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OPTIMIZING MICROGRID PERFORMANCE WITH RENEWABLE ENERGY AND EV INTEGRATION

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ABSTRACT

The rising levels of pollution, driven by greenhouse gas emissions and global warming, are accelerating the adoption of Electric Vehicles (EVs). As EVs become more integrated with the electrical grid, they significantly influence voltage stability and overall grid load. This study explores the modeling and analysis of renewable energy and EV integration within microgrid environments. The microgrid under investigation comprises a diesel generator as the primary power source, supplemented by a Photovoltaic (PV) farm and a wind farm for renewable electricity generation. Additionally, a strategically positioned Vehicle-to-Grid (V2G) system near the microgrid's load enhances flexibility in managing EV charging and discharging cycles.The increasing capacity of renewable energy sources highlights the crucial role of microgrids in meeting diverse energy demands, including those of hospitals, universities, EV charging stations, and broader community and industrial sectors. Reliable charging infrastructure is essential for sustaining EV operations, impacting grid stability and energy management strategies. This paper examines the dynamic effects of EV integration on microgrid networks, considering the nonlinear circuit components inherent in EV systems. It also provides a detailed modeling and analysis of how renewable energy integration and EV adoption can enhance microgrid performance, contributing to more sustainable energy solutions. Also, this paper reviews the analysis of the microgrid with EVs using Matlab/Simulink.

I. INTRODUCTION

The transportation sector is a major contributor to global greenhouse gas emissions, accounting for approximately 25% of energy-related emissions. Electric Vehicles (EVs) have emerged as a promising solution due to their zero-emission operation. Governments worldwide are actively promoting EV adoption through incentives and regulatory measures. However, widespread, unregulated EV charging could place significant strain on the electrical grid, leading to increased peak electricity

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demand, power losses, equipment overload, and reduced power quality.

Effectively managing EV charging patterns and utilizing Vehicle-to-Grid (V2G) technology can offer multiple benefits, including grid frequency stabilization, cost optimization, renewable energy integration, and load balancing. EVs play a crucial role not only in transportation but also in environmental sustainability by replacing Internal Combustion Engine (ICE) vehicles, which are major sources of carbon dioxide emissions.

EVs come in various forms—Battery Electric Vehicles (BEVs), Hybrid Electric Vehicles (HEVs), and Fuel Cell Electric Vehicles (FCEVs)—utilizing different energy storage technologies such as batteries, fuel cells, and ultra-capacitors. While concerns about battery longevity exist, ongoing research continues to improve battery durability. V2G and Grid-to-Vehicle technologies are critical to EV systems, enabling bi-directional energy flow where EVs can supply power back to the grid. This capability supports load leveling, cost reduction, and enhanced grid stability through smart control strategies. Aggregators play a key role in optimizing V2G operations by managing interactions between EVs and the power grid efficiently.

Efforts to integrate V2G systems aim to smooth out load profiles, reduce environmental impact, and improve power reliability and efficiency. Future EVs are envisioned not only as energy consumers but also as distributed energy resources capable of supporting grid stability. Plug-in Hybrid Electric Vehicles (PHEVs), for instance, can function both as energy consumers and providers, helping distribute electrical loads across the grid. Understanding the impact of EV charging on distribution networks is essential for both theoretical insights and practical applications. Optimizing charging times and battery efficiency can reduce operational costs, minimize environmental footprints, and improve overall system reliability.

Several research efforts focus on reducing the energy costs associated with EV charging strategies. Some studies use model predictive control and stochastic mixed-integer linear programming to optimize charging procedures and maximize aggregator revenues. However, these models often overlook factors such as distribution system dynamics, microgrid performance, peak loads, and voltage stability. Other approaches, like genetic algorithms combined with sequential quadratic programming, aim to minimize electricity costs and load fluctuations but

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do not fully account for distribution network losses and voltage stability concerns. Ant colony optimization methods focus on reducing waiting times and charging expenses but may neglect overall grid efficiency.

Existing EV charging strategies tend to address specific grid challenges—such as voltage dips, frequency variations, power losses, or peak load management—without offering a comprehensive solution. Some studies focus on reducing voltage regulation issues and active power losses in medium-voltage networks, while others prioritize peak shaving, valley filling, or energy cost reduction.

Research also highlights EVs' potential to enhance grid efficiency and facilitate renewable energy integration. Certain studies examine short-term EV benefits, while others explore centralized charging schemes to mitigate grid congestion and support ancillary services. Additionally, power management strategies for Secondary Frequency Regulation (SFR) using EV fleets have been proposed, considering longer operational time horizons.

Overall, continued research and implementation strategies aim to harness the full potential of EVs in reducing environmental impact, improving grid resilience, and enhancing the stability of transportation and electricity supply systems.

II. LITERATURE SURVEY

[1] R. K. Beniwal, M. K. Saini, A. Nayyar, B. Qureshi, and A. Aggarwal, "A critical analysis of methodologies for detection and classification of power quality events in smart grid," IEEE Access, vol. 9, pp. 83507–83534, 2021.

This paper describes is to present an exhaustive survey of detection and classification of power quality disturbances by discussing signal processing techniques and artificial intelligence tools with their respective pros and cons. Further, critical analysis of automatic recognition techniques for the concerned field is posited with the viewpoint of the types of power input signal (synthetic/real/noisy), pre-processing tools, feature selection methods, artificial intelligence techniques and modes of operation (online/offline) as per the reported articles. The present work also elaborates the future scope of the said field for the reader. This paper provides valuable guidelines to the researchers those having interest in the field of PQ analysis and exploring the better methodologies for further improvement. Comprehensive comparisons have been presented with the help of tabular presentations. Although this critical survey cannot be collectively exhaustive, still this survey comprises the most significant works in the concerned paradigm by examining more than 300 research publications

[2] J. Y. Yong, V. K. Ramachandaramurthy, K. M. Tan, and N. Mithulananthan, "A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects," Renew. Sustain. Energy Rev., vol. 49, pp. 365–385, Sep. 2015.

This paper describes Electrifying transportation is a promising approach to alleviate the climate change issue. The adoption of electric vehicle into market has introduced significant impacts on various fields, especially the power systems. Various policies have been implemented to foster the electric vehicle deployment and the increasing trend of electric vehicle adoption in the recent years has been satisfying. The continual development of electric vehicle power train, battery and charger technologies have further improved the electric vehicle technologies for wider uptake. Despite the environmental and economical benefits, electric vehicles charging introduce negative impacts on the existing network operation. Appropriate charging management strategies can be implemented to cater for this issue. Furthermore, electric vehicle deployment can bring many potential opportunities to the power grid, especially from the perspective of vehicle-to-grid operation and as the solution for the renewable energy intermittency issue. This paper reviews the latest development in electric vehicle technologies, impacts of electric vehicle roll out and opportunities brought by electric vehicle deployment.

[3] Y. Qi, G. Mai, R. Zhu, and M. Zhang, "EVKG: An interlinked and interoperable electric vehicle knowledge graph for smart transportation system," Trans. GIS, vol. 27, no. 4, pp. 949–974, Jun. 2023.

This paper describes Over the past decade, the electric vehicle industry has experienced unprecedented growth and diversification, resulting in a complex ecosystem. To effectively manage this multifaceted field, we present an EV-centric knowledge graph (EVKG) as a comprehensive, cross-domain, extensible, and open geospatial knowledge management system. The EVKG encapsulates essential EV-related knowledge, including EV adoption, electric vehicle supply equipment, and electricity transmission network, to support decision-making related to EV technology development, infrastructure planning, and policy-making by providing

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timely and accurate information and analysis. To enrich and contextualize the EVKG, we integrate the developed EV-relevant ontology modules from existing well-known knowledge graphs and ontologies. This integration enables interoperability with other knowledge graphs in the Linked Data Open Cloud, enhancing the EVKG's value as a knowledge hub for EV decision-making. Using six competency questions, we demonstrate how the EVKG can be used to answer various types of EV-related questions, providing critical insights into the EV ecosystem. Our EVKG provides an efficient and effective approach for managing the complex and diverse EV industry. By consolidating critical EV-related knowledge into a single, easily accessible resource, the EVKG supports decision-makers in making informed choices about EV technology development, infrastructure planning, and policy-making. As a flexible and extensible platform, the EVKG is capable of accommodating a wide range of data sources, enabling it to evolve alongside the rapidly changing EV landscape.

III. PHOTO VOLTAIC SYSTEMS:

Photovoltaic systems are composed of interconnected components designed to accomplish specific goals ranging from powering a small device to feeding electricity into the main distribution grid. Photovoltaic systems are classified as shown in Figure 3.1. The two main general classifications as depicted in the figure are the stand-alone and the grid-connected systems. The main distinguishing factor between these two systems is that in stand-alone systems the solar energy output is matched with the load demand. To cater for different load patterns, storage elements are generally used and most systems currently use batteries for storage.

If the PV system is used in conjunction with another power source like a wind or diesel generator then it falls under the class of hybrid systems. The balances of system components are a major contribution to the life cycle costs of a photovoltaic system. They include all the power conditioning units, storage elements and mechanical structures that are needed. They especially have a huge impact on the operating costs of the PV system.

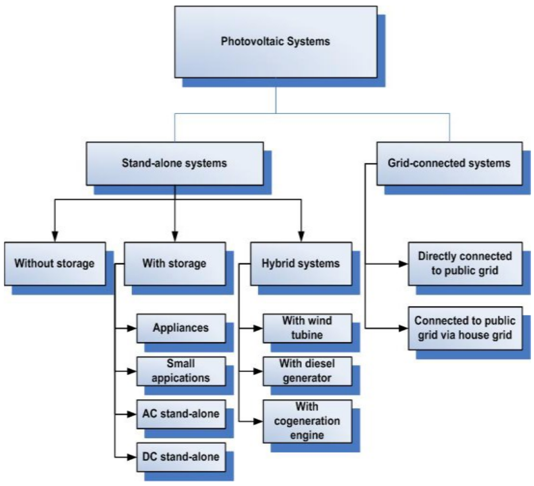

Figure 3.1: Classification of PV systems

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3.1 Importance of Wind Energy and Wind Power:

The modern lifestyle depends tremendously on the use and existence of fossil fuels. With levels of these fuels constantly decreasing, we should act now to become less dependent on fossil fuels and more dependent on renewable energy sources.

The decreasing level of fossil fuels isn't the only reason that we should begin to use renewable energy. Pollution is becoming a huge problem in many countries around the world, especially the developing world. With carbon emissions at an all time high, air quality can be very low in some areas; this can lead to respiratory diseases and cancer.

The main reason to switch to cleaner energy production methods is the global warming aspect. The more carbon dioxide we pump into the atmosphere, the greater the effect becomes. We can't just stop using fossil fuels thinking that global warming will go away, but we can slow down and dilute the effects of global warming through the wide spread use of renewable energy resources. Renewable energy flows involve natural phenomena such as sunlight, wind, tides, plant growth and geothermal heat, as the Agency explains:

Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy, energy efficiency and technological diversification of energy sources, would result in significant energy security and economic benefits.

Renewable energy replaces conventional fuels in four distinct areas i.e., electricity generation, hot water/space heating, motor fuels and rural i.e., off-grid energy services.

ELECTRIC VEHICLE

Electric Vehicle (EV) is an emerging technology in the modern world because of the fact that it mitigates environmental pollutions and at the same time increases fuel efficiency of the vehicles. Multilevel inverter controls electric drive of EV of high power and enhances its performance which is the reflection of the fact that it can generate sinusoidal voltages with only fundamental switching frequency and have almost no electromagnetic interference. This paper describes precisely various topology of EVs and presents transformer less multilevel converter for high voltage and high current EV. The cascaded inverter is IGBT based and it is fired in a sequence. It is natural fit for EV as it uses separate level of dc sources which are in form of batteries or fuel cells. Compared to conventional vehicles, Electric Vehicles (EVs) are more fuel efficient due to the optimization of the engine operation and recovery of kinetic energy during braking. With the plug-in option (PEV), the vehicle can be operated on electric-only modes for a driving range of up to 30–60 km. The PEVs are charged overnight from the electric power grid where energy can be generated from renewable sources such as wind and solar energy and from nuclear energy. Fuel cell vehicles (FCV) use hydrogen as fuel to produce electricity; therefore they are basically emission free. When connected to electric power grid (V2G), the FCV can provide electricity for emergency power backup during a power outage. Due to hydrogen production, storage, and the technical limitations of fuel cells at the present time, FCVs are not available to the general public yet. EVs are likely to dominate the advanced propulsion in coming years. Hybrid technologies can be used for almost all kinds of fuels and engines. Therefore, it is not a transition technology. In EVs and FCVs, there are more electrical components used, such as electric machines, power electronic converters, batteries, ultra capacitors, sensors, and microcontrollers. In addition to these electrification components or subsystems, conventional internal combustion engines (ICE), and mechanical and hydraulic systems may still be present. The challenge presented by these advanced propulsion systems include advanced power train components design, such as power electronic converters, electric machines and energy storage; power management; modeling and simulation of the power train system; hybrid control theory and optimization of vehicle control

IV. MODELLING OF CASE STUDY

4.1 IMPACT OF ELECTRICAL VEHICLE

4.1.1 EFFECTS OF ELECTRICAL VEHICLE CHARGING AND DISCHARGING

EVs have both advantageous and detrimental impacts on the power delivery system [25]. The charging and discharging procedure [26] of EVs is crucial in minimising the peak demand on the power system network and reducing battery degradation costs. A cost-minimization billing plan that excludes the transmission and distribution infrastructure may not be viable. Various optimisation strategies are employed to enhance the load profile, thus decreasing peak demand and ultimately reducing the overall charging expenses of EVs. The simultaneous reduction of

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battery degradation cost and peak demand on the load profile is achieved [27]. Multiple methods exist for charging electric automobiles. Charging electric vehicles during non-peak hours is more cost-effective. Conversely, charging during times of highest demand incurs more costs [28]. The primary goal of any approach is to minimise the expenses associated with EV charging and enhance the entire system's efficiency. Maintaining a greater level of charge in a charging scheme is considered desirable. There are both static and dynamic pricing plans that offer advantages to both power utility companies and electric vehicle customers.

4.1.2 IMPACT ON THE DISTRIBUTION NETWORK

4.1.2.1) EFFECT ON POWER QUALITY

The incorporation of EVs into the power grid presents many power quality issues, such as harmonic contamination, increased power dissipation, diminished voltage, and unbalanced three-phase voltage [29].

a: HARMONIC DISTORTION

Increasing the accessibility of EVs will result in higher usage of the charging infrastructure. This infrastructure comprises several intricate power electronic devices and a Direct Current (DC) link that connects the three-phase Alternating Current (AC) power source. This DC link can produce harmonic distortion, which has the potential to contaminate the electrical grid and impact the performance of distribution system components, thereby affecting power quality [29].

b: VOLTAGE DROP

The technology of EVs is steadily advancing and being implemented on a global basis. This leads to an increase in local load on the power grid. The charging of large-scale EVs will have an impact on the voltage at specific points in the network, particularly causing a decrease in voltage at the end nodes. This, in turn, affects the power demand of users [30].

c: THREE-PHASE IMBALANCE

A lower number of EVs charging at a specific location for a specific duration decreases the charging process. Consequently, this leads to an increase in the magnitude of unevenly distributed three-phase currents. However, the charging of a significant quantity of electrical vehicles results in an imbalanced current condition [30], [31].

4.1.2.2) EFFECT ON OPERATION

Regarding the economic functioning of the distribution network, it mostly manifests in terms of net loss, decreased lifespan of

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cables, and lifespan of distribution transformers [32].

a: NET LOSS

Elevated permeability results in a higher rate of charging load for EVs, which in turn leads to an increased rate of load loss [32].

b: CABLES

The high harmonic currents have a detrimental effect on the cable. Consequently, this leads to diminished efficiency and a shorter lifespan [32]

4.1.3 ENVIRONMENTAL IMPACT

If the current trend persists in the upcoming years, it will result in a rise in temperature and have an impact on the global climate [33]. In order for the efforts of smaller countries to effectively mitigate emissions and utilize renewable technologies, it is imperative that high-energy consumers likewise take measures to decrease their own emissions [34]. Ever since the introduction of the Tesla Roadster, there has been a significant surge in interest in the EV business. The factors contributing to the increase in emissions are as follows [35]: 1) Population growth. 2) Rise in production capacity. 3) Rise in energy use. 4) Rise in transportation. The production of electrical automobiles entails significant energy usage. The production of electrical automobiles emits a greater amount of dangerous pollutants compared to conventional fuel-powered vehicles. This is due to the fact that the manufacturing process entails the creation of lithium-ion batteries, which are a crucial component of electric vehicles. According to statistics, the emissions produced during the production of an EVs account for almost 33% of the total Carbon dioxide (CO_2) emissions released over the vehicle's full life cycle [36]. Nevertheless, recent technological developments and the implementation of highly efficient manufacturing procedures have led to a significant reduction in emissions produced during battery production.

4.1.3.1) POSITIVE IMPACT

EVs are indisputably proven to produce less pollution compared to conventional fuel-powered vehicles. Nevertheless, the manner in which the vehicle is controlled is contingent upon the user's anticipated advantages. When aiming for zero emissions and sustainable energy, it is important to recognise that not all sources of electricity are alike. Alternatively, it is prudent to power the car using sustainable energy sources such as solar and wind power. The installation of a solar panel eliminates the need for gasoline and allows the car to be powered by the electricity generated by the panels, free of charge.

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Additionally, it could be necessary to enlarge the dimensions of the solar panel in order to accommodate the heightened demand for charging the electrical vehicle. The number of extra solar panels needed to provide power for the electric car is contingent upon the vehicle's efficiency, frequency of usage, and the solar potential of the specific area. If it is not feasible to produce the necessary electrical power from solar resources on one's own property, an alternative option is to enrol in a communal solar charging system that operates on a sharing model. This trend is quickly gaining popularity nationwide, and the majority of utility organisations opt to procure electricity from these renewable energy sources [37].

4.1.3.2) DIRECT IMPACT

EVs possess the remarkable attribute of producing fewer tailpipe emissions. They utilise the stored energy in their batteries to propel their wheels and facilitate locomotion. Empirical research has proven that this transformation displays remarkable efficacy, as it experiences negligible thermal dissipation during the procedure. Considering the environmental repercussions resulting from the extraction of battery materials and their subsequent processing, this is of utmost importance. The primary cause of these emissions is mostly the result of coal mining and the extraction and refining of raw materials for battery production. However, the impacts of these influences are significantly less significant when compared to those induced by the operation of a gasoline engine [38].

4.1.3.3) INDIRECT IMPACT

While EVs offer numerous benefits, there are also a few areas of concern to consider. The most detrimental consequence of electric automobiles becomes apparent when we examine the supply chain. It has been discovered that the concentration of particulate matter significantly rises. This is the outcome of coal-based electricity generation. Recent studies indicate that there has been a fluctuation in the typical grid composition, with a notable transition towards renewable energy sources and natural gas. Nevertheless, this transition will not occur instantaneously. When examining the impact of EVs on climate change, research has shown that EVs powered by the current grid generally decrease climate change related effects. However, they do contribute to an increase in particulate pollution, resulting in a net overall higher environmental impact compared to existing conventional methods [39].

4.4 TECHNOLOGY AND CHALLENGE INVOLVED IN EV

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4.4.1 PROBLEM FORMULATION

The main objective of the proposed study is to reduce losses in the distribution system by implementing the V2G strategy, which is based on the fluctuating load demand. The power equations for the distribution system are based on the below one:

1) G2V

2) V2G

Equation (5.3) gives the operation of G2V [47].

$$PG = \sum_{i=1}^{24} PBL + PEV + PL \qquad 5.3$$

Here, PG is Total power generation PBL is base load, PEV is the EV load, and PL is the Losses. Equation (5.4) gives the operation of V2G [47].

$$PG + \sum_{i=1}^{24} PEVDG = \sum_{i=1}^{24} PBL + PL \qquad 5.4$$

where:

PEVDG is the power generated by EV acting as DG. EVs Power charging, discharging limits [47].

V. SIMULATION RESULTS

Electrical cars consist of two components. An internal energy source powers the batteries of electric vehicles, while an electric motor facilitates the vehicle's propulsion. Electrical vehicles require external energy sources to charge their batteries. Under these circumstances, it is necessary to charge the cars. EVs utilise several forms of charging. Charging stations can be classify into various categories based on their charging speed and voltage. The challenges facing the development of EVs involve enhancing their range and reducing the time required for charging. Currently, researchers are conducting ongoing, rigorous investigations to address these issues. To expedite the charging process of an electric car, it is advisable to charge the vehicle using DC. We enhance the power output of the charging stations to reduce the duration of charging for EVs. Consequently, the quantity of charging stations with a power exceeding 350 kW is progressively growing. Several charging plugs equip the charging stations, enabling simultaneous charging for multiple automobiles. Simultaneously charging numerous automobiles can lead to significant issues within the microgrid. The escalating load demand on the grid poses a significant issue. The integration of renewable energy sources and EVs into a microgrid is modelled in Fig. 5.1

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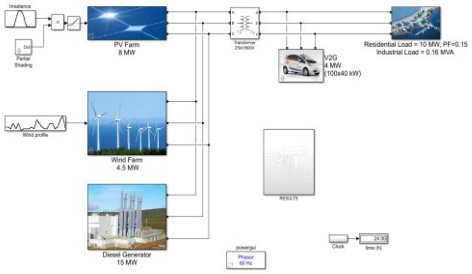

FIGURE 5.1. MATLAB/SIMULINK circuit of the proposed system

5.1 EXISTING RESULTS (LOAD POWER 14MW)

Microgrid systems rely on the precise management of fundamental quantities like current and voltage, which are represented by sinusoidal waveforms with a frequency of 50 Hz. However, these fundamental variables lose their sinusoidal features due to various factors, resulting in the presence of undesired harmonic components in the microgrid system. The exponential growth of EVs results in a surge in power demand, posing an additional burden on the microgrid. Consequently, there is an increase in the variability of the microgrid. The diesel generator within the microgrid maintains equilibrium between the electricity consumed and the power generated. You can determine the discrepancy in the grid frequency by comparing it to the rotor speed of the synchronous machine. Figure 5.2 presents the total energy output of the diesel generator over the course of the day. The drawbacks of diesel generators are their exorbitant cost and their detrimental impact on the environment. Nevertheless, when renewable energy sources are unable to meet the energy demand, the utilization of a diesel generator becomes necessary to generate the required energy. The microgrid consists of two renewable energy sources. First and foremost, the PV plant generates energy in direct proportion to the level of irradiation present in the surrounding environment. Figure 5.3 presents the diurnal energy output of solar panels. The solar farm in the microgrid generates direct current by harnessing solar irradiation. The material composition of the panels, the amount of solar irradiation they absorb, and the prevailing climatic conditions all influence the energy output. The wind farm produces electrical power in direct proportion to the strength of the wind. The turbine produces its maximum power output once the wind speed reaches its designated value. The microgrid deactivates the wind power when the wind speed exceeds its maximum threshold, until it returns to its standard level. Figure 5.4 displays the daily energy production of the wind farm in the microgrid. The use of wind power plants in microgrids is steadily rising owing to their status as a renewable energy source, uncomplicated design, and notable efficacy. Wind farms, in contrast to other conventional power facilities, exhibit distinct characteristics. The primary

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benefit of EVs is their ability to utilise V2G applications. This application is exclusively applicable to electric cars. Essentially, it enables the car to directly supply electricity to the distribution microgrid.

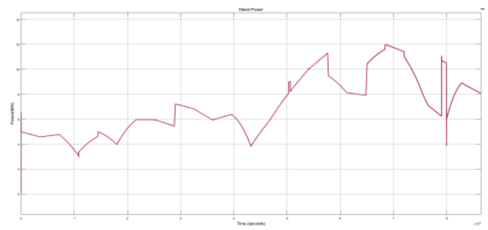

FIGURE 5.2 Power generated by the generator throughout the day.

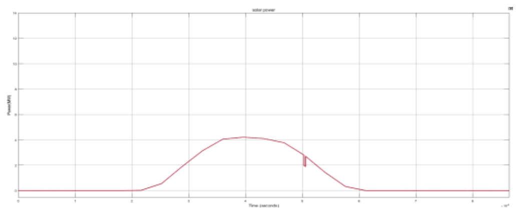

FIGURE 5.3 Power generated by the solar throughout the day.

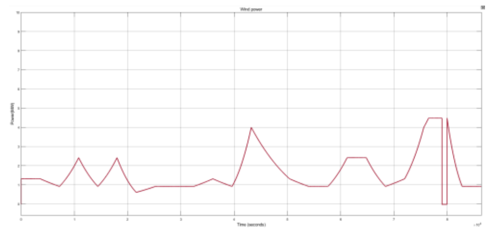

FIGURE 5.4 Power generated by the wind throughout the day.

Figure 5.5 shows the power value that the EV transmits and controls to the microgrid throughout the day. V2G refers to the process of transferring electrical energy from the battery systems of EVs to the microgrid. Within the electrical system, the batteries of EVs function as a means of storing energy. Car-to-grid technology enables the charging and discharging of a car battery based on various signals, such as energy output or consumption. The utilisation of electric vehicle charging results in a rise in the electrical demand per transformer during periods of high energy consumption inside the microgrid. This poses significant challenges to achieving energy equilibrium. Charging many EVs in the same phase leads to a phase imbalance in the microgrid. Spontaneous charging of EVs poses significant issues within the microgrid. Charging many EVs at the same time can result in a decrease in voltage at the connectors of the chargers. EVs draw a significant amount of active power from the network during charging, leading to power losses within the microgrid. V2G technology serves two primary objectives. It manages the battery charge and utilises the available power to stabilise the grid during transient events. V2G technology guarantees the immediate accessibility of current decentralised energy storage systems. A multitude of battery types are introduced into the market.

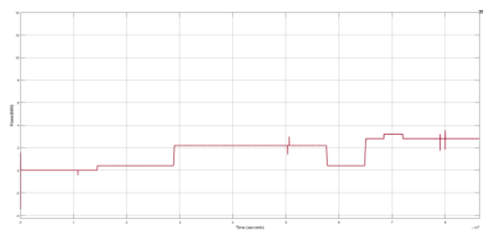

FIGURE 5.5 Charged and regulated into the microgrid throughout the day.

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The residential load is represented by the active power drawn at a specified power factor, as illustrated in Fig. 5.6 The total power generated is represented by the active power generated from the microgrid, and the power generated is equal to or more than the load. That means there is an equilibrium between demand and generation, as shown in Fig. 5.7

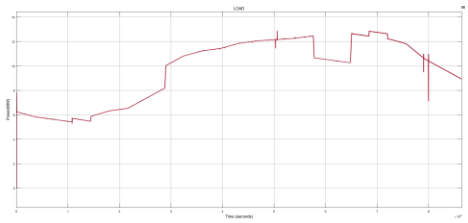

FIGURE 5.6 Load drawn power from the microgrid during the day.

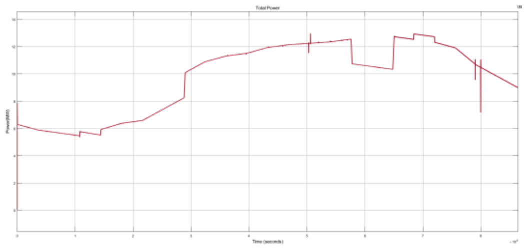

FIGURE 5.7 Total power generation from microgrid during the day.

5.2 EXTENSION RESULTS (LOAD POWER 18MW)

Figure 5.8 presents the total energy output of the diesel generator over the course of the day. The drawbacks of diesel generators are their exorbitant cost and their detrimental impact on the environment. Nevertheless, when renewable energy sources are unable to meet the energy demand, the utilization of a diesel generator becomes necessary to generate the required energy. The microgrid consists of two renewable energy sources. First and foremost, the PV plant generates energy in direct proportion to the level of irradiation present in the surrounding environment. Figure 5.9 presents the diurnal energy output of solar panels. The solar farm in the microgrid generates direct current by harnessing solar irradiation. Figure 5.10 displays the daily energy production of the wind farm in the microgrid. The use of wind power plants in microgrids is steadily rising owing to their status as a renewable energy source, uncomplicated design, and notable efficacy.

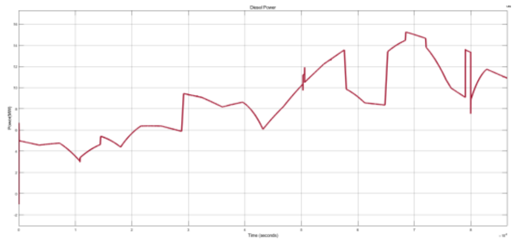

FIGURE 5.8 Power generated by the generator throughout the day.

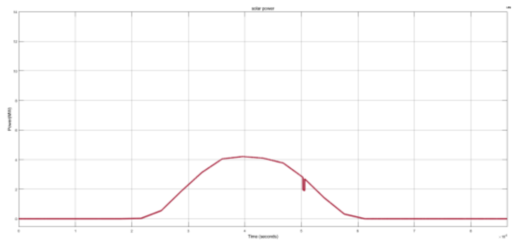

FIGURE 5.9 Power generated by the solar throughout the day.

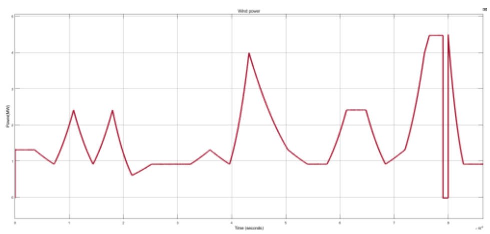

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FIGURE 5.10 Power generated by the wind throughout the day.

Figure 5.11 shows the power value that the EV transmits and controls to the microgrid throughout the day.

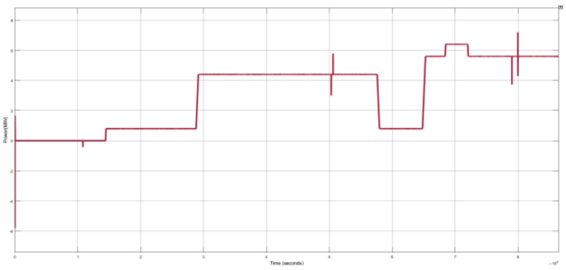

FIGURE 5.11 Charged and regulated into the microgrid throughout the day.

The residential load is represented by the active power drawn at a specified power factor, as illustrated in Fig. 5.12 The total power generated is represented by the active power generated from the microgrid, and the power generated is equal to or more than the load. That means there is an equilibrium between demand and generation, as shown in Fig. 5.7

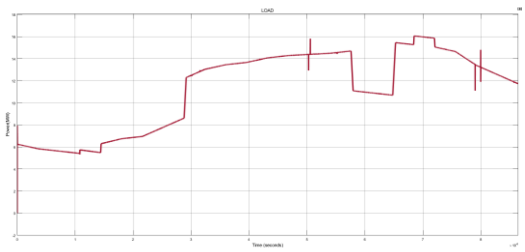

FIGURE 5.12 Load drawn power from the microgrid during the day.

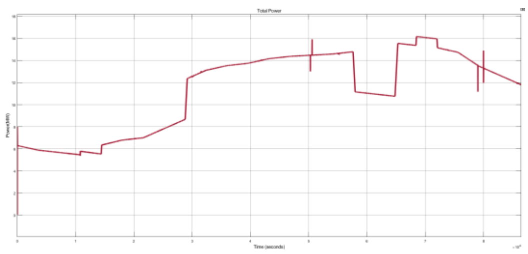

FIGURE 5.13 Total power generation from microgrid during the day.

VI. CONCLUSION

The integration of Electric Vehicles (EVs) into distribution networks is an inevitable trend, bringing both challenges and opportunities. As EV adoption grows, the increased electricity demand places additional strain on distribution systems. To address these challenges, techniques such as reactive power compensation are employed to regulate voltage levels within microgrids. By improving power factor and minimizing transmission losses, reactive power support enhances overall system efficiency. EVs integrated into microgrids can actively contribute by providing reactive power adjustments, further stabilizing grid performance. This study focuses on analyzing the operational dynamics of standalone microgrids, with a particular emphasis on various EV charging strategies. It considers key uncertainties, including fluctuating load demands, solar irradiation, and wind patterns, which are critical for optimizing microgrid performance. Given the rapid expansion of EV adoption, it is essential to investigate their impact on power quality, particularly regarding harmonic distortions. Implementing effective mitigation strategies is crucial to maintaining grid stability and ensuring

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seamless compatibility with existing electrical infrastructure. The increasing prevalence of EVs is also driving a proportional rise in charging station deployments, reflecting the growing need for accessible and efficient charging solutions. The rapid transformation of the transportation sector underscores the urgency of advancing EV technologies, which have a profound impact on both power systems and environmental sustainability. As EVs continue to reshape mobility, their seamless integration into energy networks requires strategic planning and innovative solutions to maximize benefits while minimizing disruptions to grid operations and environmental impacts.

FUTURE SCOPE

With the increasing demand for sustainable energy solutions, the integration of Renewable Energy Sources (RES) and Electric Vehicles (EVs) into microgrids has gained significant attention. This analysis explores the future scope of their integration, highlighting the benefits, challenges, and emerging technologies driving advancements in this field.

1. Enhanced Energy Efficiency and Sustainability

- The combination of RES such as solar and wind with EVs in microgrids promotes cleaner energy usage, reducing dependency on fossil fuels.
- Smart energy management systems will optimize the generation, storage, and consumption of energy.

2. Advanced Energy Storage Solutions

- Development of high-capacity battery storage systems will enhance microgrid stability.
- Vehicle-to-Grid (V2G) technology will allow EVs to act as mobile energy storage units, contributing to grid stability and peak load management.

3. Grid Resilience and Reliability

- Microgrids integrated with RES and EVs offer decentralized energy solutions, reducing vulnerability to grid failures and power outages.

REFERENCES

[1] R. K. Beniwal, M. K. Saini, A. Nayyar, B. Qureshi, and A. Aggarwal, “A critical analysis of methodologies for detection and classification of power quality events in smart grid,” IEEE Access, vol. 9, pp. 83507–83534, 2021.

[2] J. Y. Yong, V. K. Ramachandaramurthy, K. M. Tan, and N. Mithulananthan, “A

review on the state-of-the-art technologies of electric vehicle, its impacts and prospects," Renew. Sustain. Energy Rev., vol. 49, pp. 365–385, Sep. 2015.

[3] Y. Qi, G. Mai, R. Zhu, and M. Zhang, "EVKG: An interlinked and interoperable electric vehicle knowledge graph for smart transportation system," Trans. GIS, vol. 27, no. 4, pp. 949–974, Jun. 2023.

[4] M. H. Nikkhah and M. Samadi, "Evaluating the effect of electric vehicle charging station locations on line flows: An analytical approach," in Proc. 30th Int. Conf. Electr. Eng. (ICEE), May 2022, pp. 287–291.

[5] S. Habib, M. Kamran, and U. Rashid, "Impact analysis of vehicle-togrid technology and charging strategies of electric vehicles on distribution networks—A review," J. Power Sources, vol. 277, pp. 205–214, Mar. 2015.

[6] F. Garcia-Torres, D. G. Vilaplana, C. Bordons, P. Roncero-Sánchez, and M. A. Ridao, "Optimal management of microgrids with external agents including battery/fuel cell electric vehicles," IEEE Trans. Smart Grid, vol. 10, no. 4, pp. 4299–4308, Jul. 2019.

[7] S.-A. Amamra and J. Marco, "Vehicle-to-grid aggregator to support power grid and reduce electric vehicle charging cost," IEEE Access, vol. 7, pp. 178528–178538, 2019.

[8] C. Liu, K. T. Chau, D. Wu, and S. Gao, "Opportunities and challenges of vehicle-to-home, vehicle-to-vehicle, and vehicle-to-grid technologies," Proc. IEEE, vol. 101, no. 11, pp. 2409–2427, Nov. 2013.

[9] S. Shahriar, A. R. Al-Ali, A. H. Osman, S. Dhou, and M. Nijim, "Machine learning approaches for EV charging behavior: A review," IEEE Access, vol. 8, pp. 168980–168993, 2020.

[10] K. Ginigeme and Z. Wang, "Distributed optimal vehicle-to-grid approaches with consideration of battery degradation cost under real-time pricing," IEEE Access, vol. 8, pp. 5225–5235, 2020.

[11] P. Sinha, K. Paul, S. Deb, and S. Sachan, "Comprehensive review based on the impact of integrating electric vehicle and renewable energy sources to the grid," Energies, vol. 16, no. 6, p. 2924, Mar. 2023.

[12] J. James, J. Lin, A. Y. Lam, and V. O. Li, "Maximizing aggregator profit through energy trading by coordinated electric vehicle charging," in Proc. IEEE Int. Conf. Smart Grid Commun. (SmartGridComm), Sydney, NSW, Australia, May 2016, pp. 497–502.

ISSN 2454-9940
www.ijasem.org
Vol 19, Issue 1, 2025

[13] Y. Vardanyan, F. Banis, S. A. Pourmousavi, and H. Madsen, "Optimal coordinated bidding of a profit-maximizing EV aggregator under uncertainty," in Proc. IEEE Int. Energy Conf. (ENERGYCON), Limassol, Cyprus, Jun. 2018, pp. 1–6.

[14] T. Mao, X. Zhang, and B. Zhou, "Intelligent energy management algorithms for EV-charging scheduling with consideration of multiple EV charging modes," Energies, vol. 12, no. 2, p. 265, Jan. 2019.

[15] Z. Moghaddam, I. Ahmad, D. Habibi, and Q. V. Phung, "Smart charging strategy for electric vehicle charging stations," IEEE Trans. Transport. Electrific., vol. 4, no. 1, pp. 76–88, Mar. 2018.

[16] M. T. Hussain, D. N. B. Sulaiman, M. S. Hussain, and M. Jabir, "Optimal management strategies to solve issues of grid having electric vehicles (EV): A review," J. Energy Storage, vol. 33, Jan. 2021, Art. no. 102114.

[17] M. Amjad, A. Ahmad, M. H. Rehmani, and T. Umer, "A review of EVs charging: From the perspective of energy optimization, optimization approaches, and charging techniques," Transp. Res. D, Transp. Environ., vol. 62, pp. 386–417, Jul. 2018.