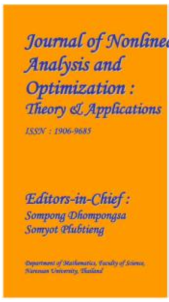
Journal of **N**onlinear **A**nalysis and **O**ptimization
Vol. 15, Issue. 1, No.15 : 2024
ISSN : **1906-9685**



Paper ID: ICRTEM24_172 **ICRTEM-2024 Conference Paper**

EXPLORING THE IMPACT OF ELECTRIC VEHICLES ON THE DISTRIBUTION SYSTEM: A LITERATURE REVIEW

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ABSTRACT: The purpose of this study is to provide an overview of previous research on electric vehicles and their impact on the power grid. We are committed to providing you with comprehensive information about the many types of charging stations for electric vehicles, how they affect the power grid, and how to design power networks that work well with them. Several factors are examined to gain a better understanding of electric cars. These include the battery's capacity, efficiency, and charging status. This article will also discuss the various ways that electric cars can be charged and how they are gradually replacing cars that use fossil fuels in the modern world. It also discusses how new technology are constantly improving electric vehicles. Finally, future potential for electric cars are discussed. After reading this review article, you may easily learn about electric vehicles and the extensive research that has been conducted on the issue.

Index Terms: *Electric vehicle, charging station, battery capacity, battery efficiency.*

1. INTRODUCTION

The primary issue in contemporary society is the depletion of fossil fuels, which are essential for daily activities such as transportation. Transportation was once nonessential for living, but it has now become a crucial component of our daily existence. Electric vehicles (EVs) have advanced significantly as a sustainable, long-term replacement for depleting fossil fuels. Electric automobiles are vehicles powered by one or more electric motors. The car can operate using batteries that may be charged by various sources such as solar panels, fuel cells, engines, or fuel cells that convert gasoline into electricity. Alternatively, it can utilize a collector system to obtain power from an external source. Electric vehicles (EVs) encompass several modes of transportation, such as cars, trains, land and watercraft, and aircraft.

Electric vehicles are available in several varieties, including plug-in hybrids, battery electric cars, and hybrid electric automobiles. Various types of electric cars are manufactured using a variety of components. In a battery-electric car, the gas tank functions as a battery, while an electric motor replaces the internal combustion engine. Hev, short for "Hybrid Electric Vehicle," is a type of car that combines an internal combustion engine capable of running on gasoline or diesel with one or more electric propulsion systems. When you only use energy, you use less oil and put out less carbon dioxide. These cars are known as plug-in hybrid electric vehicles (PHEVs). They operate similarly to hybrids, as they are equipped with an internal combustion engine, an electric motor, a gas tank, and a battery. PHEVs differ from other hybrid vehicles due to their bigger battery capacity and the presence of a charging station. This enhances their utility in various scenarios. Previously, fossil fuels were utilized to fuel a variety of vehicles to fulfill transportation requirements.

Currently, customers' preferences are evolving, and they are increasingly receptive to the latest cutting-edge technologies. Despite the numerous advantages of electric cars, they also have drawbacks, as the adage suggests that all good things come with downsides. Electric vehicles (EVs) have numerous issues that must be addressed before they can be widely accepted as the optimal choice for customers and their preferred mode of transportation. The texts we have completed have provided us with a broad comprehension of electric vehicles. Our comprehensive review paper serves as evidence, incorporating extensive research on the subject. Electric automobiles must be charged to operate. The abundance of electric vehicle (EV) charging stations may impact the distribution system. The method of charging an electric automobile significantly impacts the distribution system's performance. The increasing presence of electric cars (EVs) is straining the current equipment of the distribution system.

Charging an electric automobile requires a significant amount of energy, which could have detrimental impacts on the system. The research allowed us to examine various strategies people have developed to mitigate the impact on the distribution system produced by electric vehicles and to develop a technology that can effectively address the resulting challenges. While going through numerous items, I discovered errors in each one that required correction or adjustment.

Despite multiple restructurings and reorganizations of the electricity system, the issue has not been promptly resolved. It is conceivable to eliminate it in the upcoming years via consistent advancement. The individuals responsible for organizing and operating the power system, consisting of the transmission, distribution, and production systems, lacked a complete understanding of the impending issue. Research indicates that there are variations in load charge regulations throughout different regions of the world. Load charging is expected to be more prevalent in urban areas and less common in rural regions. Upon reviewing this summary, the reader will gain a comprehensive understanding of electric vehicles (EVs), including the various types of EVs, charging stations, the impact of charging on the distribution system, strategies to mitigate this impact, and the advantages and disadvantages of EVs.

Fig1.Types of Electric Vehicles

2. CONCEPTS IN EV

Charging Station

A charging station is a device designed to provide electricity to electric vehicles using a plug-in system. An EVSE, also known as a charge point, provides power to electric vehicles. EV charging stations are essential as they enable the charging and mobility of electric vehicles. As per the U.S. Department of Energy, 80% of electric vehicle charging takes place at home. Examining the impact of these vehicles on individuals' electricity costs and the linked utility infrastructure will become increasingly crucial. It was discovered from several sources that the majority of electric car (EV) owners charge their vehicles at home in order to reduce costs.

An electric vehicle owner will not incur any monthly charges, regardless of whether they install solar panels on their property. By the end of the day, the owners bring their automobiles in to be charged before heading home. Charging your automobile at a public station might be expensive. During relocation, there are instances when the owner must pause and recharge at a public station. At times, power failures or unforeseen circumstances compel the owner to halt operations. Studies indicate that 20% of electric vehicles recharge at public charging stations. Public charging stations are preferable to home ones since they allow for extended driving range and reduce fuel use.

The cost of charging at public and private stations varies due to the differences in power supplies and energy sources between countries. The study results highlight the significance of charging facilities in maintaining the functionality and longevity of electric vehicles. In addition to location, another factor categorizes various types of charging stations. The subsequent criteria will be utilized: There are charge ports available for both alternating current (AC) and direct current (DC). Charging batteries requires direct current (DC) energy.

The majority of energy in the electricity system is in the form of alternating current (AC). An "onboard charger" or integrated AC-to-DC converter is a crucial component in the majority of electric vehicles. The onboard charger converts AC power from a wall socket at an AC charging station into DC electricity to charge the battery. DC chargers circumvent size and weight constraints by housing the converter in the charging station rather than the vehicle. This enables high-power charging, necessitating larger AC-to-DC converters. Subsequently, DC power is transmitted straight to the vehicle from the station, bypassing the onboard converter. Many totally electric automobile models have the ability to do dual functions simultaneously. Typically, the primary method for charging cars at home involves the installation of a 240-volt charger indoors. This is known as level 2 charging. It can accelerate from 20 to 35 kilometers per hour.

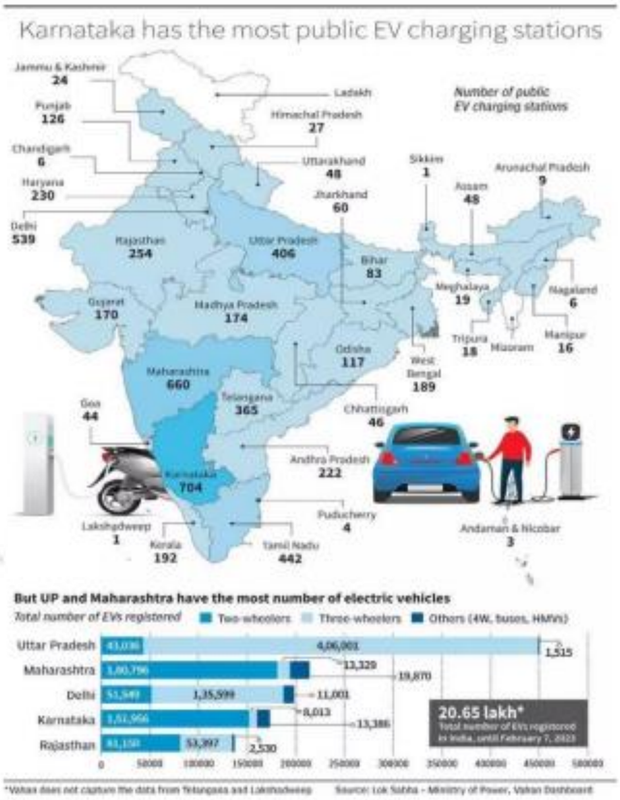

Fig2.A Map Showing no. of Charging Stations in Different States of India

Fig3.EV Charging at Public Station

Distribution System

The distribution system follows the transmission system in an electric system and is responsible for delivering electricity to the end customer. Charging electric vehicles (EVs) in an uncoordinated manner can impair the distribution system by reducing the voltage profile, inducing harmonic distortions, and increasing peak demand. According to a study, the charging load requirements for automobiles rise in tandem with the growing popularity of electric vehicles. To determine if the electrical infrastructure can accommodate the increased energy demand, it is essential to enhance power production and transmission capacities.

This subject has been examined in the context of capacity investment models and transmission networks. Research indicates that there is typically an inverse relationship between the level of load flexibility utilized and the required capacity for wholesale generation and transmission in the electrical system. Nevertheless, the majority of research on potential scenarios indicates that the additional capacity required to accommodate electric vehicle charging demands would remain relatively minima. Various sources of load demand, including corporate, industrial, and residential sectors, contribute to the existing load demand in the distribution system, leading to anomalous system behavior.

The delivery mechanism is designed to support a specific weight capacity. Anomalies in the distribution system occur when it is subjected to excessive stress. This peculiar behavior is temporary and will cease, leading to the system malfunctioning. In addition to the residential load on the grid, it must also manage the power consumption of large machinery used by individuals. Previous research on charging electric automobiles often use intricate trip data from gasoline-powered internal combustion engine (ICE) vehicles to simulate the charging process.

Various automotive technologies exhibit distinct movement patterns, particularly for early users of electric vehicles. Deviations in charging behaviors from expected patterns are also notably distinct. Electric vehicles (EVs) and the power grid can exchange energy through vehicle-to-grid (V2G) technology. ICT is integrated into the EV charging system to enable this functionality. Modeling research on the interaction between electric vehicles (EVs) and the distribution network has evolved from a unidirectional method to a bidirectional approach.

The increasing adoption of electric vehicles (EVs) necessitates a greater need for energy and power. This is causing technical challenges such as system imbalance, reduced security, power quality problems, and increased system expenses. The one-way approach, also known as the G2V mode, has been extensively researched in scholarly literature focusing on smart charging, safety, and control features. The primary objective of these investigations is to discover methods to reduce the impact on the billing or delivery system.

Electric vehicles (EVs) serve a dual role in the energy grid, serving as both a consumer and a decentralized generator and storage unit in two-way operation. Initially, peak load reduction was intended to be achieved by conserving energy in electric vehicle (EV) batteries and recharging them from the grid during periods of high demand. Reference provides a detailed overview of peak shaving techniques involving demand-side management, energy storage systems, and electric vehicles.

Distinct differences exist between the unidirectional and bidirectional modes, as illustrated in Table 1. To create an effective storage system for many electric vehicles, it must have the capability to both charge and discharge simultaneously. It is challenging due to the restricted capacity of each electric vehicle's battery. The concept of utilizing electric cars (EVs) in a bidirectional manner has not been extensively explored due to the limited prevalence of EVs. After conducting study, it was discovered that the secondary market utilizes two-way V2G in the following manners: Emphasizing voltage management and rotating storage is more crucial than reducing the peak load. Spinning reserve is compensated for its availability and the speed at which it can be utilized, unlike peak load reduction. This makes it much easier to integrate electric vehicles into the additional services provided.

Table1.ModesofinteractionbetweenEVandgrid

Features	Unidirectional	Bidirectional
Power Flow	Grid-to-vehicle (G2V)	G2V & vehicle-to-grid
Infrastructure	Communication	Communication bidirectional charger
Cost	Low	High
Complexity	Low	High
Services	Loadprofile management, frequency regulation	Backup power support, frequency regulation, voltage regulation, activepower support
Advantages	Overloading prevention, load levelling, profit maximization, emission minimization	Overloading prevention, profit maximization, emission minimization, renewable energy sources(RES) integration, voltage profile improvement, harmonic filtering
Disadvantages	Limited services	Battery degradation, high complexity and cost social barriers

Voltage control is required over 300 times a day, more frequently than peak load shaving. Peak load shaving occurs for only a few hundred hours annually.

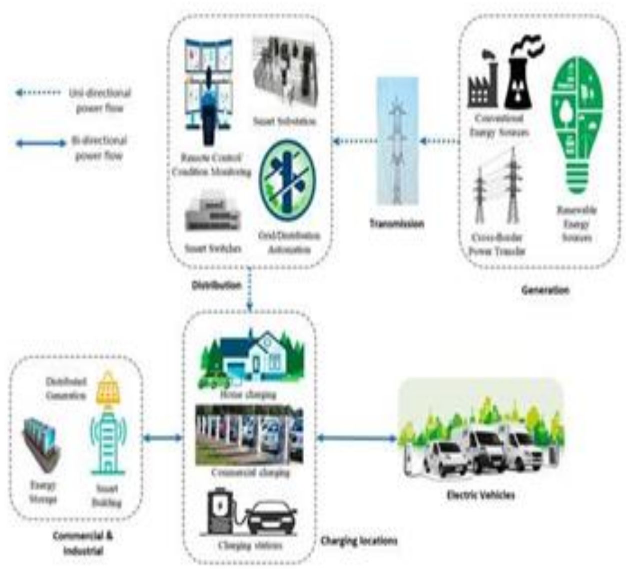

Fig4.EV integration with the electrical grid

3.METHODOLOGIES

The analysis found that several academics have proposed different ways to reduce electric vehicle charging's distribution system load. Several scholars agree that certain elements must be approximated or appraised. SOC, arrival time, disconnection time, battery capacity, efficiency, charger capacity, EV charging time, and energy consumption were constant across tests. These properties are determined using standard equations. The arrival time of an electric vehicle (EV) is when it comes home, whereas the departure time is when it is fully charged and unplugged from the grid. Several experts studied different periods. Some completed it from 6 to 12 A.M., while others from 5 to 11 P.M. Scholarly works specify different time durations, which affects results. An electric battery's capacity-based charge status is "SOC". SOC is usually a percentage.

The charging percentage determines the car's energy consumption, so the charging time and energy rely on its SOC when returned home. According to SOC range, certain people governed the research: 0.2-0.9, 0.2-0.75, and 0.2-0.7. An electric vehicle's SOC represents the battery's maximum and least charged percentages. Each approach must account for SOC_min and SOC_max separately. Parameter distribution is consistent. Data was produced randomly, gathered, or retrieved from reference papers. SOC needed indicates the vehicle's essential charge level. The calculation is:

$$SOC\_Required = SOC\_Final - SOC\_Initial$$

The amount of active material in a battery impacts its charge. Battery capacity is the most energy a battery can store under certain conditions. Battery capacity was determined consistently across several literature sources, depending on vehicle and approach. A battery's efficacy is measured by its energy loss during discharge and recharging. An 80% efficient battery can extract 80kWh every 100kWh input. Its worth was consistent across literature. The vehicle requires energy to operate. Symbolizing the computation:

$$Energy\,Required = SOC\_Required * Battery\,Capacity / Battery\,Efficiency$$

Electric vehicles (EVs) need time to reach their full charging capacity. Symbolizing the computation:

$$\text{Time Required} = \text{Energy Required/Charger Capacity}$$

In their study "A Potential Game Framework for Charging PHEVs in Smart Grid," Shahab Bahrami and Vincent W.S. Wong proposed a potential game structure. Potential games establish a Nash equilibrium due to participants' best reaction choices. The architecture minimizes charging costs and improves grid stability to reach Nash equilibrium. Game participants include PHEVs. D.Q. Oliveira, A.C. Zambroni de Souza, and L.F.N. Delboni offer a charging technique using Artificial Immune networks in their article "Optimal recharge for plug-in hybrid electric vehicles in distribution power networks." This method tries to improve PHEV charging.

A two-stage optimization technique takes into account distribution network limits, grid capacity, and electric car customer preferences. Individual electric vehicle charging schedules are optimized in the initial stage. In contrast, the second stage coordinates electric vehicle charging with distribution network operation to improve grid performance. To reduce greenhouse gas emissions and energy use. In their study "A pricing strategy for electric vehicle charging in residential areas considering the uncertainty of charging time and demand," Shidong Liang, Bingqing Zhu, Jianjia He, Shengxue He, and Minghui Ma propose a two-part tariff pricing system. The method accounts for charging time and demand fluctuations. The authors create a mathematical methodology to enhance pricing.

In "A Coordinated Electric Vehicle Management System for Grid-Support Services in Residential Networks," Mohammad Sohrab Hasan Nizami, M. J. Hossain, and Khizir Mahmud present a distributed algorithm-based system that manages electric vehicle charging and residential load demand to minimize network energy expenditure. Optimising home electric car operations involves considering renewable energy sources, battery deterioration, and power tariff prices. Simulated studies show the system works. Milad Soleimani and MladenKezunovic found that intelligent electric vehicle (EV) charging could reduce transformer failure and related risks. Data collecting on electric vehicle power usage, transformer loading, and voltage levels is followed by correlation analysis, simulation model development, and a discussion of the findings in light of earlier research. Legislators, power utilities, and charging station operators should implement sophisticated EV charging solutions to prevent power distribution transformer failure.

The 'Modeling and Analysis of Electric Vehicle Charging Load in Residential Area' study by Chuangxin Guo, Dongyu Liu, Wei Geng, Chengzhi Zhu, Xueping Wang, and Xiu Cao will collect data on residential electric vehicle charging behaviors using a mathematical model. To assess power grid impact, the model simulates various charging scenarios. Charge management solutions like smart charging and time-of-use pricing affect the charging burden and power system in this study. This study explores domestic electric vehicle charging solutions. Ward Jewell and VisvakumarAravinthan's study 'Controlled Electric Vehicle Charging for Mitigating Impacts on Distribution Assets' includes data collection on EV adoption rates and grid characteristics, distribution grid model development, simulation of uncontrolled EV charging effects, evaluation of diverse controlled charging strategies, economic analysis, techno-economic assessment, regulatory and policy barriers, and application.

Itcanbeperformedontwomethods-:

- Before billing, the number of cars per hour is optimized based on day-ahead invoicing demands.
- The second step calculates the maximum number of vehicles that can be charged in the following hour, taking operating factors into consideration, to meet distribution reliability standards.

Lisa Calearo, Andreas Thingvad, Kenta Suzuki, and Mattia Marinelli propose using surveys and other sources to collect data on actual driving patterns and electric vehicle charging habits in their study "Grid Loading Due to EV Charging Profiles Based on Pseudo-Real Driving Pattern and User Behaviour". Create a semi-realistic driving pattern model from the data. Using a driving pattern model and user behavior data to replicate EV owners' charging profiles, analyze the influence on the electric grid, including peak demand and grid stability. Proposing smart charging and time-of-use techniques to reduce the power grid impact of electric vehicle (EV) charging. Chin Ho Tie, Chin Kim Gan, and Khairul Anwar Ibrahim investigated how electric vehicle charging affected a Selangor, Malaysia, low voltage distribution network.

The Open DSS simulation program modeled a residential LV network, taking cable self- and mutual-impedance into account. A Nissan Leaf case study was used to simulate EV and charging patterns. Power consumption was predicted at 3.3 kW per EV. The following is proposed in the article "Adaptive Electric Vehicle Charging Coordination on Distribution Network" by Lunci Hua, Jia Wang, and Chi Zhou: The capital, D.C.Optimizing according to electricity flow Experiments to Validate the Parallel AC Power Flow Methodology for Incremental Feasibility Improvement As indicated by Maksym Oliinyk, Jaroslav DŽmura, and Daniel Pál in their study "The Impact of Electric Vehicle Charging on the Distribution System": Constructing a fundamental research to simulate the impact on voltage levels Conducting an overloading study of transformers in order to estimate the likelihood of overloading. Methods of control proposed to lessen the impact A case study employing the Slovak Republic to demonstrate its practical use.

T. Simolin, A. Rautiainen, J. Koskela, and P. Jarventausta propose in their article "Control of EV Charging and BESS to Reduce Peak Powers in Domestic Real Estate" the following strategies: calculate available power, manage EV charging and BESS to smooth out power demand, maximize clean energy utilization through the use of renewable energy sources, conduct simulation studies to evaluate efficacy, and analyze the effects of EV adoption. The purpose of the research undertaken by Kristien Clement-Nyns and Edwin Haesen is to examine the impact of Plug-In Hybrid Electric Vehicle charging on a residential distribution grid. The purpose is to offer coordinated charging approaches, utilize stochastic programming methods to calculate the ideal charging schedule for plug-in hybrid electric vehicles (PHEVs), and assess the performance of the suggested strategies.

Table2.EVfeaturesunderanalysis

EV Model	Battery Capacity (kWh)	Charging Power (kW)	Electrical Driving Efficiency (km/kWh)	EV number
Chevrolet Volt	16.00	3.50	3.75	01;06;11;21;26;31;36;41;46
Nissan Leaf	24.00	4.00	6.70	02;07;12;17;22;27;32;37;42;47
BMWi3	22.00	11.00	7.20	03;08;13;18;23;28;33;38;43;48
Tesla S	60.00	11.00	6.70	04;09;14;19;24;29;34;39;44;49
Renault Zoe	22.00	3.50	6.70	05;10;15;20;25;30;35;40;45

The methodologies referenced in various sources possessed specific constraints. In order to maximize the appeal of these vehicles as the truck of choice for consumers, it is imperative that these shortcomings be acknowledged and rectified. Electric vehicles (EVs) are presently indispensable for transportation and, with continued development, have the capacity to emerge as the preeminent option and future of automobiles. It improves vehicle efficiency, substantially reduces expenses, and is a pure fuel with no detrimental environmental impacts. The two-hour journey from Jaipur to Delhi via electric vehicle (EV) bus service costs Rs. 280. This is in stark contrast to alternative modes of transportation, including rail, bus, or vehicle, which require approximately six hours to complete the same distance. In addition to conserving money, electric vehicles also help us preserve time, which is a valuable resource. We must adapt to change; therefore, it is now essential to replace fossil fuel-powered automobiles with electric ones. Uttar Pradesh's chief minister, Yogi Adityanath, has announced that by 2030, all state government cars will be replaced with electric vehicles, representing a significant step forward for EVs in the state. It has been mandated that departments procure electric vehicles through nomination rather than competitive tendering. They may also, if necessary, exceed the utmost limit established for EV purchases.

4. CONCLUSION

This comprehensive review examined electric vehicles (EVs) in all their forms. Critical concepts pertaining to electric vehicles (EVs), including charging stations and the distribution system, were discussed during the debate. Additionally, the effects of charging electric vehicles and the influence of various load categories on the distribution system were examined in the paper. Methods and parameters utilized in a variety of scholarly sources were assessed. The advantages of electric vehicles (EVs) were underscored, placing significant emphasis on their critical significance for the future of transportation. This paper has endowed readers with a comprehensive understanding of the specified concepts, thereby endowing them with a profound familiarity with the pertinent academic domain.

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