Examination of the Integration of Electrical Vehicles and Renewable Energy Sources into Microgrids

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Abstract: **It is projected that the growth of electrical vehicles (EVs) will be aided by the increase in pollution, which causes greenhouse gas emissions and the associated phenomenon of global warming. As a result, EVs will connect to the power grid during this period. The loads and voltage profiles of grid components will be greatly impacted by the use of this technology. The modelling and analysis of EV and renewable energy source integration into a microgrid was the main focus of the study. A diesel generator serving as the main power source, a photovoltaic (PV) and wind farm combo for energy generation, and a vehicle-to-grid (V2G) system placed close to the microgrid's load are the four main components of the microgrid. Microgrids are significant because of their steadily rising rate of energy output. Microgrids can be built to satisfy the energy requirements of a town, district, or industrial site in addition to the energy requirements of other institutions, such as hospitals, universities, and EV charging stations. In order to recharge an EV's battery, charging stations are necessary. The impact of EVs on the microgrid network is examined in this paper. Non-linear circuit components are incorporated into the structures of EVs. Furthermore, the integration of EVs and renewable energy sources into the microgrid has been modeled and analyzed. Additionally, this article examines the Matlab/Simulink analysis of the microgrid with EVs.**

Index Terms: Vehicle-to-grid, electrical vehicles, charging infrastructure, sustainability, renewable, energy, grid-to-vehicle.

I. INTRODUCTION

Since it generates 25% of all energy-related emissions, the transportation sector is largely to blame for greenhouse gas emissions. Electrical vehicles (EVs) are the best option. Since EVs don't release any emissions from their tailpipes, they are categorized as clean and environmentally friendly. By offering incentives and enacting legislation to encourage their widespread use, a number of countries are aggressively promoting EVs [1], [2]. The electrical grid itself is impacted by the deployment of this technology. Large-scale EV adoption combined with unrestricted charging, which would let users charge their cars whenever it's convenient for them, would be harmful because it would increase the daily maximum electricity demand.

Unregulated EV charging would worsen power outages, put equipment under stress, and affect power quality. However, the advantages of EV adoption would be demonstrated by regulating EV charging or by using EVs as small distributed generators, especially while they are in V2G mode [2]. The future of our world is represented by EVs, which go beyond simple mobility. These cars are emission-free and connected to a low-voltage charging station.

To a certain extent, EVs will undoubtedly be essential to achieving this goal. Vehicles that run on fossil fuels or Internal Combustion Engines (ICE) have released large volumes of carbon dioxide into the atmosphere [3]. Batteries, fuel cells, and ultra-capacitors are alternatives to the conventional energy sources—such as gasoline and diesel—that are required for EVs. For maximum effectiveness, these sources can be used separately or in combination with conventional sources. Consequently, there are three varieties of EVs: fuel cell electrical cars (FCEVs), hybrid electrical vehicles (HEVs), and pure battery electrical vehicles (BEVs) [4]. The battery is the main problem with electric cars. Current research, however, suggests that battery life is no longer a major worry. An electric vehicle reduces pollutants in the environment by replacing gasoline or diesel engines.

Two key terminology in the context of electric vehicles are grid-to-vehicle (G2V) and vehicle-to-grid (V2G). Grid-to-vehicle, or G2V, is the accepted technique for charging electric vehicles. The mechanism by which a car acts as a power source is known as V2G technology [5]. When in V2G mode, EVs release their energy into the supply grid.

V2G technology has several uses, including balancing electrical loads, lowering peak energy consumption, optimizing prices, integrating renewable energy sources, and maintaining steady frequency and voltage levels. In order to achieve load profile flattening, the V2G optimal logic control technique is quite beneficial [6]. To guarantee the effective operation of the V2G process, an aggregator is used [7]. An aggregator is a digital platform that makes it easier for service providers to offer their services to customers in a digital format. network can be practically resolved with V2GtechnologyThe application of practical techniques aids in reducing many problems with distribution networks. The impact that electric vehicles have on the power demand profile is examined. The unpredictable nature of travel patterns is the main barrier to vehicle-togrid technology. [8]. The expenses related to battery cycle life regulation are decreased by adjusting the charging habits of electric vehicles. Consequently, the costs related to electric car battery wear are reduced. By using electric cars to deliver frequency regulation services, the goal is accomplished. The effect of EV battery efficiency and charging duration on the overall load profile is examined. In order to reduce environmental pollution and lower operational costs systems, the objective is to maximize the performance of V2G systems. Furthermore, raising the standard, stability, and dependability of power supply. The expenses related to battery cycle life regulation are decreased by adjusting the charging habits of electric cars. Consequently, the costs related to electric car battery wear are reduced. In the future, EVs will function as a form of decentralized power generation in addition to placing a strain on the electrical grid. They will also be very important in dispersing the load across the system. By using electric vehicles to provide frequency control services, the plug-in hybrid electrical vehicle (PHEV) can both supply and achieve the goal.

The effect of EV battery efficiency and charging duration on the overall load profile is examined. The objective is to maximize V2G system performance in order to reduce environmental pollution and operational costs for both modes of transportation.

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

consume power, allowing it to function both the grid's source and load. Thus, there is great theoretical and practical significance in examining how EV charging affects the distribution network. [11]absorb power, enabling it to function both the grid's source and load. Therefore, it is both theoretically and practically crucial to look into how EV charging affects the distribution network [11].

II. ELECTRICAL VEHICLE IMPACT. IMPACT OF CHARGING AND DISCHARGING ELECTRICAL VEHICLES

EVs affect the power delivery system in both positive and negative ways [25]. EV charging and discharging protocols [26] are essential for reducing the peak lowering the costs associated with battery degradation and the strain on the power system network It might not be feasible to implement a cost-minimization billing strategy that leaves out the transmission and distribution infrastructure. Numerous optimization techniques are used.to improve the load profile, which will lower peak demand and, eventually, EV charging costs overall.

B. DISTRIBUTION NETWORK IMPACT.

1) IMPACT ON QUALITY OF POWER

Numerous power quality problems, including harmonic pollution, increased power dissipation, decreased voltage, and unbalanced three-phase voltage, arise when EVs are integrated into the electrical grid [29].

(A) Harmonic distortion

As EVs become more widely available, more people will use the infrastructure for charging them. This infrastructure includes a Direct Current (DC) link that joins the three-phase Alternating Power System with a number of complex power electronic equipment. Power quality may be impacted by harmonic distortion from this DC link, which could contaminate the electrical grid and compromise the functionality of distribution system components [29].source of current (AC) electricity.

b: DROP IN VOLTAGE

EV technology is continuously developing and being adopted globally. The electrical grid experiences an increase in local load as a result. Large-scale EV charging will affect the voltage at particular times in the network, especially resulting in a drop in voltage at the terminals. Users' power demands are subsequently impacted by this [30].

c: THREE-PHASE HARMONIAL

Charging takes less time when fewer EVs are charging at a given spot for a predetermined amount of time. As a result, the magnitude of three-phase currents that are irregularly distributed increases. Nevertheless, the cost of a An uneven current state is caused by a sizable number of electrical vehicles [30], [31].

2) IMPACT ON WORKING

Reduced cable and distribution transformer lifespans, as well as net loss, are the main indicators of the distribution network's economic operation [32].

a: NET LOSS

For electric vehicles (EVs), greater permeability raises the charging load rate, which raises the load loss rate [32].

b: CABLES

For the cable, the strong harmonic currents are harmful. As a result, this results in decreased effectiveness and a shorter lifespan [32].

C. IMPACT ON THE ENVIRONMENT

The global climate will be impacted and temperatures will rise if the current trend continues in the years to come [33]. High-energy consumers must also take steps to reduce their own emissions in order for smaller nations' efforts to use renewable technology and effectively mitigate emissions to succeed [34]. Interest in EVs has significantly increased since the launch of the Tesla Roadster he following are the causes that have contributed to the rise in emissions [35]:

1) Population expansion.
2) Increased capability for output.
3) Increased energy usage.
4) Growth in transportation.

The manufacturing of electric cars requires a large amount of energy. When compared to traditional fuel-powered vehicles, the manufacturing of electrical cars releases more harm

This is because the production process involves the development of lithium-ion batteries, an essential part of electric cars. Statistics show that over 33% of the carbon dioxide (CO2) emissions emitted during an EV's entire life cycle are caused by emissions generated during production [36].

However, the pollutants generated during battery production have significantly decreased as a result of recent technological advancements and the adoption of extremely effective manufacturing techniques. A GOOD IMPACT

It is undeniably true that EVs emit less pollution than traditional fuel-powered automobiles. However, the way the car is operated depends on the expected benefits of the user. It's critical to acknowledge that different electricity sources have different characteristics when striving for sustainable energy and zero emissions. As an alternative, it makes sense to use renewable energy sources like solar and wind to power the vehicle. A solar panel installation removes the need .The efficiency of the vehicle, how often it is used, and the solar potential of the location all affect how many additional solar panels are required to power the electric car. If generating the required amount of electricity on one's own property using solar resources is not practical, there is another choice is to sign up for a shared solar charging system that is available to anyone. Most utility companies choose to purchase electricity from these renewable energy sources, and this trend is rapidly gaining traction across the country [37].

2) DIRECT IMPACT

One of the most notable features of EVs is their reduced tailpipe emissions. They move more easily by using the energy that is stored in their batteries to power their wheels. Because there is very little heat dissipation throughout the process, empirical study has demonstrated the exceptional efficacy of this transformation. This is crucial given the effects that the extraction of battery materials and their subsequent processing have on the environment. Coal mining and the extraction and refinement of raw materials used in battery manufacturing

3) IMPACT INDIRECTLY

Even though EVs have many advantages, there are still things to be wary about. When we look at the supply chain, the greatest negative effect of electric cars becomes clear. Particulate matter concentrations have been found to increase noticeably. This is the result of producing power from coal. According to recent studies, the usual grid composition has fluctuated, with a noticeable shift towards natural gas and renewable energy sources. This change will not, howe

III. INFRASTRUCTURE CHARGING

The battery of the electrical car must be recharged after use. It is critical to take into account the charging demand from the standpoint of the power grid as the number of EVs and individual battery ratings rise. Based on the existing standards, the EV/PHEV charging methods can be divided into three different groups, as shown in Table 1. [40]

A. STANDARD CHARGING (CHARGING TIME < 8 h < MODE 1, 6 h)

An electrical car with 3.3 kW of power can be charged conventionally by utilizing a socket outlet that has a voltage of 230 V and a current of 16 A. This charging method, which calls for a single-phase AC charger, is mostly used in Europe. It usually takes between six and eight hours to fully charge an automobile. Furthermore,

(MODE 2, 1 h < Charging Time < 3 h) B. SEMI-FAST CHARGING

Power levels ranging from 7 to 22 kW are utilized for semi-fast charging. For a 30 kWh battery, this translates to a single phase current of 32 A or a three-phase current of 16 A.

It has the benefit of double the power that is accessible. It allows for a moderate charge rate of two to six hours. This is the same as charging in Mode 2. The car is directly connected to an AC power source in this mode.

C. Quick Charging (Charging Time < 1 H, Mode 3)

The method of charging an automobile with an external charger that runs on a DC power source is known as "mode 3 charging." Rapid charging is a benefit of this method, but it requires the use of established and deployable technology [43].

The quick chargers that are available are as follows:

1) Quick charger
2) An extremely quick charger
3. A charger with a high AC rating.

A rapid charger is a type of charging device that uses power

The vehicle charges more slowly at a rapid charging station than it does at a gas station. It takes about 25 to 35 minutes for the battery to fully charge.

This charging station's maximum power is between 50 and 75 kW. The goal of a super-fast charger is to recharge a battery in the same time as a normal car's fueling. This component's recharge time is comparable to the "battery swapping" technique used by the Renault project Better Place. A specialist component is required to handle the high power because of the peak power's significant magnitu

IV.EV-PRODUCED HARMONIC COMPONENT

Modern EV charging adds harmonic elements to the microgrid. The harmonic components of the current waveforms are higher than those of the voltage waveforms. A microgrid's electrical system may be impacted by the degree of total harmonic distortion (THD). Additionally, the power quality of the microgrid will be impacted by the THD value. In the context of the charging station, the THD assessment is essential.

AC/DC and DC/AC converters are used in the charging systems of electric vehicles. They are the main harmonic sources.

The electrical parts of an electrical automobile are listed below. In electric cars, the electrical motor is powered by a battery pack. The fact that EVs are extremely eco-friendly and emit no emissions is a big plus. Furthermore, they rely on a renewable energy source to power the car instead of using any fossil fuels.

1) Power distribution lines that are overheated.
2) In the smart microgrid, harmonics appear as resonance events.
3) Transformer and electronic device lifespan.
4) Reactive capacitor disruption.
5) Protective switches enable circuits to be opened on schedule in a microgrid.
6) Communication facilities have disruptions.

Nowadays, smart microgrid systems heavily rely on renewable of the harmonic distortion found in intelligent microgrids. Eq. can be used to define . THDV = q V 2 2 + V 2 3 + V 2 4 + · · · + V2 n V 2 1 (1)

THDv will equal "0" if the harmonics are equal to that number. where n = 1 is the voltage of the fundamental frequency and Vn is the RMS voltage of the nth harmonic. where n = 1 is the current fundamental and In is the effective current of the nth harmonic. THDi will be "0" when the harmonic components are equal to zero. In microgrids with charging stations, the THDi value is greater than the THDv value. The harmonics level for PV inverters is a contentious issue. The current total harmonic distortion is limited to 5% by the IEEE 929 standard [46]. V. The Technology and Difficulty of EV

A. Formulation of the Problem

The primary goal of the proposed study is to use the V2G approach, which is based on the variable load demand, to reduce losses in the distribution system.

The distribution system's power equations are derived from the following one:

1) G2V 2) V2G.

Equation (3) gives the operation of G2V [47].

$$PG = \sum_{i=1}^{24} PBL + PEV + PL \quad (3)$$

Here, PG is Total power generation PBL is base load, PEV is the EV load, and PL is the Losses.

Equation (4) gives the operation of V2G [47].

$$PG + \sum_{i=1}^{24} PEVDG = \sum_{i=1}^{24} PBL + PL \quad (4)$$

B. V2G technology

Both the grid and the EV are advantageous methods for power and energy management. The electrical gridusually doesn't have energy storage provisions. The total capacity of the pumped storage plant is no more than 2.2%. It is essential to maintain efficient control and continuous management of energy transmission and generation in order to adapt to changing customer demands. Vehicles powered by electrical drives that are fed by batteries or hybrid sources are known as electric vehicles, or EVs. As a result, they are frequently contrasted with conventional automobiles that have internal combustion engines. One significant benefit of

e. They can supply electricity to the grid if they have strong connections with a number of auxiliary parts in the system. This kind of connectivity is referred to as a V2G connection [48]. An EV may have a hybrid design that combines both of these energy sources, or it may be powered solely by a battery or fuel cell. However, the primary responsibility is to supply power to the power system when it is not moving or parked. Peak power, spinning reserves, and regulation are the three most important characteristics in power markets [49]. Because batteries have a slow rate of charging and discharging, battery-powered EVs are charged when power demand is low and discharged when power demand is high, like during driving mode or acceleration. Vehicles with fuel cell propulsion can run on liquid or gaseous fuel. Both of these types of operation are possible with PHEV.

C. CONTROL OF CHARGING

1) HARMONIC CONTROL

Because they add to the system's harmonic buildup, converters are essential components of battery charging systems. One can use a multilayer converter operation or the pulse width modulation technique to control or lessen the occurrence of harmonics [50]. The Root Mean Square (RMS) current's harmonics will significantly decrease if the number of pulses is increased. Furthermore, reactive power mitigation strategies can be used to preserve the u

2)CHARGINGCOORDINATION

A concentrated charging pattern brought on by widespread EV charging may have an effect on power grid regulation. As a result, coordinated charging is categorized as a regulated load and utilized to control the grid. Optimizing economic efficiency while minimizing its impact on the grid is the main goal of this approach.

The state of the grid, battery performance traits, and customer needs are the main factors we take into account when managing the charging process. It also helps to prevent the creation of new peak loads and stabilize undesirable variations in load demand. This strategy can improve the distribution network's cost efficiency, power uniformity, and dependability [51].

Scheduling the charging procedure and making sure that the distribution of electric vehicles is in sync with the grid are essential for the successful implementation of coordinated charging.

Because it was difficult for the grid to oversee the charging process directly, the idea of an intermediary was born.

Additionally, using multi-agent technology can help accomplish this goal [52]. When smart grid technologies are integrated with electric vehicles, charging times during peak hours are naturally shortened.

D.V2G CHARGER/FREQUENCY CONTROL

Frequency control is used to maintain the frequency within the permitted range, which is f0 ± 1f, by adjusting the active power output.

Metrics for frequency adjustment are specifically divided into three sub-controls [53]. A quick regulation process known as primary control kicks in when a frequency surpasses the permitted threshold, with the aim of minimizing the Rate of Change of Frequency (RoCoF) as well as the transient frequency. A regulatory mechanism known as secondary control intervenes after primary control and does so with a delayed reaction.

Even if the frequency deviates from the permitted range, the objective is to maintain it at a constant value. In order to correct the frequency and return it to the appropriate range, tertiary control finally takes place after secondary control. Currently, high-inertia, high-capacity power plants, including nuclear or coal-fired facilities, provide tertiary control. Demand response technologies or long-lasting, high-capacity storage are expected to conduct tertiary control management in future power grids [54].

Thus, it is reasonable to assume that V2G charges primarily and specifically contribute to secondary frequency regulation based on a wealth of information from the literature [55], [56]. For primary and secondary regulation, the energy and electricity provided by a V2G fleet must abide by laws and market forces. EV fleets are encouraged to provide secondary frequency regulation by compensating for capacity reserve and activation through a market auction procedure [57].

VI. MICROGRID ANALYSIS USING EV

There are two parts to electrical autos. Electric vehicles' batteries are powered by an internal energy source, and their propulsion is facilitated by an electric motor. External energy sources are necessary for electrical vehicles to recharge their batteries. In these situations, charging the vehicles is essential. EVs are charged in a variety of ways. Based on their voltage and charging speed, charging stations can be divided into a number of categories. Improving EVs' range and cutting down on charging time are the two main issues facing their development. To address these problems, experts are now carrying out thorough, continuous studies. It is recommended to use DC to charge an electric automobile in order to speed up the charging process.

We improve the power output of the charging stations to shorten the time needed for EV charging. Therefore, the amount of charge stations with more than 350 kW of electricity are steadily increasing. The charging stations are equipped with numerous charging connectors, allowing multiple cars to be charged at once.

Several cars being charged at once may cause serious problems for the microgrid. One major problem is the grid's increasing load demand. Fig. 3 shows how EVs and renewable energy sources can be integrated into a microgrid.

There are four parts to the microgrid that is being examined.

Diesel generators serve as the primary power source, while renewable energy is produced via a photovoltaic facility equipped with wind turbines.

Additionally, we use the V2G system to put strain on the network.

One thousand homes with low usage and 100 EVs make up the neighbourhood's microgrid load. EVs outnumber households by a ratio of 1:10. The objective functions of electrical vehicle integration into the distribution system are minimized in

Figure 2. Minimization Objective Functions Of Electrical Vehicle Integration Into The Distribution System.

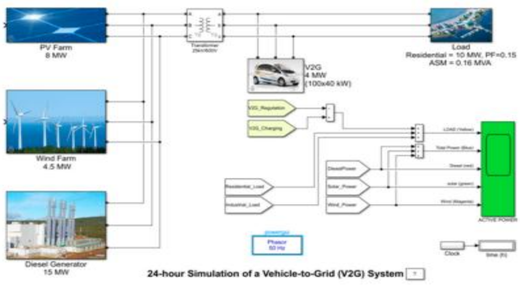

FIGURE 3. Microgrid and electrical vehicles.

Encouraging the production of renewable energy helps to protect the environment. However, environmental factors have a significant impact on the energy produced by renewable energy sources.

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.

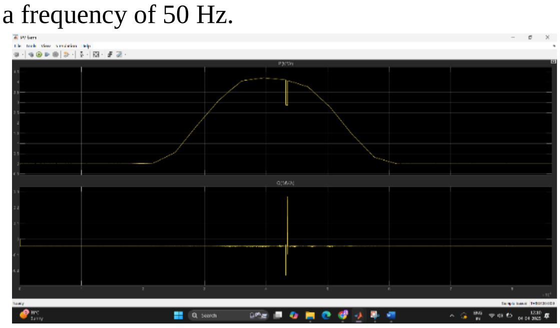

Fig 8: Power Generated By The Solar Throughout The Day.

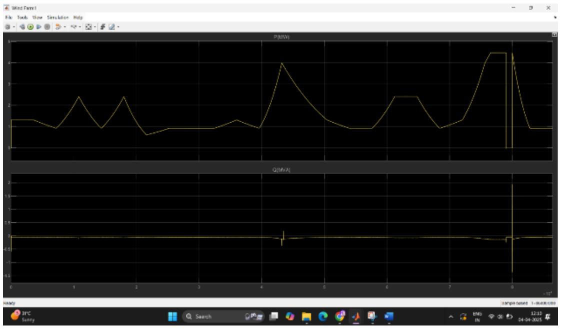

Fig 9: Power Generated By The Wind Throughout The Day.

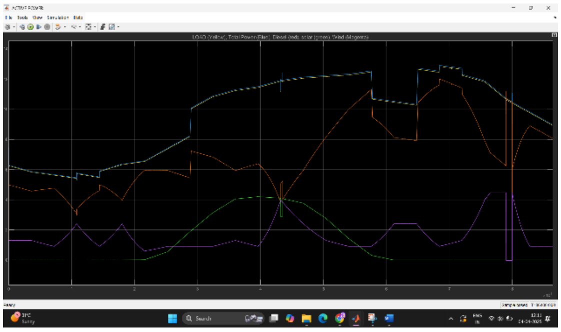

Fig10: Total Power Generation from Microgrid During The Day

ctricity used. By contrasting the grid frequency with the synchronous machine's rotor speed, you may ascertain the difference.

Diesel generators' high cost and harmful effects on the environment are major disadvantages. However, using a diesel generator to produce the necessary energy becomes essential when renewable energy sources are unable to match the demand.Two renewable energy sources make up the microgrid. Above all, the PV plant produces electricity in direct proportion to the amount of radiation in the surrounding area. The solar panels' daily energy output is shown in Figure 5.

Using solar radiation, the microgrid's solar farm produces direct current. The energy output is influenced by the panels' material makeup, the quantity of solar radiation they collect, and the current weather.

The power generated by the wind farm is directly proportional to the wind speed. When the wind speed reaches its specified value, the turbine generates its maximum power output. When the wind speed above its maximum threshold, the microgrid cuts off the wind power until it reaches its normal level again. The wind farm's daily energy generation within the microgrid is shown in Figure 6.

Due to their status as a sustainable energy source, their ease of design, and their remarkable effectiveness, wind power plants are increasingly being used in microgrids. Wind farms have unique features when compared to other traditional power plants.

The ability of EVs to use V2G applications is their main advantage. This application is only suitable for electric vehicles. In essence, it makes it possible for the vehicle to feed the distribution microgrid with electricity directly. The power value that the EV sends and regulates to the microgrid during the day is displayed .

The process of moving electrical energy from EV battery systems to the microgrid is known as "V2G." The batteries in EVs serve as a source of energy storage inside the electrical system. Car-to-grid technology makes it possible to charge and discharge a vehicle's battery in response to a variety of signals, including energy use or output. The use of electric vehicle charging raises the demand for electricity.

CONCLUSION

An inevitable development in the growth of distribution networks is the integration of Electrical Vehicles (EVs). The increased use of EVs will increase the likelihood of distribution system problems. Reactive power is decreased in order to guarantee microgrid voltage regulation. Reactive power support reduces power losses in power transmission lines and raises the power factor.

Moreover, it leads to increased efficiency. When connected to the microgrid, EVs can provide reactive power modifications. The study's main objective is to analyze how a freestanding microgrid functions, with a particular focus on different EV charging protocols. Uncertainty has an impact on the anticipated values of solar radiation, load demand, and win. The current transportation industry's rapid transition calls for the quick development of EVs, which will have a big impact on the environment and the power grid.

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