Revolutionizing Energy Management: The Integration of Progressive Technology and Competitive Power Market for Interconnected Multi-Smart System

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***ABSTRACT*-----The idea behind revolutionizing energy management is to use cutting-edge technology and systems to replace the conventional approaches to energy management. The goal of this strategy is to develop intelligent, networked energy systems that can effectively track and manage energy use across a range of settings. Technology integrations such CT/PT, PIC controller, relay, load current, LCD, and IOT provide real-time data analysis and decision-making to improve energy use. This lowers costs while simultaneously ensuring a steady and long-lasting supply of energy. Through this idea, businesses and people may cut operating expenses while also doing their part to lessen the carbon imprint. Revolutionizing Energy Management offers the possibility of cost savings and sustainable energy management, as well as improved integration and administration of renewable energy sources. This idea provides a way to efficiently integrate and use renewable energy sources in the current energy system in light of the growing push toward renewable energy. It creates the foundation for a more effective and environmentally sustainable energy system by automating and improving the energy production and consumption processes.**

Additionally, it assists in identifying possible problems and enhancing the entire energy management infrastructure with the use of data analytics and predictive maintenance. Finally, Revolutionizing Energy Management is an innovative idea that has the potential to alleviate the world's energy concerns and lead us toward a cleaner, more sustainable future.

Keywords-----Cutting edge technology, Conventional approach, Carbon imprint, Data analytics.

I.INTRODUCTION

Energy management has always been an essential part of human existence. Energy is a fundamental necessity and has a direct influence on the quality of life, whether it is used for residential, commercial, or industrial reasons [1]. The conventional techniques of energy management are insufficient now due to the expanding population and rising energy consumption [2]. Energy management must be revolutionized to provide future generations with a reliable and efficient energy source [3]. The alteration of the current energy management system to make it more creative, intelligent, and effective may be referred to as revolutionizing energy management. It entails utilizing a competitive power market and integrating cutting-edge technology to build linked multi-smart systems [5]. Through this integration, the energy management process will be made more effective overall and energy usage will be optimized [6]. The supply-driven strategy, which formed the foundation of the conventional energy management system, assigned exclusive responsibility to energy suppliers for the production and distribution of energy to satisfy customer demand [7]. This strategy frequently produced a centralized structure that was ineffective and susceptible to changes in demand [8]. Additionally, the use of non-renewable energy sources has resulted in environmental damage and energy scarcity in some parts of the world [9]. The idea of modernizing energy management emerged as a solution to these problems. Its main objective is to replace the current system of energy management with a more sustainable, decentralized, and client-centered one [10]. The integration of cutting-edge technologies, including smart grids, renewable energy sources, and data analytics, as well as a competitive power market are required for this change. Data analytics is a crucial process in energy management, involving data collection, storage, cleaning, analysis, visualization, predictive analytics, automation, and decision-making. It involves collecting data from sources like smart meters, sensors, weather forecasts, and historical energy consumption records. The data is stored in a centralized database, cleaned and pre-processed, and analyzed using statistical and machine learning techniques. Data visualization aids in understanding and interpreting the data. Advanced machine learning algorithms can predict future energy consumption, optimize efficiency, and generate reports for decision-making. Data analytics not only reduces costs but also promotes sustainable practices [12].

The idea of revolutionizing energy management includes using smart grids as well as a competitive power market. Smart grids utilize advanced metering infrastructure (AMI) and energy management systems (EMS) to monitor energy consumption and generate renewable energy. These systems optimize the use of both traditional and renewable energy sources based on weather conditions, demand, and availability. Advanced control systems and communication technologies, like IoT, manage distributed energy resources, enhancing renewable energy integration. Virtual power plants (VPPs) connect and manage distributed energy resources, creating a flexible, dynamic system that adapts to changes in energy supply and demand [13]. An atmosphere that is more competitive and encourages efficiency and innovation is created by a competitive power market, which enables many suppliers to offer energy services to customers. This market-driven strategy encourages energy providers to make investments in clean, green energy sources, therefore lowering dependency on non-renewable energy sources [14]. In addition, merging of a competitive energy market with smart grids and other cutting-edge technology enables the development of integrated multi-smart systems [15]. Real-time communication between energy providers and consumers made possible by these technologies enables better coordination of energy production and consumption [16]. The fusion of these systems and technology has the prospective to transform energy management in diverse manner [17]. First off, it encourages a more environmentally friendly and sustainable method of using energy, so lowering carbon emissions and lessening their negative effects on the environment [18]. Additionally, it encourages the utilization of clean energy sources and lessens credence on finite sources, making world a little bit more sustainable in the long run [19]. Thirdly, using a competitive power market allows users to pick their energy provider and encourages providers to provide better services, improving energy efficiency and lowering costs for consumers [20]. As a result, the idea of reinventing energy management via the incorporation of cutting-edge technology and a competitive power market for linked multi-smart systems is an essential step towards a more sustainable future [21]. It has the ability to completely change the energy industry, making it more dependable, efficient, and environmentally benign. Governments, energy providers, and customers must work together and cooperatively to achieve this idea [22].

II.EXISTING SYSTEM

Residential structures are among the greatest power users, accounting for 35.3% of total electricity produced in the United States (US) in 2020 and 25.77% of electricity in India. According to reports, a significant amount of electricity is lost in buildings due to unawareness about automatic control and management systems. Building owners fail to set up energy management systems (EMS) for a variety of reasons, including a lack of understanding, the expense of the system, and a lack of motivation, among others. The EMS employs new strategies to make the system eco-friendly, and reduce energy expenditures and client hardships.

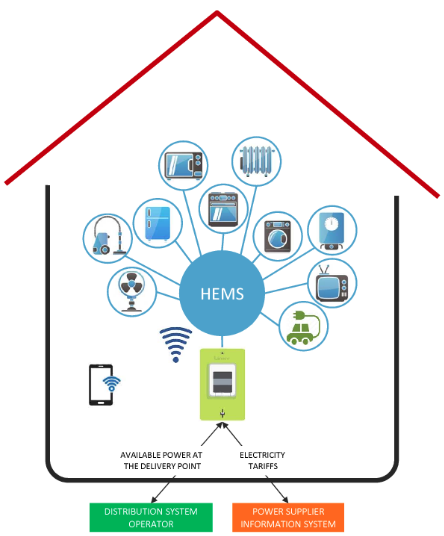

Figure 1: Home Energy Management System

Figure 1 explains the integration of different loads or energy-consuming equipment in a home with the Home Energy Management System (HEMS) is referred to as the notion of systematic connection. It entails connecting the various loads and the HEMS in real-time via a Wi-Fi module, enabling ongoing monitoring and control of energy use. Several facets of HEMS, including renewable energy resources (RERs) and particular goals, have been examined in earlier research. Nevertheless, it has neglected to consider the energy market's rivalry as well as the possibility of intelligent structure and distribution frameworks collaborating to accomplish various objectives. By merging the idea of competitive energy markets with the usage of a connected multi-building setting, this study seeks to close the gaps in earlier studies. As a result, prosumers i.e energy producers and consumers can engage in this market and sell their extra energy to surrounding buildings for the utility export price (UEP) or the market clearing price (MCP). This study is unusual because it incorporates the limitations identified in previous research and presents a fresh strategy for energy management in a cutthroat market.

III.PROPOSED SYSTEM

<u>Block Diagram</u>

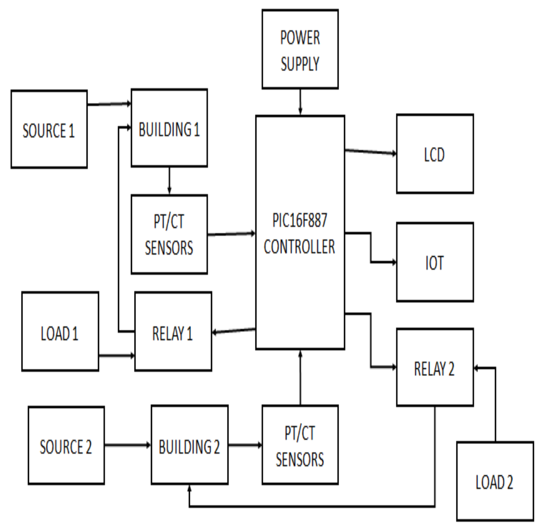

Figure 2: Block diagram of the proposed system

Figure 2 entails the installation of CT/PT (Current Transformer/ Potential Transformer) devices at energy consumption sites. These devices detect current and voltage levels and transmit the information to a PIC (Programmable Integrated Circuit) controller. Programmable Integrated Circuits (PIC) are microcontrollers used in energy management systems to collect data from sensors and devices, enabling real-time monitoring and efficient control of energy usage. They can communicate with other systems, integrating technology and systems, and enabling the use of renewable energy sources, reducing carbon emissions. This data is then processed by the controller, which connects with relay and load current devices to manage the flow of energy to different appliances and equipment.

A. CT/PT Device Installation

The installation of CT/PT devices at energy consumption sites is the initial stage in the operations flow of Revolutionizing Energy Management. These devices are used for assessing the current and voltage levels of the consumed energy. The CT/PT devices are connected in series with the electrical circuit and are meant to lower the voltage and current levels to a level that the PIC controller can safely measure. Depending on the application and the quantity of energy consumed, CT/PT devices come in a variety of sizes and ratings.

B.Data Collection and Processing

When the CT/PT devices are placed, they begin measuring the current and voltage levels of the energy being used. The data acquired by the CT/PT devices is then transferred to the PIC controller for interpretation. The PIC controller is a microcontroller-based device that is configured to accept, process, and store data acquired by the CT/PT devices. The PIC controller is intended to function in real-time and can process enormous volumes of data rapidly and correctly.

C.Interaction with Relay and Load Current Devices

After the PIC controller has acquired and analyzed the data, it interacts with the relay and load current devices to manage the flow of energy to various appliances and equipment. The relay devices turn the energy flow on and off to various appliances and devices, whereas the load current devices control the amount of energy utilized by each gadget and device. The PIC controller connects with these devices using various communication protocols such as the Modbus protocol, CAN, or Ethernet.

D. Analyzing and Optimizing Energy Use

By modifying the energy flow to various appliances in accordance with their demand, the networked system including CT/PT devices, PIC controller, relay devices, and load current devices may optimize energy usage and identify trends in energy consumption. The energy flow is continually adjusted by the PIC controller based on its continuous monitoring of the various appliances' and gadgets' patterns of energy usage.

E.Energy Waste or Malfunction Detection

Users can also be alerted to any problems or energy waste via the integrated system of relay devices, load current devices, PIC controller, and CT/PT devices. The PIC controller can identify any anomalous patterns in the energy usage of various appliances and gadgets by continually monitoring their patterns. This increases energy efficiency by locating and fixing any problems or energy waste.

<u>Software Integration</u>

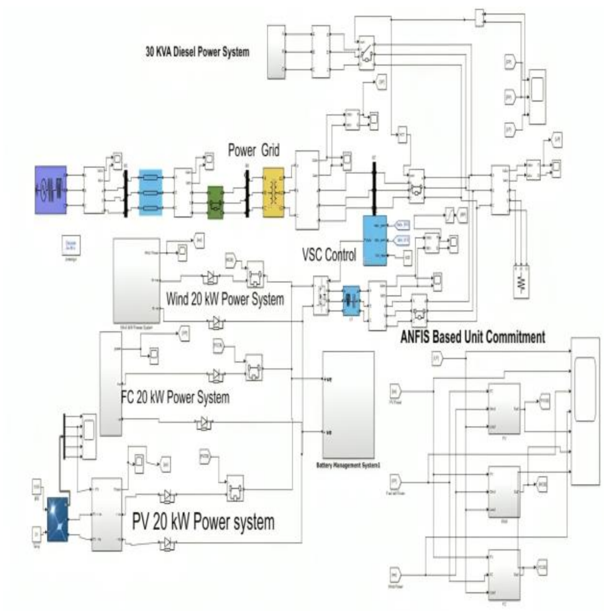

Figure 3: Mat lab Simulink Diagram of Proposed System

Figure3 depicts the general concept of the revolutionary energy management system using a Matlab Simulink graphic. The core software platform serves as a command and control center, collecting, analyzing, and visualizing data from all linked devices via user-friendly dashboards and reports. It also allows users to establish energy consumption objectives, monitor progress, and receive warnings if there are any abnormalities or departures from the stated targets. It also employs machine learning techniques to forecast future energy usage trends and provide optimization options for increased efficiency. To optimize energy management, identify key areas for improvement, such as energy production, distribution, and consumption. Implement intelligent and networked energy systems, integrating technologies like CT/PT, PIC controller, relay, load current, LCD, and IoT. Track and analyze energy data in real-time to gain insights into usage patterns and trends. Optimize energy use by identifying high consumption areas and implementing changes to reduce usage without compromising efficiency. Utilize renewable energy sources by determining the most efficient ways to incorporate them into the energy mix. Automate processes and enable remote management for better control and monitoring. Continuously analyze data and make changes to improve energy management methods, reducing costs and increasing efficiency.

Implementation

To simulate the mentioned system, the MATLAB's Simulink application, which is a framework for block diagrams used for constructing systems using multi domain representations, simulate before moving to hardware, and employ without composing code. Here are the steps to creating a simulation:

1.Model Creation: Create a Simulink model that reflects the system. This is accomplished by dragging and dropping blocks from the Simulink library browser onto the model canvas. Blocks mean to represent the current and voltage sensors, the PIC controller, the relay, and the load current devices in this system.

2.Simulation Configuration: Change the simulation parameters, such as the solver type, simulation time, and beginning circumstances. This may be accomplished by utilizing the Simulink model configuration parameters dialog box.

3.Simulation Execution: Run the simulation and examine the results. This is accomplished by pressing the "Run" button in the Simulink model window. The simulation results may be seen via scopes and graphical displays.

To maximize energy usage, the system may evaluate energy consumption trends and alter energy flow to different appliances based on their need. This is possible with Simulink's optimization tools, such as the Optimization Toolbox and the Simulink Design Optimization tool. Furthermore, the system may encompass renewable energy sources such as solar panels or wind turbines. This might be accomplished by adding blocks to the Simulink model that represent renewable energy sources and altering the controller to regulate the energy flow from these sources.

Overall, MATLAB's Simulink program is a great tool for modeling and optimizing complicated systems like the one presented. The use of Simulink is to develop an intelligent and networked system that continually monitors, manages, and optimizes energy use, resulting in enhanced energy efficiency and sustainability.

Advantages

The proposed approach for implementing Revolutionizing Energy Management provides several advantages to both companies and families. These are some examples:

1. Cost Reduction: Because the system can effectively monitor and manage energy use, it may assist reduce energy costs by finding inefficiencies and recommending optimization measures.

2. Reliable Energy Supply: Real-time monitoring and management of energy use aid in the identification of possible system difficulties or failures. This enables preventative maintenance and provides a consistent energy supply.

3. Environmentally Friendly: By optimizing energy use and eliminating waste, the system helps to reduce the carbon impact. This helps to create a more sustainable and environmentally friendly future.

4. Transparency: The single software platform enables improved decision-making and planning for future energy objectives by providing transparency and insight into energy consumption and prices.

5. Integration with the Competitive Power Market: Integration with the Competitive Power Market is possible thanks to the usage of IOT and other sophisticated technologies. This allows for improved

energy management and procurement techniques, resulting in cost savings and efficiencies.

IV.RESULTS AND DISCUSSION

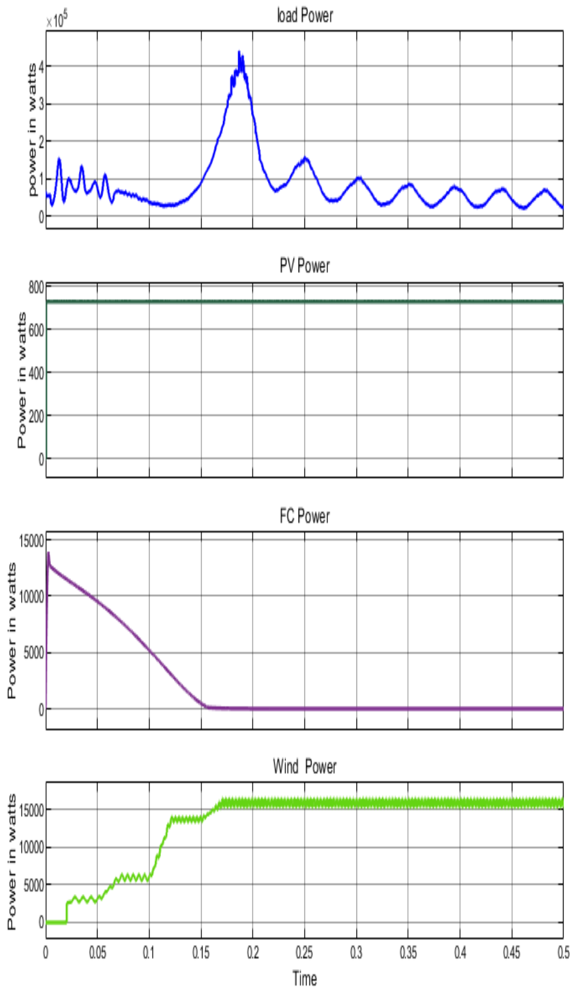

Figure 4: Simulation Output waveforms

Figure 4 shows details for the concept of Revolutionizing Energy Management as follows:

The load power graph depicts real power use over time, which may be used to study energy usage trends and make modifications for more effective energy management.

The PV power graph depicts the quantity of power generated by solar panels over time. This may be examined to the load power graph to see which portion of the energy demand is fulfilled by solar power.

The FC power graph depicts the amount of electricity produced via fuel cells over time. This can be contrasted to the load power graph to determine the part of fuel cells to overall power generation.

The wind power graph depicts the quantity of power generated through wind turbines over time. This may also be examined to the load power graph to better understand the contribution of wind power in the total energy balance.

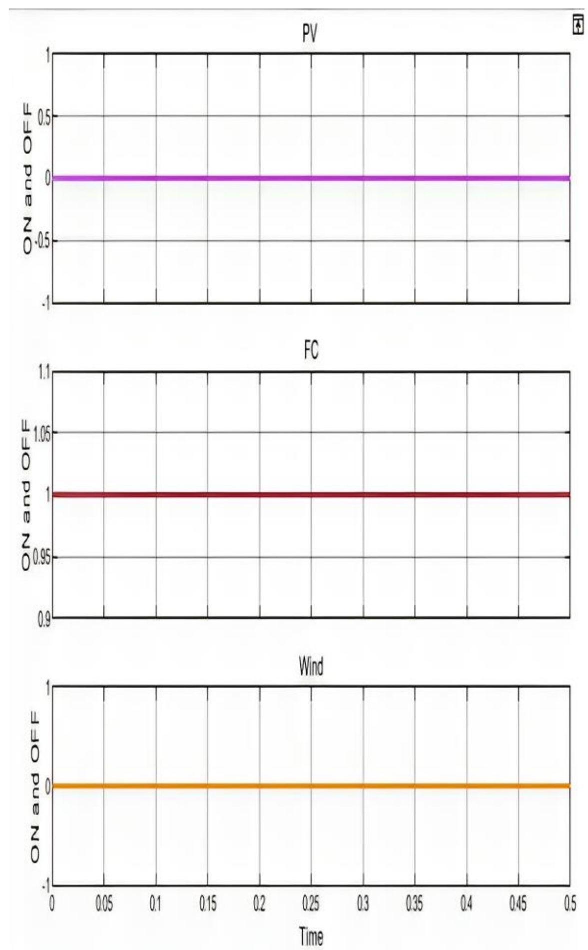

Figure 5: ON and OFF time indicating waveforms of Renewable Energy Resources

Figure 5 indicate the PV, FC, and wind power ON and OFF graphs. At certain seasons, wind and photovoltaic systems will be in an off-peak condition and not actively producing electricity. The renewable resource fuel cell will be producing electricity and in the ON state concurrently. To maximize power production and reduce energy waste, this data may be utilized to spot trends and develop management plans for the fluctuating nature of these sources.

To sum up, these graphs offer useful information for examining trends in energy use and improving energy efficiency in networked multi-smart systems. Additionally, they can aid in the creation of control techniques for handling sporadic energy sources to produce energy more sustainably and efficiently. Real-time data analysis, optimization of energy usage, adoption of renewable energy sources, automation of processes, implementation of energy-efficient technology, education and stakeholder involvement are key to revolutionizing energy management. Continuous monitoring and setting measurable goals can help identify areas for improvement and track progress towards energy-saving goals. Encouraging stakeholders to actively contribute to energy conservation efforts can further enhance performance.

V.CONCLUSION

A possible answer to our society's energy problems is provided by the idea of revolutionizing energy management. This strategy has the potential to transform, to create, distribute, and use energy by utilizing cutting-edge technology and building smart, linked systems. It not only has major economic advantages, but it also lowers carbon emissions and fosters a more sustainable and environmentally friendly future. Implementing Revolutionizing Energy Management is a critical first step in developing a more effective, resilient, and sustainable energy ecosystem to face rising energy needs and environmental issues. Revolutionizing Energy Management also creates opportunity for the creation of cutting-edge new technologies. Intelligent and self-sufficient energy networks may be built thanks to the application of artificial intelligence, machine learning, and internet of things (IOT) in energy management systems. These networks will be able to adapt themselves and optimize energy use in real-time without assistance from a person. This will not only increase the effectiveness of energy management but also lighten the workload for energy operators. Renewable energy sources will be incorporated into the current energy infrastructure without interruption. This will make it easier to overcome the difficulties associated with utilizing sporadic sources of energy and facilitate a more seamless transition to a more sustainable and greener future. Furthermore, the application of sophisticated energy management systems will enhance the forecasting and prediction of the output of renewable energy, resulting in improved exploitation of these resources.

VI.CHALLENGES AND RESEARCH GAP

The substantial upfront expenditures involved in putting new technology and systems into place are one of the main obstacles to modernizing energy management. This makes broad acceptance difficult and may impede the rate of advancement in the energy management industry. Furthermore, integrating various energy management devices and systems may be difficult and take a lot of experience, which can be difficult for both individuals and enterprises. The absence of uniformity and interoperability across various energy management solutions is a noteworthy obstacle.

Furthermore, research on the long-term effects and efficacy of these novel energy management methods is lacking. Although effective case studies and pilot programs exist, little is known about the long-term advantages and cost reductions of these approaches. To completely grasp these technologies' potential and to pinpoint any possible downsides or restrictions, more study is required. Further studies on behavior modification and customer uptake of smart systems for energy administration are also necessary. Even while these technologies can offer data and insights in real time, it is ultimately up to the people to modify their behavior and use less energy. The broad success of modernizing energy management depends on our ability to understand what drives people to embrace sustainable energy habits.

In conclusion, there is a lot of promise for the future of revolutionizing energy management; nevertheless, there are a number of obstacles and knowledge gaps that require attention. Revolutionizing energy management may result in major improvements in energy use, environmental consciousness, and cost reserve for all stakeholders if these challenges are overcome and ongoing innovation and improvement are pursued.

VII.FUTURE SCOPE

Optimizing energy usage and minimizing waste are two of Revolutionizing Energy Management's primary objectives. Smart energy meters, which offer real-time data on energy consumption, are used to do this. Organizations may identify places where energy is being wasted and take the required actions to increase efficiency by having a thorough understanding of energy usage trends. People will have more control over their energy consumption and costs by installing smart energy management systems in their homes. Future industrial processes that are more efficient and sustainable may potentially be made possible by revolutionizing energy management. Industries may lower their energy use and carbon emissions by incorporating smart energy management technologies into the production process. Their operations will become more ecologically friendly as a result, and in the long term, this will also result in cost savings.

Advanced technology, including artificial intelligence and machine learning, enables precise monitoring and analysis of energy usage, identifying high consumption areas and potential energy-saving opportunities. This proactive approach promotes efficiency and cost savings. Smart meters and sensors enable real-time monitoring, enabling quick detection and resolution of issues. This results in a more efficient, cost-effective, and sustainable energy management system, enhancing accuracy and efficiency. Furthermore, substantial developments in energy storage technologies can be done with the adoption of Revolutionizing Energy Management. Batteries may be used to store extra energy for later use, which eliminates the requirement for conventional fossil fuel-based power plants. Smart grids are revolutionizing energy management by integrating various energy storage technologies. These include Battery Energy Storage Systems (BESS), Pumped Hydro Storage, Flywheel Energy Storage, Thermal Energy Storage, Compressed Air Energy Storage (CAES), and Super capacitors. BESS stores excess energy from renewable sources, while CAES stores compressed air in underground caverns or tanks. Flywheel Energy Storage stabilizes power outputs from renewable sources, while Thermal Energy Storage uses a thermal medium. CAES can incorporate renewable sources like wind power. Super capacitors can store and release large amounts of energy quickly, improving overall system efficiency. By integrating these technologies, smart grids can balance energy supply and demand, store excess energy, and maintain grid stability. Additionally, by bringing the supply and demand of energy into balance, a more stable and dependable energy system will result. Therefore, the idea of revolutionizing energy management has a promising future. All stakeholders, including people, businesses, and the environment, stand to gain from it by developing a more sustainable and effective energy system. Revolutionizing Energy Management will be crucial in influencing the development of a sustainable and green future for future generations through constant breakthroughs and improvements.

REFERENCES

[1] U.S. Energy Information Administration. (2018). Annual Energy Outlook 2023.

[2] 80% Energy Consumed by Buildings—News | Khaleej Times. Accessed: Sep. 27, 2022

[3] S.-H. Choi, A. Hussain, and H.-M. Kim, ‘‘Adaptive robust optimization based optimal operation of micro grids considering uncertainity anddeparturetimesofelectricvehicles,’’Energies,vol.11,no.10,p. 2646, Oct. 2022, doi: 10.3390/en11102646.

[4] H. Kikusato, K. Mori, S. Yoshizawa, Y. Fujimoto, H. Asano, Y. Hayashi, A. Kawashima, S. Inagaki, and T. Suzuki, ‘‘Electric vehicle charge– discharge management for utilization of photovoltaic by coordination between home and grid energy management systems,’’ IEEE Trans. Smart Grid, vol. 10, no. 3, pp. 3186–3197, May 2022, doi: 10.1109/TSG.2018.2820026.

[5]A.Najafi-Ghalelou,K.Zare and S. Nojavan, "Optimal scheduling of multi-smart buildings energy consumption considering power exchange capability", Sustain. Cities Soc., vol. 41, pp. 73-85, Aug. 2018.

[6]A. Barbato, A. Capone, G. Carello, M. Delfanti, M. Merlo and A. Zaminga, "House energy demand optimization in single and multi-user scenarios", Proc. IEEE Int. Conf. Smart Grid Commun. (SmartGridComm), pp. 345-350, Oct. 2011.

[7] Z. Pooranian, J. Abawajy, V. P and M. Conti, "Scheduling distributed energy resource operation and daily power consumption

for a smart building to optimize economic and environmental parameters", Energies, vol. 11, no. 6, pp. 1348, May 2018.

[8] R. V. Rao, "Jaya: A simple and new optimization algorithm for solving constrained and unconstrained optimization problems", *Int. J. Ind. Eng. Comput.*, vol. 7, no. 1, pp. 19-34, 2016.

[9] A.Sinha, A. K. Basu, R. N. Lahiri, S. Chowdhury, S. P. Chowdhury and P. A. Crossley, "Setting of market clearing price (MCP) in microgrid power scenario", Proc. IEEE Power Energy Soc. Gen. Meeting Convers. Del. Electr. Energy 21st Century, pp. 1-8, Jul. 2008.

[10] M. K. Rafique, Z. M. Haider, K. K. Mehmood, M. S. Uz Zaman, M. Irfan, S. U. Khan, et al., "Optimal scheduling of hybrid energy resources for a smart home", Energies, vol. 11, no. 11, pp. 1-19, 2018.

[11] Muhammad Ibrar, Aiman Erbad, Mohammed Abegaz, Aamir Akbar, Mahdi Houchati, Juan M. Corchado, "REED: Enhanced Resource Allocation and Energy Management in SDN-Enabled Edge Computing-Based Smart Buildings", 2023 International Wireless Communications and Mobile Computing (IWCMC), pp.860-865, 2023.

[12] Seyed Amir Mansouri, Siavash Maroufi, Amir Ahmarinejad, "A tri-layer stochastic framework to manage electricity market within a smart community in the presence of energy storage systems", Journal of Energy Storage, vol.71, pp.108130, 2023.

[13] Seyed Amir Mansouri, Ángel Paredes, José Manuel González, José A. Aguado, "A three-layer game theoretic-based strategy for optimal scheduling of microgrids by leveraging a dynamic demand response program designer to unlock the potential of smart buildings and electric vehicle fleets", Applied Energy, vol.347, pp.121440, 2023.

[14] Salman Habib, Amir Ahmarinejad, Youwei Jia, "A stochastic model for microgrids planning considering smart prosumers, electric vehicles and energy storages", Journal of Energy Storage, vol.70, pp.107962, 2023.

[15] Saeid Fatemi, Abbas Ketabi, Seyed Amir Mansouri, "A multi-level multi-objective strategy for eco-environmental management of electricity market among micro-grids under high penetration of smart homes, plug-in electric vehicles and energy storage devices", Journal of Energy Storage, vol.67, pp.107632, 2023.

[16] Saeid Fatemi, Abbas Ketabi, Seyed Amir Mansouri, "A four-stage stochastic framework for managing electricity market by participating smart buildings and electric vehicles: Towards smart cities with active end-users", Sustainable Cities and Society, pp.104535, 2023.

[17] Sayyed Ahmad Ali, Arif Hussain, Waseem Haider, Habib Ur Rehman, Syed Ali Abbas Kazmi, "Optimal Energy Management System of Isolated Multi-Microgrids with Local Energy Transactive Market with Indigenous PV-, Wind-, and Biomass-Based Resources", Energies, vol.16, no.4, pp.1667, 2023.

[18] B. R. Sathyanarayana and G. T. Heydt, "A roadmap for distribution energy management via multiobjective optimization", Proc. Power Energy Soc. Gen. Meeting, pp. 1-8, 2010.

[19] P. Palensky and D. Dietrich, "Demand side management: Demand response intelligent energy systems and smart loads", IEEE Trans. Ind. Informat., vol. 7, no. 3, pp. 381-388, Aug. 2011.

[20] Y. Guezennrc, T. Choi and G. Paganelli, "Supervisory control of fuel cell vehicles and its link to overall system efficiency and low-level control requirements", Proc. IGERT Graduate Student Res. Conf., pp. 2055-2061, 2003-Jun.

[21] S. Abu-Sharkh, "Can microgrids make a majorcontribution to the UK energy supply", Renewable Sustainable Energy Rev., vol. 10, no. 2, pp. 78-127, April 2006.

[22] D. Pudjianto, G. Strbac, F. van Overbeeke, A. I. Androutsos, Z. Larrabe and J. T. Saraiva, "Investigation of regulatorycommercial economic and environmental issues in microgrids", Proc. Int. Conf. Future Power Syst., pp. 1-6, 2005-Nov.