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Paper Authors
GUMPA SAGAR

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A REVIEW OF EFFECT OF ELECTRIC VEHICLE CHARGING STATIONS ON POWER NETWORK(GRID)

GUMPA SAGAR[1*]
GMR Institute of Technology,
Rajam-532127, India.
Sagargumpa102@gmail.com

Abstract:

As recent studies showed that 15 percent of environmental pollution is caused due to transportation, through automobile vehicle emissions (toxic gases). The rapid usage of automobile vehicles will result in the gradual decrease of fossil fuels, which adversely affect the environment. Among the nations, environmental pollution seems to be a big issue. So that we are moving towards flexible alternatives such as electric vehicle technology. Although they are eco-friendly, implementing charging stations hugely will be a big challenge for the power network (Grid). As the technologies move toward the fast charging of electric vehicles (EV) charging stations, it ultimately impacts the grid system. The studies estimated that a fast charger of an electric vehicle uses 350kw's of power to fulfill its lifespan. To maintain the optimal utilization of charging for EVs, coordination of EV charging demand is essential to avoid the overload on the grid. The moment connecting a huge number of EVs to the grid causes high production of short circuit currents, voltage levels enormously different from the standard limits. As the power demand increases the reliability of the grid equipment will gradually decrease. This paper appraises the charging power levels based on monthly peak load demand and annual electricity bills.

Keywords: Electric vehicle, V2G technology, Load demand, Coordinated and un-coordinated charging, Grid network.

1. Introduction:

An increase in the usage of conventional vehicles in a huge manner results in a rapidly increasing in environmental pollution, mainly air pollution. Apart from air pollution, it causes a dangerous phenomenon called catastrophic climate change. By taking preventative efforts to lessen the catastrophic climate change that threatens life on this planet, carbon dioxide output can be decreased [1]. In this aspect, electric vehicle technologies are going to be the best alternative to reduce pollution due to the transportation sector [2]. Most countries like California have banned the new evaluating powered gas passenger cars starting in 2035. As the new evaluation of electric vehicles started, they came with some other challenges like the establishment of charging stations, charging infrastructures, peak demand, ramp rates, frequency/voltage deviations, etc.… From 2016 to 2020 the number of public and private charging stations increased from 34,000 to over 85,000. There came another challenge called power demand on the grid. The inability to charge is a barrier for EVs [1,2]. Recent research has demonstrated that EVs have a distinct advantage over other conventional energy-saving technologies due to their simplicity of use and assurance of an environmentally pleasant atmosphere. These EVs are expected to increase significantly by becoming more popular on the market thanks to their improved efficiency, especially in metropolitan areas [4].

As 68 percent of India's greenhouse Energy production is the main source of greenhouse gas emissions, followed by manufacturing, forestry, improved land use, and waste. Adding 19.6%, 6.0%, 3.8%, 1.9%, and 3.8% in terms of greenhouse gas emissions [1]. When charged at home, EV electric load accounts for a sizeable amount of the typical household's energy use. As a result, it is anticipated that an increase in EV adoption would have a major influence on network peak demand, particularly in regions with convenient access to charging stations like homes, businesses, and offices. EVs will increase the grid's need for electricity, but they also can supply power back to it, a process known as "vehicle-to-grid" (V2G) [20]. Three implementation frameworks for grid-connected EVs have been identified in recent studies. The EVs' connection to the grid at home supplies additional renewable energy for the building. Vehicle to Grid is a two-way energy flow between EVs and the grid, whereas Vehicle to Vehicle refers to the charging and discharging of electricity between two EVs [3]. A V2G application is simply the capability of a vehicle to provide direct passage of power into the DN, which is only achieved by an EV. We can create a variety of instantly accessible distributed energy storage devices thanks to the concept of V2G. With this idea, several battery kinds and applications enter the market [6].

1.2 CONTROL AND EFFECT PARAMETERS OF EVS ON GRID:

1.2.1 CHARGING CONTROLS OF ELECTRIC VEHICLES

Based on the various economic factors charging strategies for electric vehicles have been proposed in recent journals. The distribution networks are significantly impacted by the charging profile of EVs. There are several charging techniques for controlling the amount of time and frequency that EVs need to charge. The main charging control strategies that have been proposed to maintain the reliability of the grid are listed below.

1)coordinated charging
2)un-coordinated charging

COORDINATED CHARGING:

In recent years, interest in the regulated EV charging-discharging approach has grown. The operator may swiftly adopt and monitor this synchronized approach while setting up the charging-discharging schedule to minimize power quality problems and disruptive instability while also fulfilling the driver's charging needs and achieving financial or operational review goals. The infrastructure and system upgrades are tied to the operator's performance goal. Established charging-discharging can be integrated into indirect controlled, intelligent controlled, and bi-directional controlled systems depending on the types of control parameters. In an indirect controlled method, the charging parameters—such as the charger's control, the loading duration, and the charging extent are not constrained by the design. These systems should ideally be in charge of any external variables that affect the charging procedure. The system will help in avoiding grid overloading [9].

UN-COORDINATED CHARGING:

Consumer behavior and choices are taken into account by the indirect control approach. Indirect charge-discharge is rising in frequency in recent years the flexible pricing incentives and the electrical market time structure. The predicted push of rising energy costs During times when there is extra grid capacity, some charging loads have moved to the grid from being overloaded by making resources accessible [4]. There is called "spatial load shifting," an indirect control technique. That is to say, The EV user's self-determination criterion can be used to coordinate the shifting of spatial burdens. Two separate approaches may be used to accomplish this strategy: the first is based on charging costs, and the second entails offering ancillary services to EVs to assure optimal grid operation. A real-time EV charging system has been put out that takes into account real-time price and time-of-use, helping to control demand. Three research factors were taken into account in the time-of-use approach. The distribution network's energy and charging costs were taken into account first. It was also noted that market-based cost control and EV management may be achieved by hierarchical EV management, in which the top layer of the controller directly controls the lower-level controller. The holistic design approach was the third parameter, which was then followed by a cost-control model that used spatial load shifting. With no infrastructure upgrades, several penetration levels of EVs were examined in the time-of-use scenario. At penetration levels of 20%, 30%, and 50%, several network characteristics including transformer burden, battery SOC, voltage, load profile of the distribution network, and plug-in EV status were evaluated [4,5]. Table (1) shows the differences between coordinated charging and uncoordinated charging based on the different aspects like pros, consequences, and their effect on the grid [3,4].

Unplanned EV integration may lead to the overloading of feeders and transformers, decreased voltage profiles, increased system losses, and increased operational and charging costs. Coordinated integrations can significantly reduce the detrimental effects on system performance if haphazard integration. The amount of EV penetration has a significant impact on system performance. The two charging patterns have differing impacts on peak shaving and valley filling, according to the examination of the three charging techniques' effects on the variation of the microgrid's basic load. When electric vehicles (EVs) are linked to the microgrid in the home-charging pattern, the coordinated charging schedule plan can decrease the variation of the basic load. However, the public-charging pattern's fundamental load variance may grow as a result of EV charging. First off, while charging at home rather than in a public location, EVs spend more time there on average. The EVs are linked to the microgrid at around 18 hours and detached from the microgrid at about 8 hours in the home-charging schedule. However, EVs typically have connections in the public-charging pattern[4].

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Table (1): Differences between charging strategies.

Name of the charging method	Benefits	Consequences	Impact on the grid
Co-ordinated charging	Peak power is decreased, the demand profile is rounded, and improved auxiliary services provided Successful distribution system, Low cost of maintenance.	• Complex design of a distribution network • Battery SOC is rapidly decreasing • More grid losses • Customers must be prepared. Various regulated procedures are necessary for several key circumstances	• Peak load is readily handled • Simple integration of grid and load •Enhanced stability and dependability in the energy grid • Lower cost of power • Grid components are under less stress • There have been real-time optimum algorithms Designed Supply-side management • Dynamic, linear optimization issue has been solved Valley filling with the most accurate calculation
Un-coordinated charging	Simple to use During immediate system adoption peak demand.	• Extreme voltage swings • Grid overloading has increased, with negative effects discovered grid components • Expensive electricity lackluster power factor	• Grid overload • More power losses • More electricity cost

1.2.2 V2G TECHNOLOGY:

According to this theory, the parked electric vehicle (EV) has a bidirectional charger that may be used to either transmit electricity to the grid or recharge the battery. The effect of V2G and Grid to Vehicle Li-ion cell bidirectional charging has been proposed to determine its cell functionality [8]. This section provides an overview of using energy storage technology in the design and management of a distribution system. They researched battery technology and V2G legislation technology. They proposed a way to control battery deterioration, which may be applied to increase the lifespan of the utilized battery within the electric car.

A Nordic investigation on the opinions of hundreds of specialists about electric recommendations for V2G and EV mobility replicate policies. Experimental research on the effects of V2G operation on Li-ion battery degradation was conducted by DuBarry et al. in 2017. By employing readily available Li-ion batteries, they also discovered how important bi-directional charging is for increasing EV consumers' profits. Further research by employing an empirical model to determine the practicality of V2G while accounting for the cost of energy and the battery's lifespan in the face of battery deterioration. To examine their effects on the power distribution network, Habib et al. (2015) conducted a comparative analysis of V2G technology and an EV's charging method [4]. The advantages of the V2G are listed below:
actively controlling power, encouraging reactive power, Valley fillings for load balancing, filtering for current harmonics, peak load reduction, reducing service costs overall and utility running costs, Increasing the load factors, generating revenue, and reducing emissions. [3-4,11] Monitoring renewable energy sources (RES) that are subject to change.

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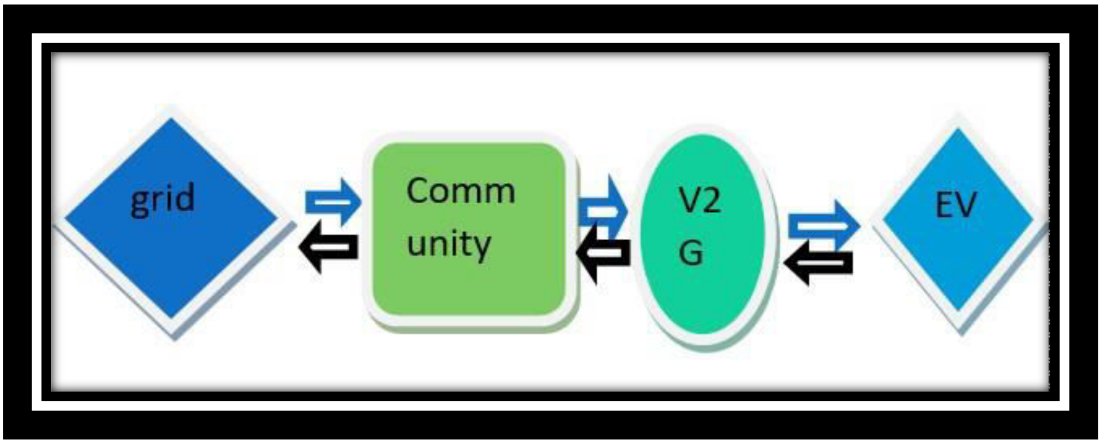

Fig.1 V2G system structure

2. LITERATURE SURVEY:

There is a huge tendency toward bringing EVs to the market because of the present environmental and energy challenges. On the one hand, the technology utilized in the most modern EVs makes them environmentally friendly cars with nearly no emissions, but on the other hand, a vast number of EVs already on the road can be seen as a major threat to the grid, and that concern is demand variability. As was said, an average of 90 to 95 percent of an EV's daily time was spent free and idle while it was typically parked. The electric batteries that can be recharged help electric vehicles (EVs) go about and are also an emergency backup storage system for the grid [3].

There have been several research on this technology over the last few decades, each of which concentrated on a distinct part of the subject. Environmental concerns, such as the detrimental consequences of the old transportation system, have dominated most of these investigations. Many studies have examined the potential benefits and drawbacks of introducing an EV fleet and V2G system into society, and some have used cutting-edge algorithms to search for the best possible outcomes in a variety of areas, including revenue, battery life, supply stability, scheduling, emissions, and others. Many review articles have examined earlier investigations and provided the basic structure of the V2G system [11]. There isn't a definite road map to follow in this area of research, which causes problems.

In this study, we will fill this knowledge gap, suggest a complementary research path for the future, and examine the research gaps in this area. Consequently, we suggest a foundation for future researchers that uses a scientific classification of earlier research according to their methods. The information obtained from the data reveals. The majority of authors concentrated on environmental concerns such as GHG emissions, air pollution, the depletion of oil and gas resources, petroleum dependence, the earth's rising temperature, and so forth. The authors of certain research, utilizing cutting-edge algorithms similar to the evolutionary algorithm or the Monte Carlo cycle have attempted to find the ideal answer. These models often revolve around the EV owners' overall revenue optimization, grid efficiency, GHG emission, and other related topics [3,4].

Goel, S. Sharma Et al. [1] have discussed and determined the key strategies, obstacles, and difficulties of operating a battery-powered, grid-connected car in a developing nation like India. The major topic of this paper is India's EV adoption challenges. They have researched the many kinds of electric cars that are now on the road throughout the globe. In addition, they have identified EV market hurdles in India. Also mentioned several optimizing approaches. The fuel efficiency of automobiles can be improved by hybrid, plug-in hybrid, and electric vehicles, although these vehicles are more expensive to acquire than conventional vehicles. Over the course of their lifetime, buyers, society, automakers, and policymakers generally benefit economically from their decreased petroleum consumption and increased productivity. The Indian government's recent measures and several incentives will support the country's move toward e-mobility. When unconventional energy sources are not accessible, a novel idea called "vehicle-to-grid" can either supply energy to the grid or be utilized to recharge the battery. This technology is crucial for energy security

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and renewable energy and provides many opportunities to address global warming challenges. The major originality of the study is a description of the obstacles and issues with electric vehicles in the Indian setting. The methodologies proposed in this paper have advantages. We may categorize the numerous benefits of switching from fossil fuel to electric power into three primary categories: environmental, technological, and economic. This is true particularly for the transportation sector. Has drawbacks included Battery Wearing Limited access to recharge stations and related technology high investment requirements, etc.

Gilleran, Madeline Et al. [2] discussed the potential grid consequences of charging stations for electric vehicles, particularly when greater power levels are used more frequently. Even if the overall market share for electric vehicles is still small, strong adoption clusters might have a significant impact on some locations, like metropolitan locations with large box retailers. While understanding is essential. There is currently a lack of appropriate knowledge on the energy needs of non-residential buildings and the possible effects of quick charging at these retail outlets. impact of charging on the annual cost of electricity, peak power demand, and monthly electricity usage of a large box store. Based on the mechanical, electrical, and architectural as-built drawings, they developed an Energy Plus building energy model of a large box retailer in Centennial, Colorado to provide precise building demand profiles. They trained the model using five years' worth of detailed sub-metered data to make sure it accurately depicts the electric power profile of each subsystem, including lighting, plug loads, ventilation, heating, and air conditioning. By submetering for equipment, refrigeration, interior and outside lighting, and plug loads, they calibrated it using five years' worth of precise sub-metered data. By submetering on interior and outdoor lighting, equipment, refrigeration, and air conditioning, they will be able to compare their predicted electricity consumption to that of the actual structure in Centennial, Colorado, ensuring that the model is accurately projecting the energy use of a real building. The peak power demand at a location can be significantly impacted by rapid charging (raising monthly peak power demand at the site by over 250% in some circumstances), yet the difference is minimal to its yearly power use. As per-port increases, this impact gets stronger. Power output rises. The yearly electricity bill is particularly vulnerable to major fluctuations in prices, which can increase by as much as 88%. Recognizing that station loads that overlap with existing ones will most certainly cause capacity concerns. When creating and designing an electric car Loads frequently happen.

The peak power demand at a location can be significantly impacted by rapid charging (raising monthly peak power demand at the site by over 250% in some circumstances), yet the difference is minimal to its yearly power use. As per-port increases, this impact gets stronger. Power output rises. Furthermore, we discover that cold-climate regions (along with rate schemes that include high demand) and lower AC loads. The introduction of vehicle-to-grid (V2G) technology as a form of mobile energy and its integration with RESs and the smart grid are the most effective ways to address potential supply and demand issues. This technology has been the subject of several research in recent years, and various components of the system have been examined. The environmental problems in these kinds of investigations.[15]

3. DISCUSSIONS:

Various studies have listed out the effects of EV charging stations on the grid. The studies are summarized below.

3.1 Regulation of voltage and frequency:

Due to greater market value and reduced strain on the electricity grid, regulatory services are the first step in deploying V2G technology. EV systems balanced active power supply and demand by regulating frequency, this is accomplished. recirculating big generators are used to regulate frequency, although they are expensive. In V2G, EV batteries offer quick charging and discharging speeds. This method is an effective substitute for frequency control because of the system’s reactive market with balanced supply and demand. The EV charger's careful selection of the current phase angle can aid to adjust reactive power from inductive and capacitive sources. Charging when the supply grid's voltage is lower, and it can restart if there is a high voltage. union for maintaining frequency stability Three criteria are given for the coordination of power transmission. There are three different forms of control: primary, secondary, and tertiary. The battery of EVs might be charged to accomplish down-regulation moreover if the battery is drained on the grid, we might get up to the law [6].

3.2 Load Demand Management on Grid:

By discharging the battery into the grid during times of high demand and charging during times of low demand, such as night-time and off-peak hours, the V2G system can regulate the power load. Intelligent charging schedules change the load curve and assist in managing peak demand.

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By switching to EVs, the grid's impact from the EV fleet is effectively decreased. The Controlled battery chargers are used to change the energy requirement by balancing the peak load [12]. Impact on the grid with the rapid increase in charging stations: If electric car charging takes place in large amounts, it will result in overloaded, and overloading puts transformers in danger. The primary feeder will also be affected if there is a lot of fast charging. conductors will be overloaded. The energy lost when charging One of the financial concerns for distribution operators is the procedure. should be minimized, and hence, overloading of the transformer and the feeder should be avoided. Power losses, the production of harmonic deviations in the voltage profile during the charging process, are power quality problems [6]. EVs act as load with leading qualities for the DNS For a phone's battery to be recharged, there is a requirement for electricity. The main power requirement for EV charging load depends on the grid.

3.3 Stability of voltage:

One of the crucial challenges for network stability is voltage constancy. The capacity to maintain all bus voltages at values at a steady state following system adjustments. the abrupt voltage drop in the system is caused by unpredictable load variations. Distribution system If the decline exceeds what is acceptable voltage collapse may occur at certain limitations. The safe level for the 6% voltage loss is the standard. [7]

3.4 Phase disparity:

Unbalanced loads on the three-phase power system are one of the causes of the phase imbalance issue. The answer phase imbalance is caused by the response of EV users to the Smishing assault of the specified system. Consequently, the distribution system's capacity is. Because the grid cannot be used effectively, there are increased energy losses on the distribution feeders, more protection devices trip, and consumers lose power as a result. This issue also results in overheating damages to home appliances by overheating. The electricity system's voltage imbalance issue signifies that one phase's voltage is different from its neighboring phases' magnitude and the phase angle of voltages.

3.5 Transformer overloading:

Transformer loading is a critical factor in the performance and lifespan of the transformer. To lessen the damaging effects of EV a synchronized load on the transformer, the DSO should use among the EVs' charging methods. In [15], the detrimental effects were offered as an example of a disorganized EV charging approach. The transformer's aging process is accelerated by this uncontrolled overload.

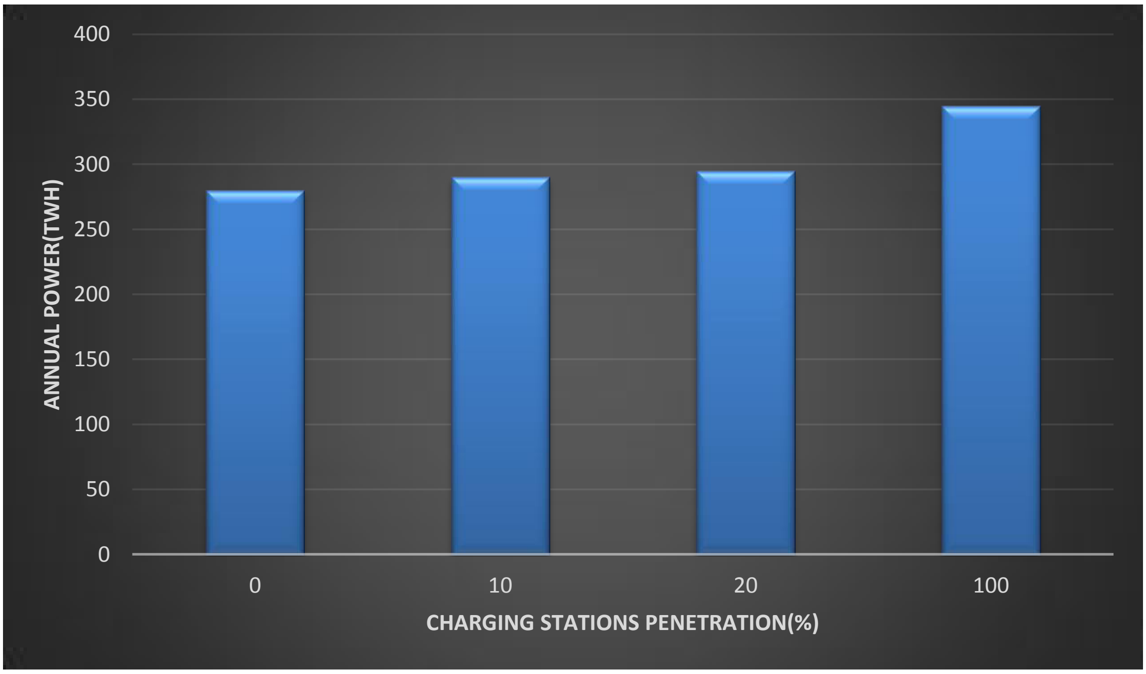

fig.2 shows the power utilized by charging stations with different penetration levels.

As Electric vehicles' evolution is increasing day by day, their dependence on the grid also goes on increasing. The load demand of various penetration levels of charging stations has been listed in fig.3[4].

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As we know power is necessary for residential purposes Apart from that PEV demand is also increasing exponentially. Another best methodology used by the authors/ researchers to assess the challenges of the grid is the big box grocery store simulation. The method gave the best results for them regarding the monthly increase in the electricity bill. All charging station implants need not be of the same capacity. Hence, there will be another challenge raised here, which is the capacity of the charger connected to the station. People always search for fast chargers as a normal charger takes most of the time to charge the battery. When a huge number of chargers are connected in a bulk quantity then the power drawn is also increased as a result the electricity bills increase. The simulated results of the annual electricity bills have been shown in [2]. Fig. 4 shows the amount of power drawn by various types of chargers.

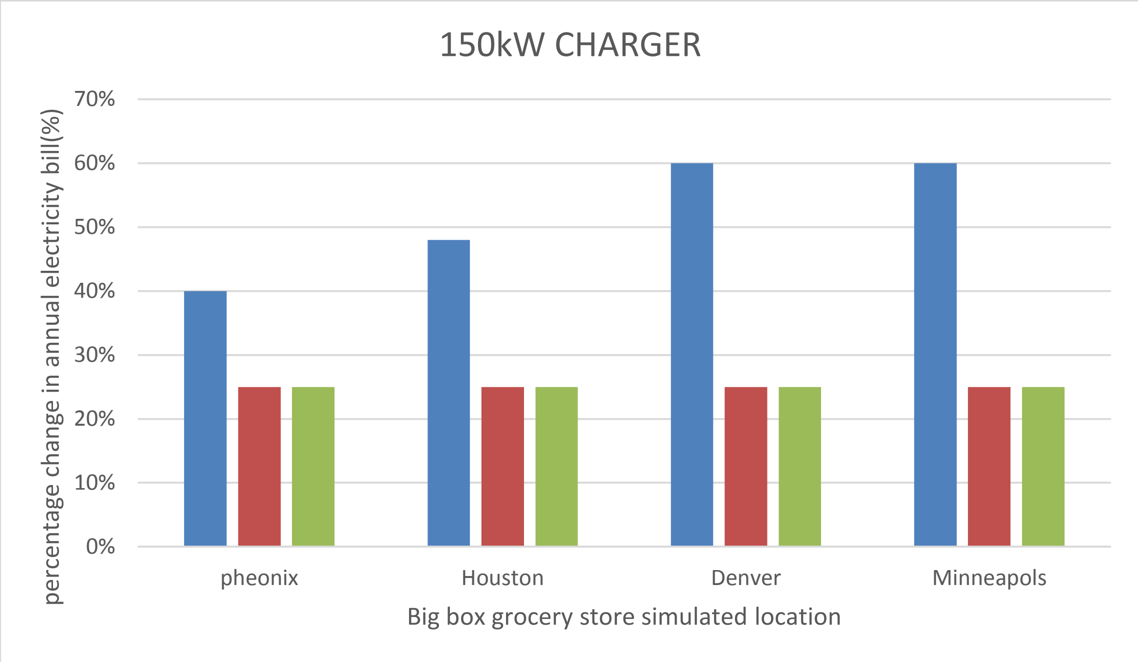

Fig3: Change in annual electricity bill with 150 chargers.

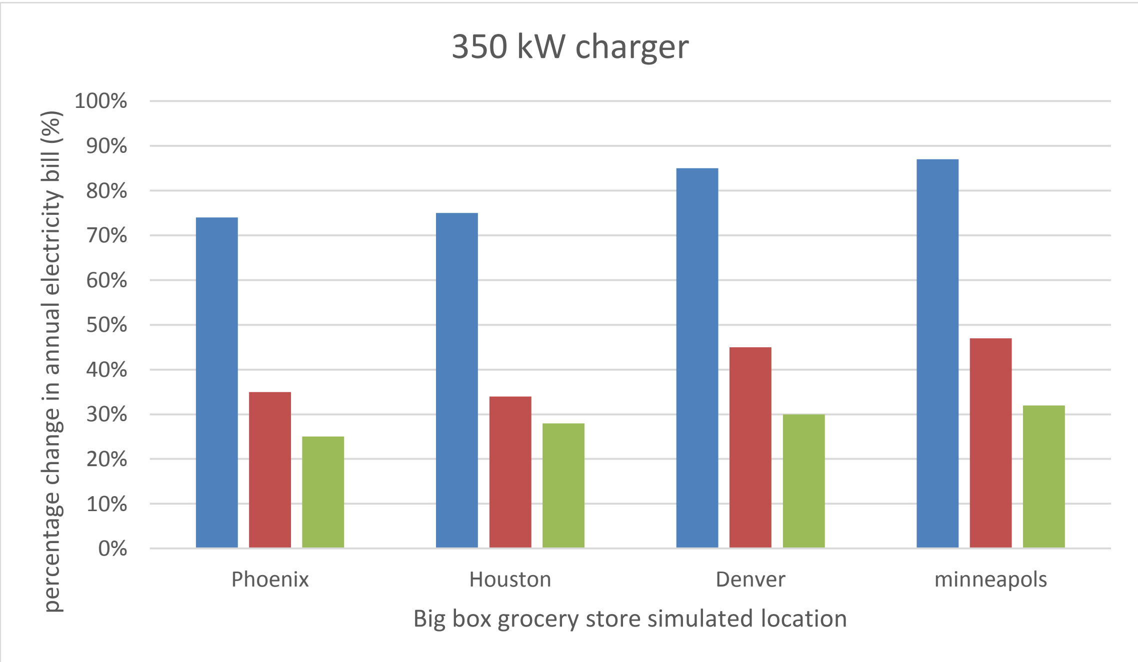

Fig 4: Change in annual electricity bill with 350Kw chargers.

4. CONCLUSION:

This paper presents a unique analysis of electric vehicle charging stations' impact on the grid network. The most researcher has brought out various methodologies to evaluate various consequences of charging stations. As the requirement for EVs increases, the impact on the grid also goes on increasing. we have gone through the various papers that have been published in various journals and found the best

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methodologies to assess the reliability and utilization of the grid. Among all the studies, the Common methodology proposed to increase the reliability of the Grid is V2G technology. To maintain the efficiency of any system to be stable we need to satisfy the condition that input should give the desired output. Like that, generated power should equal the load demand. In case of failure of the condition in terms of the grid, V2G will act as the best method to increase its reliability.

Charging plays a crucial role in electric vehicle technology. To maintain the grid in the proper condition, we need to go for coordinated charging which will be a helpful aspect in increasing the efficiency of the grid. Many researchers have suggested coordinated charging. When a huge number of charging stations are connected to the grid network various losses will occur in the grid equipment and power quality. We have listed some of them, transformer overloading, phase disparity, regulation of voltage and frequency, etc...,

The most effective method to resolve any potential issues with supply and demand is the introduction of vehicle-to-grid grid (V2G) technology as mobile energy and its integration with RESs and smart grids. Numerous investigations have been conducted recently concentrated on this technology and many system components have undergone analysis. Within such studies, the authors shared concerns and the majority of them are related to the environment. The detrimental effects of emissions have been attempted to be reduced by the use of mathematical models. The V2G system and its integration with RESs and SG are the subjects of various review publications, however, there is no comprehensive classification of earlier research on this subject. Various simulation results have been shown to assess the load demand due to EV charging stations.

This journal also reviews charging techniques such as coordinated charging, uncoordinated charging, and intelligent scheduling. A synchronized charging meta maximized to reduce power demand and maximize charging time. Smart charging and discharging reduce daily power costs, voltage variations, load spikes in transformers, and line currents enhancing a grid's technical performance, and the components of a system's stability, effectiveness, and dependability. Therefore, synchronized charging is the most effective and beneficial method for Grid operators and EV owners. The advantages of EVs will undoubtedly increase. EV owners and distribution grid operators will pay close attention shortly.

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