
ISSN: 2321-2152
IJMECE
International Journal of modern electronics and communication engineering
E-Mail
editor.ijmece@gmail.com
editor@ijmece.com
www.ijmece.com

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 2, 2025

Analysis of Renewable Energy Sources and Electrical Vehicles Integration into Microgrid

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Abstract:

It is believed that the growth of electric vehicles will be prompted by the increase in pollution levels, which will cause the release of greenhouse gases and, ultimately, the occurrence of climate change. Therefore, during this period, EVs will connect to the power grid. The loads and voltage profiles of grid components will be greatly affected by the introduction of this technology. The focus of the research was on developing models and conducting analyses of microgrid integration of renewable energy sources and electric vehicles. There are four main components that make up a microgrid: a diesel generator that serves as the main power source, an array of photovoltaic (PV) and wind farms that work together to generate energy, and a vehicle-to-grid (V2G) system that is located close to the microgrid's load. Microgrids are becoming more significant due to the continuously rising rate of energy output they provide. Microgrids may be tailored to suit the specific energy requirements of a variety of buildings, such as schools, hospitals, and electric vehicle charging stations, or even a whole town, district, or industrial site. In order to refuel an electric vehicle's battery, charging stations are necessary. How electric vehicles affect the microgrid network is the subject of this research. Electric vehicles use non-linear circuit components The incorporation of electric vehicles (EVs) and renewable energy sources (RES) into microgrids is the primary emphasis of this research. and this research summarises the results of a Matlab/Simulink investigation of an electric vehicle microgrid.

Index Terms Vehicle-to-Grid, Electrical Vehicles, Charging Infrastructure, Sustainability, Renewable Energy, Grid-to-Vehicle.

INTRODUCTION

With 25% of all energy-related emissions coming from the transportation sector, it's clear that this industry is heavily to blame for global warming. The best option is EVs, or electric vehicles. Because they do not release harmful gases into the atmosphere, electric vehicles are considered clean and eco-friendly. In order to encourage the broad use of electric vehicles, a number of countries have passed legislation and instituted incentives [1-2]. The electrical grid is another target of this technology's deployment. An increase in the daily maximum power consumption may be disastrous if a lot of people start charging their electric cars whenever they want, thanks to uncontrolled charging. Charging electric vehicles without proper regulation would increase power losses, strain equipment, and degrade power quality. Still, regulating EV charging or using EVs as small distributed generators, especially in V2G mode, would make the positive effects of EV adoption obvious [2]. More than merely a mode of transportation, EVs herald a brighter future for humanity. These emission-free automobiles are connected to a low-voltage charging station. To a certain extent, EVs will unquestionably be pivotal in achieving this goal. Vehicles driven by fossil fuels, often known as internal combustion engines (ICEs), have released large quantities of carbon dioxide into the atmosphere [3]. Batteries, fuel cells, and ultra-capacitors may replace the conventional energy sources like gasoline and diesel that are required for electric vehicles. For maximum effectiveness, these sources may be used alone or in combination with more conventional ones. As a result, there are three distinct kinds of electric cars: BEVs, HEVs, and FCEVs (fuel cell electrical vehicles) [4]. The electric vehicle's battery is its main problem. New research, however, suggests that battery life is essentially a non-issue. To lessen the impact on the environment, electric vehicles are becoming more popular as a replacement for diesel and gasoline engines. Two important words in the electric vehicle industry are grid-to-vehicle (G2V) and vehicle-to-grid (V2G). The most common way to charge electric cars is via the grid-to-vehicle, or G2V, connection. The method by which a moving vehicle may be used as an energy source is called vehicle-to-grid technology [5]. When plugged into the grid, electric vehicles release their energy. Among the many functions performed by V2G technology are the following: balancing electrical loads, integrating renewable energy sources, minimizing peak energy consumption, optimizing prices, and maintaining stable frequency and voltage levels. If you want to flatten your load profile, then the V2G optimal logic control method is a great choice [6]. The effective operation of the V2G process is guaranteed by the use of an aggregator [7]. An aggregator is an online hub that connects service suppliers with customers who are looking to purchase digital services. When the power system or distribution network experiences a surge in demand, V2G technology provides a workable answer. Distribution networks may alleviate many problems with well-executed techniques. The main problem with vehicle-to-grid technology is the unpredictable nature of travel patterns, which is why an investigation of the impact of EVs on power demand profiles is undertaken [8]. Reducing the costs of electric vehicle battery wear is possible via controlling charging patterns, which in turn reduces the costs of battery cycle life regulation [9]. Delivering frequency regulation services via electric cars accomplishes the goal. The effect of electric vehicle (EV) battery efficiency and charging duration on the overall load profile is examined. The objective is to maximize the efficiency of V2G systems so that transportation and power supply systems can run more cheaply and with less impact on the environment. Increasing the reliability, consistency, and quality of power supply is also important [10]. In addition to putting a strain on the power infrastructure, the impending EVs will eventually generate electricity independently of the central authority. The distribution of the load through the system is another important function they will perform. The plug-in hybrid electric vehicle (PHEV) is able to serve as a power source and a load for the grid due to its ability to consume and produce electricity. Therefore, there is great theoretical and practical value to studying the effects of electric vehicle charging on the distribution network [11]. Optimal and minimal integration of EVs into an EV distribution system are shown in Figs. 1 and 2, respectively, as objective functions.

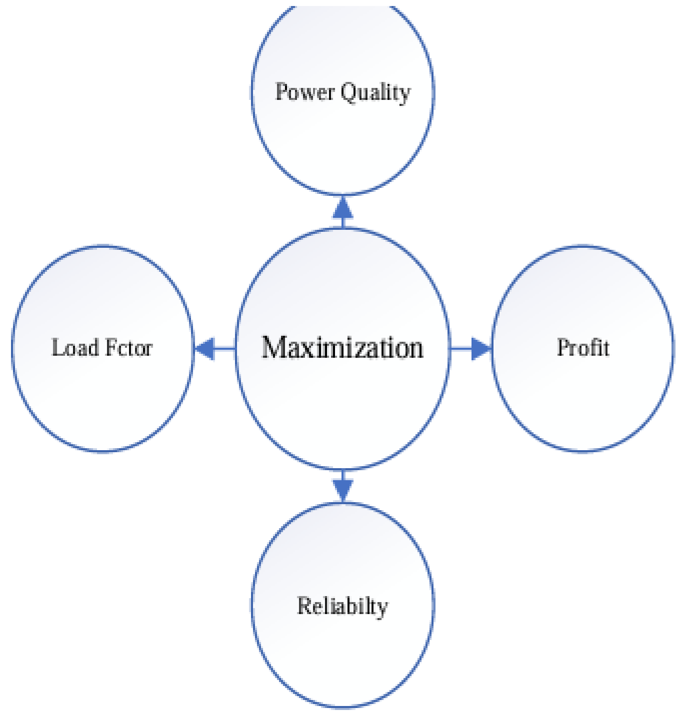

Fig. 1. Maximization objective functions of electrical vehicle integration into the distribution system.

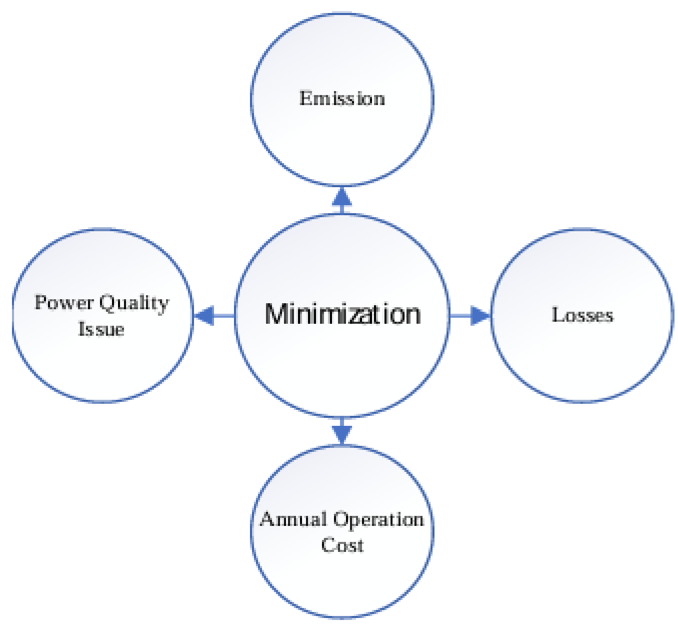

Fig. 2. Minimization objective functions of electrical vehicle integration into the distribution system. Power Quality Load Fctor Maximization Reliabilty

Figure 1: Goal functions for optimizing the integration of electric vehicles into the distribution system. Review of the Literature: Focusing on cutting down on energy use was another line of inquiry. References [12] and [13] use model predictive control and stochastic mixed integer linear programming strategies, respectively, to find the best EV charging processes that will maximize the aggregator's income. To be clear, none of the aforementioned research has included distribution system, microgrid performance, peak load, or voltage dips in their models. The method described in [14] uses genetic algorithms and sequential quadratic programming to reduce electrical energy costs and load variations. But the distribution networks' overall losses and voltage dips remained unaddressed by this method. Without taking distribution grid efficiency into account, ant colony optimization is used in [15] to minimize billing costs and waiting times. The evaluations in [16] and [17] found, among other things, that most EV charging approaches focused on a single or double power grid problem: extreme voltage dips, load/frequency fluctuations, total power losses, or peak shaving. This was true independent of the additional issues that may arise. Specifically for MV networks, the authors of [18] sought to reduce active power losses and voltage control. While reducing energy costs was the only goal in [20], peak shaving and valley lling were the only concerns in [19]. Electric vehicles' potential to provide control that can improve grid efficiency has been the subject of some research. One of the many benefits of electric vehicles is that they may facilitate the use of renewable energy sources, as mentioned in [21]. For very short temporal periods, see [22]. On top of that, [23] shows how sophisticated centralized PEV charging systems may mitigate issues like distribution grid congestion caused by electrical mobility while simultaneously increasing the potential advantages of EVs as suppliers of system ancillary services. A power management strategy for Secondary Frequency Regulation (SFR) with an integrated fleet of EVs is presented in reference [24], which takes longer time horizons into account. This paper's contributions include: Electric vehicles (EVs) may serve as both a load and a generator for electrical power. Research on a microgrid that incorporates the capture of electrical loads, EVs, and renewable and non-renewable energy sources is detailed in this article. The study of electric vehicles (EVs) as both a load and an energy source, as well as their impact on grid performance and their function in sustaining the grid during peak hours, are also part of the research. The modeling and analysis of renewable energy sources and the integration of electric vehicles into the micro grid are the primary foci of this work. The findings of the analysis of the microgrid with EVs, conducted using Matlab/Simulink, are discussed in this work. This document is organized in the following way: The effects of EVs are briefly explained in Section II, which offers technical context. The charging infrastructure is detailed in Section III. Part IV provides a synopsis of the harmonic components generated by EV. The technologies and difficulties associated with electric vehicles are detailed in Section V. Section VII is the conclusion, whereas Section VI displays and discusses the findings of the simulation (study of the microgrid with electrical car). electricity generator. Power quality may be affected by harmonic distortion that this DC connection can generate, which can pollute the electrical grid and influence the functioning of components in the distribution system [29]. ii) Decrease in Voltage Electric vehicle technology is expanding and being used all over the world. As a result, the local electrical grid experiences an increase in load. There will be voltage drops at some nodes in the network as a result of charging large-scale EVs, especially near the network's termini. Users' power demands are subsequently impacted by this [30]. (iii) Time length of three-phase imbalance The charging procedure is made more efficient when there are fewer electric vehicles using a given site. As a result, the amplitude of the three-phase currents that are not uniformly distributed increases. A current imbalance occurs, however, when a large number of electric cars are charged simultaneously [30–31]. 2. Operational Impact

IMPACT OF ELECTRICAL VEHICLE

A) The Impact of Powering Up and Powering Down Electric Vehicles When it comes to the power supply system, EVs are both helpful and bad [25]. Reducing expenses associated with battery deterioration and peak demand on the power system network are both affected by the way electric vehicles are charged and discharged [26]. The transmission and distribution infrastructure are essential components of any cost-minimization billing scheme. To improve the load profile, which in turn lowers peak demand and, eventually, EV charging costs, a number of optimization techniques are used. At the same time that the peak demand on the load profile is reduced, the cost of battery deterioration is also reduced [27]. Electric vehicles may be charged in a variety of ways. It is more economical to charge EVs at off-peak times. Charging during peak demand periods, on the other hand, results in higher expenses [28]. Reducing costs and increasing overall system efficiency should be the fundamental objectives of any strategy for electric vehicle charging. In a charging system, it is preferable to keep the charge level higher. Consumers of electric vehicles and power utility businesses alike may benefit from either static or dynamic pricing strategies. B) How It Will Affect The Distribution System 1. Impact on Electrical Efficiency There are a number of power quality problems that arise when electric vehicles are connected to the grid. These include harmonic pollution, increased power dissipation, decreased voltage, and imbalanced three-phase voltage [29]. (a) Distortion of harmonics The charging infrastructure will see more utilization as the availability of electric vehicles increases. There are a number of complex power electronic equipment that make up this infrastructure, as well as a DC connection that links the three-phase AC It mostly shows up in terms of net loss, shorter cable lifespans, and shorter distribution transformer lifespans when it comes to the distribution network's economic functioning [32]. (a) Economic Loss An increase in the charging load for electric vehicles is caused by an increase in the rate of load loss due to increased permeability [32]. ii) Wires Cables are vulnerable to damage from large harmonic currents. As a result, performance degrades and durability is reduced [32]. Environmental Consequences (C) A temperature increase and its effects on the global climate are possible outcomes of the present trend if it continues into the future years [33]. Large energy users must reduce their own emissions if smaller nations are to make headway in reducing emissions and making use of renewable technology [34]. There has been a dramatic increase in enthusiasm for the electric vehicle industry ever since the Roadster was unveiled by Tesla. Here are the variables that have contributed to the growth in emissions: Increasing human population. • An increase in the ability to produce. • A use of more energy. A surge in the transportation sector. Significant energy consumption occurs during the construction of electric vehicles. Compared to traditional fuel-powered vehicles, the manufacturing of electric cars releases more harmful emissions. The reason for this is that electric car components like lithium-ion batteries are made throughout the manufacturing process. Data shows that, during an EV's lifetime, the manufacturing process is responsible for about one-third of all carbon dioxide (CO_2) emissions [36]. Having said that, cutting-edge tech news and the introduction of super

Manufacturing processes have resulted in a significant decrease in emissions generated by the creation of batteries. One positive impact of EVs is that they are demonstrably less polluting than traditional gas-powered cars. However, the way the vehicle is operated depends on the benefits that the user expects. Realizing that different forms of power generation produce different amounts of pollution is a crucial first step in achieving zero emissions and sustainable energy. Solar and wind power, on the other hand, are environmentally responsible options that might power the vehicle. You may do rid of petroleum altogether by installing solar panels on your automobile; the energy they produce can run your vehicle at no cost to you. It may also be required to increase the size of the solar panel to meet the increased demand for charging the electric car. The efficiency of the vehicle, the frequency of use, and the solar potential of the given region determine the amount of additional solar panels required to power the electric car. Participating in a shared solar charging system is

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 2, 2025

an alternate to developing one's own solar power infrastructure if it is not practical to do so on one's own land. The bulk of utility organizations choose to purchase power from these renewable energy sources, and this practice is rapidly gaining popularity throughout the country [37]. It is essential to charge the battery of the electric car after each use. It is critical to think about the charging demand from the power grid's point of view as the number of EVs and individual battery ratings rise. Table 1 shows that, according to the current guidelines [40], there are three separate categories for electric vehicle and plug-in hybrid charging systems. Charge Methods for Various Electric and Hybrid Vehicle Types (KVA) (Table 1) Charging duration: Average 5–6 hours Approach to charging 120 VAC, single phase, 16/32 A Slow to medium from 10 to 25 1-3 hours three-phase, 230 volt, 32/63 amps: AC Speedy 180–400 5–15 minutes Unknown, DC charging system located off-board A) Charging time for standard mode (mode 1, 6 hours < 8 hours) 2) The Effects on the Body Directly Electric vehicles have the outstanding quality of reducing emissions from vehicle tailpipes. They move around by powering their wheels with energy that they store in their batteries. Since it undergoes almost little heat loss during the process, empirical studies have shown that this transformation is very effective. This is crucial because of the negative effects on the environment caused by mining for and manufacturing battery ingredients. Mines that harvest and refine raw materials for batteries and those that mine coal are the principal sources of these emissions. On the other hand, compared to the effects caused by running a gasoline engine, these consequences are negligible [38]. Thirdly, the Effects That Are Not Direct Electric vehicles have many advantages, but there are also some drawbacks to think about. Upon inspection of the supply chain, the greatest damaging effect of electric vehicles becomes clear. It has been shown that there is a dramatic increase in particulate matter concentration. This is what happens when power is generated from coal. The average grid composition has changed, according to recent research, with a noticeable shift towards natural gas and renewable energy sources. The change will not, however, happen immediately. Studies looking at the influence of EVs on global warming have shown that EVs run by the existing grid tend to mitigate some of the consequences of climate change. Nevertheless, they do add to the problem of particle pollution, making them more harmful to the environment than the current traditional approaches. the number 39.

Charging Infrastructure

It is essential to charge the battery of the electric car after each use. It is critical to think about the charging demand from the power grid's point of view as the number of EVs and individual battery ratings rise. Table 1 shows that, according to the current guidelines [40], there are three separate categories for electric vehicle and plug-in hybrid charging systems. Methods of Electric Vehicle and Hybrid Electric Vehicle Charging (Table 1)

Type	KVA	Charging time	Charging method
Slow/Normal	1–5	6 h	AC: 1 phase, 230 V, 16/32 A
Semi-fast/Medium	10–25	1–3 h	AC: 3 phase, 230 V, 32/63 A
Fast	180–400	5–15 min	Undetermined, DC off-board charging

The standard way to charge a 3.3 kW electric car is to use a wall outlet that draws 16 A from a 230 V outlet. This charging technique is often used in Europe and needs a single-phase AC charger. Most cars usually need about 6 to 8 hours to charge completely. It also has a charger that is built into the vehicle, which is called an on-board charger. When charging a car at home or the office, Mode 1 charging is the most convenient alternative. Nevertheless, there are some safety risks with this system since it depends on the supply-side breaking capability of the residual current circuit breaker. A large number of countries mandate this level of safety for all new devices [41]. B) Charging with a semi-fast speed (Mode 2, 1 hour < charging time < 3 hours) For powers between 7 and 22 kW, semi-fast charging is used. For a 30 kWh battery, this is the same as 32 A single-phase current or 16 A three-phase current. You get twice as much power, which is a huge plus. The result is a charging time of between two to six hours, which is rather slow. This is the same as charging in Mode 2. Here, the car is hooked up to an electrical outlet. The control pilot conductor is responsible for providing the essential protection to both the equipment and the users [42]. C) Charging in Mode 3, which takes less than one hour To charge an electric vehicle in "Mode 3," one must use an external charger that draws electricity from a direct current (DC) source. Although this mode offers the benefit of quick charging, it does need technology that is both mature and deployable [43]. The fast chargers that are now available are as follows: 3 different types of chargers: quick, super-speed, and high AC. The use of power electronics allows for the operation of a rapid charger. For recharging the EV battery, it converts AC to regulated DC. Rapid charging facilities in Europe fall under the category of Mode 3.

The most expensive option is this one. Only public charging outlets are eligible to use it. At a comparatively slower than at a fuel station. It will take around 25–35 minutes for the battery to charge completely. This charging station can handle up to 50–75 kilowatts of electricity at its max. Recharging a battery with a super-fast charger should take about the same time as filling up a regular gas tank in a vehicle. This part's charging time is comparable to Renault's Better Place project's "battery swapping" technique. The peak power is so large that it needs a dedicated component to manage it. Charging currents as high as 250 A are within the range of the Mode 3 high AC charger. At present, traction batteries are recharged using high-capacity AC sources via the traction inverter. Here, a smart microgrid's external mains transformer is used to alter the voltage. Based on equation (1), we can define THDv as follows: The equation one can write as = √𝑉2 2 + 𝑉3 2 +𝑉4 2 +⋯+𝑉𝑛2 𝑉1 2 (1) is correct. When the harmonics are equal to zero, 𝑇𝐻𝐷𝑎 will also be zero. A voltage of fundamental frequency is represented by n=1, and the root-mean-square (RMS) voltage of the nth harmonic is (Vn). The following equation (2) may be used to calculate THDI: **b**𝐷𝑖 = ^𝐼2 2 +𝐼3 2 +𝐼4 2 + ⋯+𝐼𝑛 2 𝐼1 2 [44].

HARMONIC COMPONENT PRODUCED BY EV

Modern electric vehicle charging adds harmonic components to microgrid. The harmonic components of current waveforms are greater than those of voltage waveforms. A microgrid's electrical system may be affected by the amount of Total Harmonic Distortion (THD). In addition, the microgrid's power quality is affected by the THD value. When thinking about the charging station, the THD evaluation is vital. Disruptions to the sinusoidal properties of voltage and current signals have resulted from the increasing use of non-linear loads in electric vehicles. The components of non-linear waveforms include In order to charge, electric vehicles need AC/DC and DC/AC converters. They are the main places where harmonics come from. The many electrical components that make up an EV are detailed below. Electric vehicles rely on a battery pack to power their electric motors. One major perk of EVs is how little pollution they create; they're also very good for the environment. Furthermore, they depend on an environmentally friendly energy source to power the car, since they do not use any fossil fuels. The third, fifth, seventh,..., and fifteenth harmonics, 150 Hz, 250 Hz, 350 Hz, and 750 Hz, respectively, are produced as integer multiples of the principal harmonics at 50 Hz. In most cases, a non-linear waveform within a smart microgrid is the root cause of THD. A smart microgrid is vulnerable to a number of threats caused by electrical harmonics. Excessive heat in electricity transmission cables [45]. • Power distribution lines that are overheated. In a smart microgrid, harmonics show up as resonance events. • How long circuit breakers and other electrical devices last. • The reactive capacitors have been perturbed. • A microgrid's protection switches enable the circuits to be opened at the appropriate times. • Problems with communication infrastructure develop. Smart microgrid systems currently rely heavily on renewable energy sources. These systems pose no threat to the environment. Alternatively, they don't harm the environment. The typical metric for gauging harmonic distortion is THD.

$$THD_v = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \cdots + V_n^2}}{V_1^2} \quad (1)$$

$$THD_i = \frac{\sqrt{I_2^2 + I_3^2 + I_4^2 + \cdots + I_n^2}}{I_1^2} \quad (2)$$

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 2, 2025

TECHNOLOGY AND CHALLENGE INVOLVED IN EV

Issue Proposal Using the V2G strategy—which is based on the variable load demand—to decrease distribution system losses is the primary goal of the proposed research. Here is the equation that forms the basis of the distribution system's power equations: In order to charge, electric vehicles need AC/DC and DC/AC converters. They are the main places where harmonics come from. The many electrical components that make up an EV are detailed below. Electric vehicles rely on a battery pack to power their electric motors. One major perk of EVs is how little pollution they create; they're also very good for the environment. Furthermore, they depend on an environmentally friendly energy source to power the car, since they do not use any fossil fuels. The third, fifth, seventh,..., and fifteenth harmonics, 150 Hz, 250 Hz, 350 Hz, and 750 Hz, respectively, are produced as integer multiples of the principal harmonics at 50 Hz. In most cases, a non-linear waveform within a smart microgrid is the root cause of THD. A smart microgrid is vulnerable to a number of threats caused by electrical harmonics. Excessive heat in electricity transmission cables [45]. • Power distribution lines overheating. • Smart microgrid resonance phenomenon caused by harmonics. • How long circuit breakers and other electrical devices last. • The reactive capacitors have been perturbed. • Microgrids include protection switches that activate circuits at the right times. • Communication facilities may experience disruptions. Smart microgrid systems currently rely heavily on renewable energy sources. These systems pose no threat to the environment. Alternatively, they don't harm the environment. Harmonic distortion (THD) is a popular metric for measuring G2V and V2G levels. The functioning of G2V is given by Equation (3) [47].

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

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

Vast2Growth (4) When it comes to controlling energy and power, the grid and the EV are complementary systems. In most cases, energy storage is not integrated into the electrical grid. The total capacity of the pumped storage facility is less than 2.2%. In order to keep up with the ever-changing demands of consumers, it is essential to maintain tight control over the production and transportation of energy. When a vehicle's propulsion system is an electric motor powered by a battery or a hybrid powertrain, we call it an EV. Hence, they are often likened to conventional cars powered by internal combustion engines. One major benefit of electric vehicles is their ability to produce or store electrical energy, even while they are not moving. Their ability to provide power to the grid depends on the strength of their connections to various system auxiliary components. This connection type is known as a V2G connection [48]. Electric vehicles may run on either battery power alone or a combination of battery and fuel cell technology. But the most important thing is to keep the electrical system powered up while it's not moving or parked. Peak power, regulation, and spinning reserves are the three most important characteristics of power markets [49]. Because of the slow charging and discharging rates of batteries, electric vehicles that use them charge their batteries when power demand is low and discharge them when power demand is high, such when the vehicle is accelerating or in driving mode. Vehicles that use fuel cells may run on either gas or liquid fuel. Both of these modes are within the capabilities of PHEVs. Section C: Control of Charging (i) Harmonic Regulation Due to their role in the system's harmonic buildup, converters are essential components of battery charging systems. Pulse width modulation and multilayer converter operation are two methods for controlling or reducing harmonics [50]. One way to reduce harmonics in the Root Mean Square (RMS) current is to increase the number of pulses. Furthermore, reactive power mitigation strategies may be used to keep the unwanted harmonics. Ongoing monitoring is necessary to swiftly resolve any unexpected difficulties that may arise as a consequence of harmonics, which might lead to further power quality issues within the system. (ii) Hybrid Billing Concentrated charging, which may occur as a consequence of widespread EV charging, may affect power grid control. As a result, we use coordinated pricing to control the grid since it is a controlled load. Maximizing economic efficiency while reducing grid impact is the main goal of this technique.

With the state of the grid, the peculiarities of the batteries' performance, and the needs of the

ISSN 2321-2152
www.ijmece.com
Vol 13, Issue 2, 2025

consumers in mind, we mainly oversee the charging process. It also helps to moderate unwelcome variations in load demand and prevents new peak loads from being generated. Improved distribution network reliability, electricity consistency, and economic efficiency may result from this strategy [51]. Scheduling the charging process and coordinating the distribution of electric cars with the grid are two essential components of an efficient coordinated charging implementation. Since the grid found it difficult to directly oversee the billing process, the idea of an intermediary arose. Furthermore, using multi-agent technology may accomplish this goal as well [52]. Charging electric cars with smart grid integration naturally shortens the time it takes during peak hours. To keep the frequency within the permitted range, which is f0 ± Δf, frequency control is used to modify the active power output. In particular, there are three sub-controls that measure frequency adjustment [53]. In order to minimize the transient frequency and the Rate of Change of Frequency (RoCoF), primary control is a fast regulatory system that acts when a frequency deviation over the permitted threshold. An additional regulatory mechanism known as secondary control steps in after the main control has already taken effect, causing a delayed response. The objective is to maintain a constant frequency value regardless of whether it deviates from the permitted range. Finally, after secondary control, tertiary control is used to fix the frequency and return it to an appropriate range. At present, nuclear or coal-fired power plants, which have a high inertia but a large capacity, are responsible for providing tertiary control. Future power grids will likely use demand response technologies or long-term, high-capacity storage to manage tertiary control [54]. In light of the substantial data presented in the literature, it is reasonable to assume that V2G charges play a crucial role in secondary frequency control [55], [56]. Primary and secondary energy and power provided by a V2G fleet must comply with regulations and market processes. Electric vehicle (EV) fleets are incentivized to provide secondary frequency control since they are rewarded for capacity reserve and activation via a market auction mechanism [57].

ANALYSIS OF THE MICROGRID WITH EV

Electric vehicles include two main parts. Electric cars are able to go forward thanks to an electric motor and batteries charged by an internal energy source. To power their batteries, electric cars need to be connected to an external power source. It is essential to charge the autos in this situation. Numerous charging methods are used by EVs. Different types of charging stations are distinguished by the voltage and speed with which they charge. Improving the range of electric vehicles and making them charge faster are two of the biggest obstacles to their further growth. In order to resolve these challenges, researchers are now doing thorough studies on a continuous basis. Charging an electric automobile utilizing DC current will make the process go more quickly. For electric vehicles, we shorten the charging time by increasing the power output of the stations. As a result, there is a steadily increasing number of charging stations with powers more than 350 kW. At the charging stations, you may charge numerous cars at once thanks to the various plugs. There may be major problems with the microgrid if a lot of cars are plugged in at once. A major concern is the increasing demand for power on the system. Figure 3 shows a concept of a microgrid that incorporates renewable energy sources and electric vehicles.

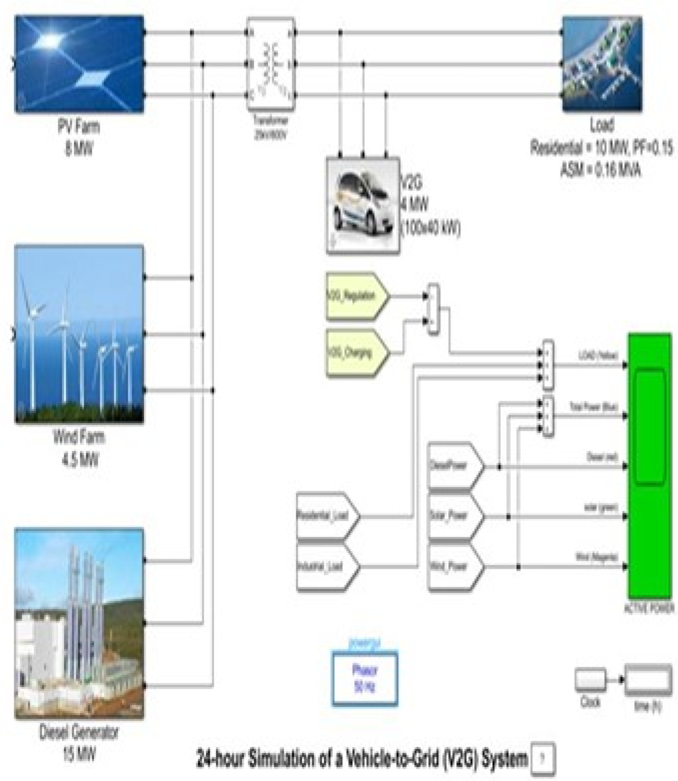

Fig. 3. Microgrid and electrical vehicles.

There are four parts to the microgrid that are being studied. Renewable energy is produced by a PV plant that incorporates wind turbines, while diesel generators are the primary source of electricity. Additionally, we use the V2G technology to place a strain on the network. A microgrid load of one hundred electric vehicles and one thousand low-consumption homes makes up this neighborhood. Electric vehicles to residential units is 1:10. A step toward environmental preservation is increasing the production of renewable energy. Nevertheless, environmental factors have a significant impact on the reliability of renewable energy sources. Precise control of basic values, like as current and voltage, which are shown by 50 Hz sinusoidal waveforms, is essential to microgrid systems. Nevertheless, the introduction of undesirable harmonic components into the microgrid system occurs when these basic variables lose their sinusoidal characteristics for a variety of reasons. An extra strain on the microgrid is caused by the meteoric rise of electric vehicles, which causes a spike in power consumption. As a result, the microgrid's unpredictability has grown. In a microgrid, the diesel generator keeps the power produced and consumed in balance. Finding the difference between the grid frequency and the synchronous machine's rotor speed will reveal the source of the frequency differential. The cumulative energy production of the diesel generator throughout the day is shown in Figure 4.

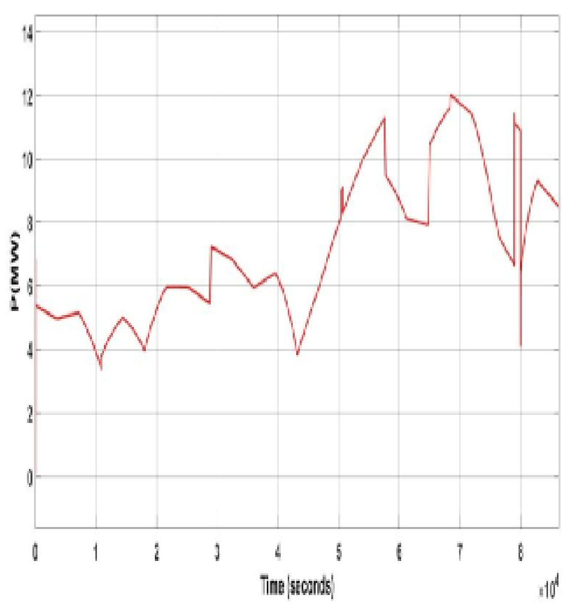

Fig. 4. Power generated by the generator throughout the day.

One major problem with diesel generators is the damage they do to the environment and how expensive they are. Still, a diesel generator is needed to provide enough electricity when renewable sources can't. A pair of green power plants make up the microgrid. To start with, the amount of irradiation in the area has a direct correlation to the amount of energy that the PV plant produces. The energy production of solar panels throughout the day is shown in Figure 5.

The microgrid's solar farm converts sunlight into direct current. Solar panels' ability to absorb light, the quantity of light reaching them, and the weather all have a role in determining the final energy production.

The amount of electricity generated by the wind farm is proportional to the wind speed. When the wind speed reaches the specified value, the turbine will generate its maximum power output. When the wind speed goes beyond a certain threshold, the microgrid switches off the wind power until the wind speed goes back down to a normal level. Figure 6 shows the microgrid wind farm's daily energy generation.

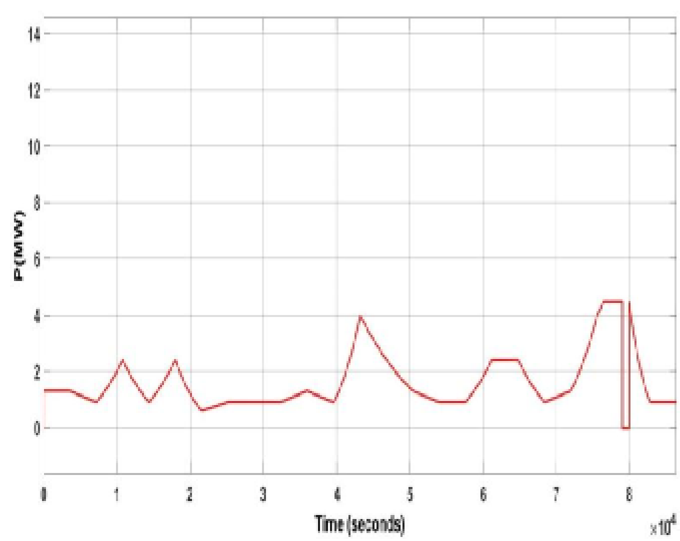

Fig. 6. Power generated by the wind throughout the day.

Because of their efficiency, simplicity of design, and position as a sustainable energy source, wind power plants are being more and more integrated into microgrids. There are noticeable differences between wind farms and other types of traditional power plants. Electric vehicles' capacity to use vehicle-to-grid (V2G) applications is their principal advantage. This software is designed specifically for use with electric vehicles. What it really does is lets the vehicle feed power into the distribution microgrid. Throughout the day, the EV regulates and sends a power value to the microgrid, as shown in Figure 7. Ref. 7. Charged and regulated into the microgrid throughout the day. Transmission of electrical energy from electric vehicle (EV) battery systems to a microgrid is known as vehicle-to-grid (V2G) technology. Electric vehicle batteries store energy inside the electrical system. The ability to charge and discharge a car's battery in response to signals like energy use or output is made possible by car-to-grid technology. At times of peak energy consumption within the microgrid, the use of electric car charging causes an increase in the electrical demand per transformer. Attaining energy balance is greatly complicated by this. A microgrid phase imbalance may occur when many EVs are charged simultaneously. There are major problems with the microgrid caused by EVs charging themselves. The voltage at the charger connections can drop if a large number of EVs are being charged simultaneously. When charging, EVs use a lot of network active power, which causes the microgrid to lose power. Two main goals are accomplished by V2G technology. During brief disruptions, it controls the battery charge and makes use of the available power to stabilize the grid. The instant availability of existing decentralised energy storage devices is ensured by V2G technology. There are a plethora of new battery kinds available. The active power consumed at a specific power factor represents the home load, as shown in Figure 8.

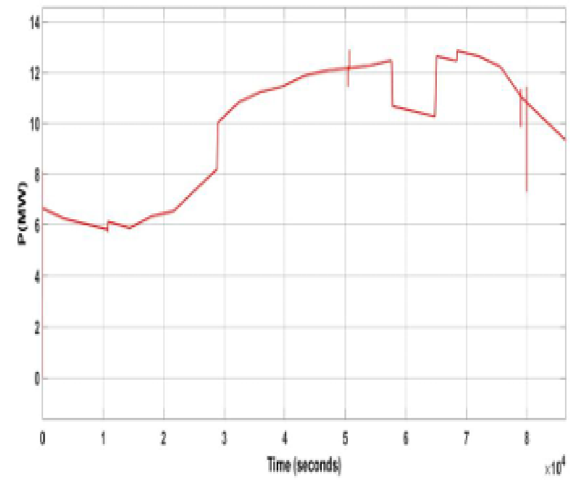

Fig. 8. Load drawn power from the microgrid during the day.

The active power produced by the microgrid is a measure of the overall power generated, which is either more than or equal to the load. This indicates that, as seen in Figure, the demand and generation are in balance.

Fig. 9. Total power generation from microgrid during the day.

The study was severely constrained by the absence of adequate research on the whole lifecycle emissions associated with the production of lithium-ion batteries. The focus of future efforts will be on developing better batteries with longer lifespans and higher efficiency. to lessen the pollution caused by the production of electric vehicles.

CONCLUSION

As distribution networks continue to grow, the adoption of electric vehicles (EVs) is becoming more inevitable. Distribution system concerns may become more severe as the number of EVs on the road continues to rise. In order to maintain voltage control in the microgrid, reactive power reduction is used. Power transmission line power losses may be reduced by reactive power assistance, which also increases the power factor. It also leads to increased productivity.

Electric vehicles (EVs) connected to the microgrid may provide reactive power changes. Examining different EV charging techniques is the main emphasis of the research, which aims to analyze the functioning of a freestanding microgrid. Predicted values of wind speed, solar radiation, and load demand are all affected by uncertainty. It is critical to investigate the power quality of EVs, paying special attention to harmonic components, in light of their increasing numbers on the road, and to apply solutions that are suitable for this kind of vehicle. As the number of electric vehicles on the road continues to rise, so does the network of charging stations. A fast evolution of electric vehicles is required to keep up with the current rate of change in the transportation sector; this has far-reaching consequences for the environment and the power grid.

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