated Charging of EVs for Load Shaping and Energy Balancing in Smart Grids,” Energy, vol. 96, pp. 229–243, 2016.
[15] R. Ghorbani, H. Karimi, and H. Hooshyar, “Demand Response for Peak Load Reduction Using EV Energy Storage,” Electric Power Systems Research, vol. 195, 2021.
[16] T. Ma and O. A. Mohammed, “Optimal of plug-in electric vehicles for a car-park infrastructure,” IEEE Transactions on Industry Applications, vol. 50, no. 4, pp. 2323–2330, Jul. 2014.
[17] Z. Wei, J. He, M. Xing, and L. Cai, “Utility maximization for electric vehicle with admission control and scheduling,” in Proc. IEEE Int. Conf. Communications, pp. 661–666, 2015.
[18] S. Chen, L. Tong, and T. He, “Optimal deadline scheduling with commitment,” in Proc. Annual Allerton Conf. Communication, Control, and Computing, pp. 111–118, 2011.
[19] M. M. Golias, M. Boile, and S. Theofanis, “A lambda-optimal based heuristic for the berth scheduling problem,” Transportation Research Part C, vol. 18, no. 5, pp. 794–806, 2010.
[20] A. Imai, E. Nishimura, and S. Papadimitriou, “The dynamic berth allocation problem for a container port,” Transportation Research Part B, vol. 35, no. 4, pp. 401–417, 2001.
[21] A. Imai, E. Nishimura, and S. Papadimitriou, “Berth allocation with service priority,” Transportation Research Part B, vol. 37, no. 5, pp. 437–457, 2003.
[22] A. Imai, E. Nishimura, and S. Papadimitriou, “Berthing ships at multi-user container terminal with a limited quay capacity,” Transportation Research Part E, vol. 44, no. 1, pp. 136–151, 2008.
[23] G. R. Mauri, A. C. M. Oliveira, and L. A. N. Lorena, “A hybrid column generation approach for the berth allocation problem,” Springer Berlin Heidelberg, vol. 4972, pp. 110–122, 2008.
[24] C. J. Ting, K. C. Wu, and H. Chou, “Particle swarm optimization algorithm for the berth allocation problem,” Expert Systems with Applications, vol. 41, no. 4, pp. 1543–1550, 2014.
[25] M. A. Rahman, S. K. Das, and P. K. Saha, “AI-Based Smart Charging Strategy for Electric Vehicles in Smart Grid Environment,” IEEE Access, vol. 12, pp. 14523–14538, 2024.

| e-ISSN: 2278 – 8875, p-ISSN: 2320 – 3765| www.ijareeie.com | Impact Factor: 8.807 | A Monthly Peer Reviewed & Refereed Journal |

|| Volume 15, Issue 3, March 2026 ||

| DOI:10.15662/IJAREEIE.2026.1503015 |

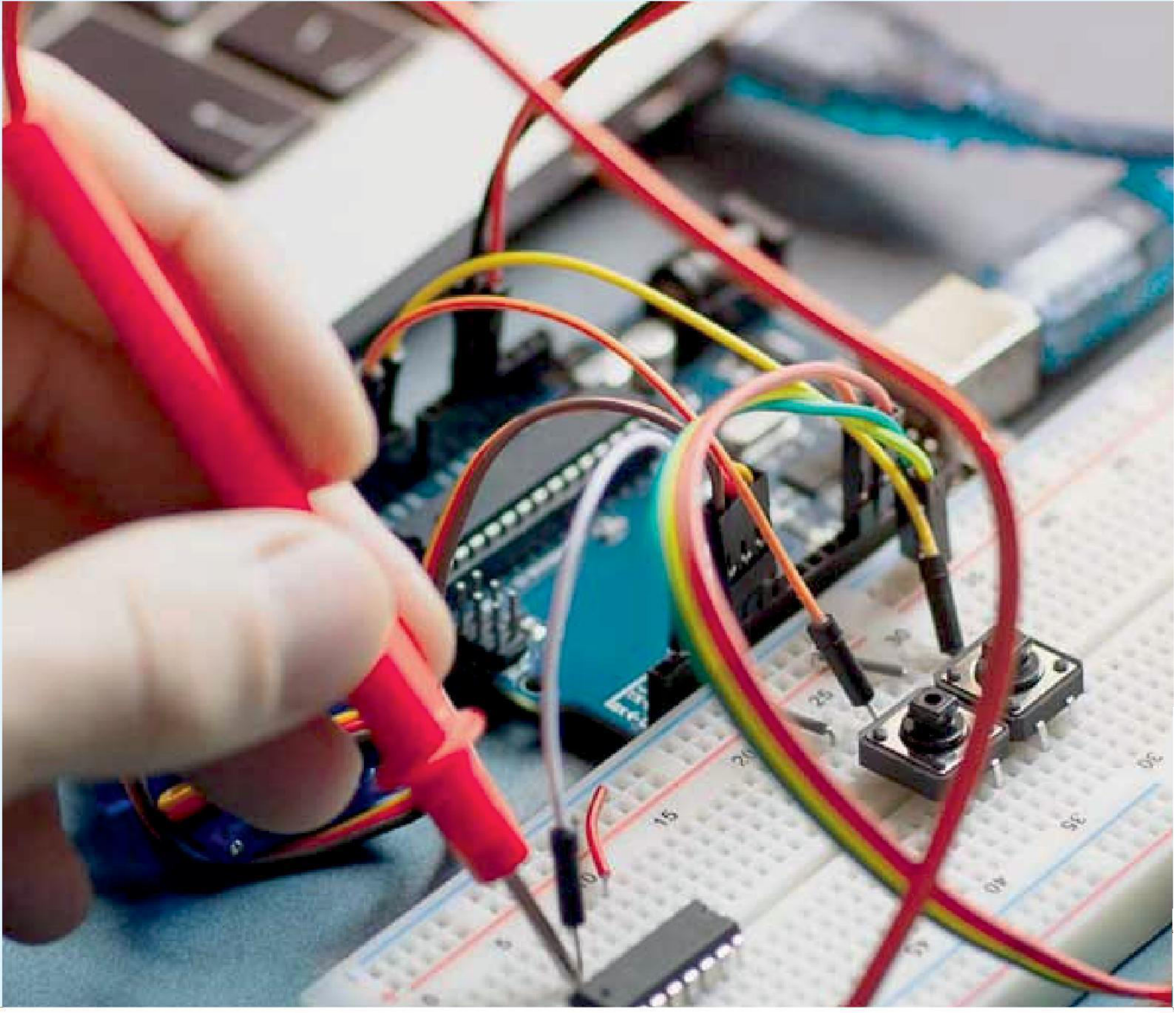
[26] J. Liu, Y. Wang, and H. Zhang, "IoT-Enabled Electric Vehicle Charging Infrastructure for Real-Time Monitoring and Control," IEEE Internet of Things Journal, vol. 11, no. 4, pp. 3120–3132, 2024.

[27] R. Kumar, A. Singh, and M. Tiwari, "Solar Integrated EV Charging System Using IoT and Energy Management Techniques," Renewable Energy, vol. 224, pp. 1195–1208, 2024.

[28] S. Patel, V. Shah, and N. Mehta, "Smart EV Charging System with Load Balancing Using Artificial Intelligence," Energy Reports, vol. 10, pp. 567–578, 2025.

[29] L. Chen, X. Zhao, and Y. Li, "IoT-Based Energy Management System for Electric Vehicle Charging Stations," Sustainable Energy, Grids and Networks, vol. 41, 2025.

[30] D. Gupta, R. Sharma, and A. Verma, "Real-Time Energy Management of EV Charging Stations Using IoT and Cloud Computing," Journal of Cleaner Production, vol. 435, 2025.



International Journal of Advanced Research

in Electrical, Electronics and Instrumentation Engineering

9940 572 462 6381 907 438 ijareeie@gmail.com

Scan to save the contact details

www.ijareeie.com