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Review on "Energy Management Scheme for Electrical Vehicle Charging Station"

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Abstract: As the adoption of electric vehicles (EVs) continues to grow, the efficient management of energy resources in charging stations becomes imperative. This review paper presents an in-depth analysis of various energy management schemes employed in electrical vehicle charging stations. The primary objective is to investigate and evaluate the existing strategies that optimize the utilization of available energy resources, ensuring reliable and sustainable charging services for EV users.

Index Terms – EV's, Energy management

I. INTRODUCTION

In instances where a large number of electric vehicles (EVs) simultaneously charge without centralized control on the distribution network, the resultant scenario may lead to grid instability and the emergence of new peak loads. The performance of the large-scale charging problem of electric vehicles on the grid is significantly influenced by various factors, including driver behavior (such as driving patterns), weather conditions, electric vehicle battery size, state of charge (SOC), rate of charge (RoC), and other unidentified variables. The integration of grids poses significant challenges in managing the energy demand and economic load control associated with the charging of numerous electric vehicles (EVs). Previous research has demonstrated that optimization is the most effective approach for addressing these types of problems [3,4].

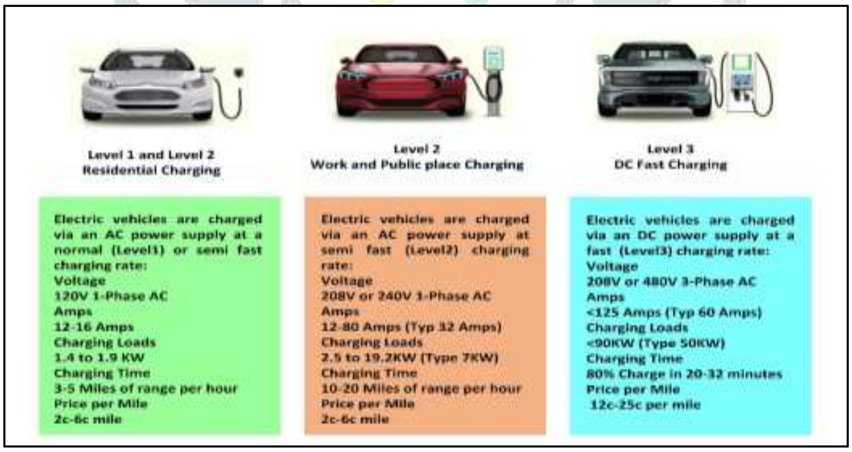

Figure 1: Charging infrastructure for electric vehicles (EVs) [19]

In the field of optimization, various factors of interest are manipulated in order to achieve specific objective functions. For instance, in cases where electric vehicles (EVs) are charged without active monitoring, periods of high demand are prone to exhibit increased energy consumption and potential disruptions in the functioning of the power grid. In the scenario where a substantial number of electric vehicles simultaneously charge without proper control on the distribution network, it would result in grid instability and the attainment of unprecedented peak loads. The efficacy of integrating electric vehicle (EV) charging on a grid at a large scale is heavily influenced by various factors, including driver behaviors such as driving patterns, prevailing weather conditions, the size of the EV battery, the state of charge (SOC) of the battery, and the rate of charge (RoC) applied. Additionally, there exist numerous other unidentified variables that can impact the overall outcome. The reason for this inquiry pertains to the examination of diverse electricity requirements in the context of distributed energy systems. The challenges of grid connection arise in managing the energy consumption and cost load control associated with a significant quantity of electric vehicle chargers. Previous research has demonstrated that optimization is the most effective approach for resolving such problem types [3,4]. During this process, crucial variables are modified in order to achieve specific objectives. During periods of high demand, such as peak hours when a significant number of electric vehicles (EVs) are being charged simultaneously, it is anticipated that the power system will experience increased energy consumption and potential operational challenges.

LITERATURE REVIEW

Efthymiou et al. [5] examined the necessity for European towns to implement extensive electric vehicle charging infrastructure in order to effectively accommodate the increasing demand. Additionally, it was suggested that in order to promote the widespread adoption of electric vehicles and mitigate carbon emissions, strategic placement of charging infrastructure in optimal locations within European urban areas is imperative. In order to address the issue pertaining to the placement of charging equipment, a Genetic Algorithm (GA) was employed.

Elmehdi et al. [6],examined the optimal approach for managing the charging schedule of a significant quantity of electric vehicles (EVs). In this particular scenario, the optimal approach for determining the most effective charging and discharge strategy for a substantial fleet of electric vehicles (EVs) involves the utilisation of a genetic algorithm (GA). One strategy involved the placement of electric vehicles (EVs) at charging stations during periods of reduced electricity costs, such as off-peak hours.

Gampa et al. (2020) [7]proposed a two-stage fuzzy approach for optimal placement of distributed generation (DG), shunt capacitors, and charging points. The initial implementation involved the establishment of DGs (distributed generators) and SCs (substation controllers) through the utilisation of a multi-objective optimisation problem. In the subsequent stage, a multi-objective placement problem was employed. The utilisation of power loss and voltage patterns was employed as a means to address the optimisation problem. Ultimately, the issues were resolved through the utilization of a grasshopper optimization algorithm (GOA).

According to a study (Lee et al., 2020) [8]the prevalence and indispensability of charging stations for battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) are primarily observed in residential settings. An effective communication network is essential for the dissemination of information. Additionally, the implementation of an optimization unit is necessary to minimize the charging time at a charging station. Furthermore, the integration of a prediction unit is crucial to facilitate informed decision-making by the optimization unit.

Clair et al. (2018) [9]Distribution System Operators (DSOs) and Transmission System Operators (TSOs) are required to collaborate with Electric Vehicle (EV) providers in order to deliver technical services. The electric vehicle (EV) broker will serve as an intermediary between individuals who own EVs and are seeking necessary resources, employing market mechanisms, and prospective EV buyers. This agent provides customizable demand packages that are suitable for grid managers and other interested parties. Electric vehicle (EV) owners have the ability to achieve flexibility by adjusting the power of their charging. The electric vehicle (EV) broker has the potential to assist transmission system operators (TSOs) and distribution system operators (DSOs) in effectively managing the electrical grid. Additionally, it can facilitate optimal utilization of energy portfolios for various power partners. In the foreseeable future, Transmission System Operators (TSOs) and Distribution System Operators (DSOs) are expected to employ Demand Response brokers to effectively manage the fluctuating energy demands originating from residential households, commercial enterprises, and industrial sectors within their respective operational domains.
Soares et. al. [10]among other researchers, the electric vehicle (EV) broker will collaborate with Transmission System Operators (TSOs) and Distribution System Operators (DSOs) in order to address technical challenges arising from fluctuations in load. The aforementioned load will be considered due to its rigidity. The organisation collaborates with a diverse range of service providers on a consistent basis in order to address prevalent technological challenges. By incorporating the fixed load into the EV charge load, the EV battery will compensate for the additional power demand. The broker adjusts the charging rate of electric vehicles (EVs) based on the network's requirements. This approach ensures that the process of charging electric vehicles does not exceed the current power supply capacity.

McKenzie et. al. [11] The short-term profitability of electric cars appears to be higher due to their increased utility compared to internal combustion engines (ICEs). However, advocating for their widespread adoption on the road network may have potential negative implications for their long-term profitability. If there were restrictions on the distance that polluted vehicles could travel, the demand for electric cars in the second-hand market would significantly increase compared to its current level.
Li et. al. [12] The global crisis prompted governments worldwide to implement various benefits, thereby stimulating the demand for electric vehicle (EV) chargers in the year 2021. However, the COVID-19 pandemic has presented challenges in the extraction of resources such as steel, copper, and other metals from their respective sources. In the month of May 2021, the price of copper reached a milestone of $10,000 per metric tonne, marking the first occurrence of such a value in a span of ten years. This phenomenon occurred due to the escalating costs of raw materials. However, there has been a noticeable increase in the sales of electric vehicles (EVs) manufactured by leading companies during the previous two years. In response to a decline in sales, Tesla implemented workforce reductions in October 2020. However, the company experienced increased profitability upon its expansion into the Chinese market in previous years. The business exhibited favourable performance in the year 2021, with the exception of the adverse impact caused by the COVID-19 pandemic. In the beginning of 2022, a retail establishment in China ceased operations, resulting in a further decline in sales. Due to global initiatives aimed at phasing out internal combustion engine (ICE) vehicles, the impact of the outbreak on the electric vehicle (EV) industry was mitigated.
Li et al., [13] The reduction in the cost of electric vehicle (EV) batteries, which constitute a significant portion of an EV's overall expenses, has been observed. According to available data, the cost of an electric car battery in 2010 was approximately $1100 per kilowatt-hour. In contrast, the price experienced a decline to a minimum of USD 120 per kilowatt-hour (kWh) in 2021, while

reaching a maximum of USD 137 per kWh in 2020. In China, batteries are available for purchase at a minimum price of $100 per kilowatt-hour (kWh). The declining cost of battery production can be attributed to several factors, including the reduction in wage costs, the decreasing prices of cathode materials, and the increase in production output. It is anticipated that by the year 2030, with the projected reduction in battery costs to approximately USD 60 per kilowatt-hour (kWh), electric vehicles (EVs) will likely become more cost-effective compared to conventional internal combustion engine (ICE) vehicles.

Zhang et. al. [14] Insufficient infrastructure for electric vehicle (EV) charging is observed in several nations. The limited availability of public charging infrastructure for electric vehicles has been identified as a significant deterrent to consumer adoption. Despite ongoing efforts to develop charging infrastructure for electric vehicles (EVs) in various countries, a significant number of states have encountered challenges in establishing an adequate number of charging points. With the increasing proliferation of electric vehicle (EV) charging infrastructure on a global scale, it is anticipated that there will be a corresponding rise in the adoption of EVs. The establishment of such charging networks is still lacking in most countries. The Netherlands boasts the highest density of electric vehicle chargers per 100 miles compared to all other nations. The Netherlands boasts the highest number of charging stations per 100 kilometres, with a range of 19-20 stations. This achievement positions the country as the global leader in terms of charging infrastructure. China ranks second in terms of charging station density, boasting an average of three to four charging stations per 100 kilometres. In light of the United Kingdom's objective to discontinue the sale of internal combustion engine (ICE) vehicles by the year 2030, it is anticipated that a network of three charging stations will be established within every 100-mile radius. Charging infrastructure has been established globally, encompassing countries such as Germany, the United Arab Emirates, Japan, Singapore, South Korea, Sweden, France, the United States, and Russia, with the aim of facilitating the transition to electric vehicles.

Yang et. al. [15]The Asia-Pacific region represents the largest market for electric passenger cars. Europe and North America represent the two largest markets in terms of size and significance. In the Asian region, the primary markets for electric vehicles consist of China, Japan, and South Korea. The governments of these nations exhibit a strong inclination towards promoting the adoption of electric passenger vehicles. Electric vehicle (EV) passenger cars are experiencing a surge in popularity within various European countries, including Germany, France, the Netherlands, Norway, Sweden, and the United Kingdom. Several countries have implemented various incentives, such as handouts, rebates, and other benefits, with the aim of promoting the adoption of electric vehicles. As a result of these sequential measures, the sales of electric vehicles (EVs) in Europe surpassed those in China during the year 2020. In the year 2021, the increasing demand for mini-electric vehicles (EVs) in China resulted in Europe's EV sales surpassing those of China once more. States in the United States and provinces in Canada are leading the way in the process of electrifying North America. The nations situated in the Middle East and North Africa (MENA) region have accelerated the expansion of their electric vehicle (EV) markets, projecting them to exhibit the most rapid rates of growth in the near future.

Shen et. al. [16]China, Japan, and South Korea are among the prominent nations within the Asia-Pacific region that exhibit high sales volumes of electric vehicles. China holds the distinction of being the foremost producer and consumer of electric vehicles (EVs), thereby establishing itself as the preeminent market for this burgeoning industry. The government has implemented several measures to promote the adoption of electric vehicles (EVs). These include providing rebates to individuals purchasing EVs, enacting legislation mandating automakers to produce a certain proportion of electric cars relative to their overall production, allocating significant funds for the establishment of charging infrastructure in major urban areas, and enforcing regulations that restrict excessive vehicle emissions. The market for electric vehicles (EVs) has experienced notable growth in both Japan and South Korea.

Ehrenbergeret. al. [17] The growth of the electric vehicle (EV) industry in these countries has been facilitated by governmental initiatives, which include the establishment of deadlines for drivers to transition from internal combustion engine (ICE) vehicles to fully electric or hybrid EVs, the development of charging infrastructure, and the implementation of emission regulations. India is actively endeavoring to enhance the consumer demand for electric vehicles within the market. As a consequence of the implementation of the new scrappage policy, which permits the disposal of old automobiles in order to accommodate low-emission vehicles, the nation is projected to emerge as the most rapidly expanding electric vehicle (EV) market in the region within the forthcoming years. In addition to Thailand, Indonesia, Malaysia, and Vietnam, these nations are implementing regulations aimed at mitigating vehicular pollution and transitioning towards electric mobility.

Sanguesa et al. [18] The method employed in this study utilizes a dual-coil arrangement based on electromagnetic induction. Subsequently, the charging coil is positioned on the ground, while the receiving coil is situated within the vehicle. Recent advancements in wireless power transfer (WPT) technology have resulted in enhanced convenience and enhanced safety when it comes to charging electric vehicles (EVs). This indicates that electric vehicles (EVs) are experiencing increased prevalence. The charger is capable of being utilized during motion and does not require a conventional connection. Nevertheless, the utilization of standard coupler technology is imperative.

V. CONCLUSION

The rapid increase in uncontrolled charging of large-scale electric vehicles (EVs) presents a complex problem that requires effective solutions beyond traditional optimization methods. The current limited number of EV charging stations is insufficient to meet the growing demand caused by the increasing production and adoption of EVs. This infrastructure capacity deficit leads to congestion control, coordination control, sequential decision-making, economic load dispatch, and high energy consumption cost per capita problems. While large-scale integration of EVs can offer valuable ancillary services and benefits to the electricity grid, simultaneous uncontrolled charging can cause instability, grid fluctuations, and violations of transformer and substation capacities.

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