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A Review on Electric Vehicles and Renewable Energy Synergies in Smart Grid

Susmita Dhar Mukherjee*, Abhishek Dhar, Saurabh Adhikari, Rituparna Mukherjee, Suvraujjal Dutta and Promit Kumar Saha

Department of Electrical Engineering, Swami Vivekananda University, Kolkata – 700121, West Bengal, India; susmitadm@svu.ac.in

Abstract

The environment and the world's energy system currently face formidable obstacles. Energy usage is more environmentally friendly in the context of the energy internet as transportation fleets switch to electric, plug-in, and fuel-cell vehicles. To guarantee energy security, avoid air pollution, and encourage energy conservation and emission reduction, the smart grid's electric car, and renewable energy synergies are of utmost importance. The combination of renewable energy and electric vehicles, however, is fraught with difficulties because of the randomness, intermittent nature, and electrical nature of renewable energy. This article first illustrates the smart grid design and the relationship between electric vehicles and renewable energy sources. The effects of electric vehicles and the growth of renewable energy sources are then examined, and the main techniques, such as smart charging, coordinated scheduling, and energy management, are investigated based on the problem. Additionally, synergy effects on the economy and environment are studied. After discussing the current development issues, a brief overview of the prospects for renewable energy and electric vehicles is provided..

Keywords: *Electric Vehicle, Energy Internet, Renewable Energy Source, Smart Grid*

1.0 Introduction

Due to the greenhouse gases released by the use of fossil fuels, the world's energy system and ecosystem are currently facing enormous problems. Due to its potential to lower emissions, boost the use of Renewable Energy Sources (RESs), and reduce fuel consumption, Electric Vehicles (EVs) are growing in popularity. Five million EVs will be sold in China by 2020, and more than 30 million will be sold worldwide[1].With the advancement of EVs, the demand for charging will dramatically rise. Since 75% to 80% of the electricity in our nation is produced by burning coal, the carbon emissions of electric vehicles that are charged via the grid are equal to those of conventional fuel vehicles[2]. The best strategy to minimise carbon will therefore be to increase the use of renewable energy sources in the grid emissions. Currently, renewable energy sources include biomass, solar, wind, and other sources. The limitations of nature, energy density, development costs, technical level, and power generating efficiency, among other factors, make the use of wind and solar energy for charging electric vehicles more practical. Energy use will switch to renewable energy sources, the transportation fleet will switch to electric vehicles, and the internet technology will be used to revolutionize the power grid with the introduction of Energy Internet in combination with new energy technology and information technology. The synergy of EVs and RESs will be encouraged by a smart grid architecture[3].

**Author for correspondence*

2.0 Smart Grid

The addition of EVs gradually resulted in the formation of a new smart grid. When EVs are taken into account as a load, optimal charging can be accomplished using technical and economical techniques to schedule charging time, allowing for peak-load shifting, increasing system efficiency, and minimizing the impact on grid security. When considered as distributed energy storage units, EVs are able to contribute electricity to the grid, enhancing the power system's safety and dependability. V2G technology allows for two-way communication between the grid and EVs. In comparison to the conventional grid, the smart grid applies significant amounts of distributed generation that uses RESs as fuel. These generations struggle to manage the load due to the intermittent nature of distributed energy sources like solar and wind energy. Smart grid adjustments are necessary. Figure 1 depicts the smart grid's architectural layout. AMI is a piece of electronic equipment that can record and gather real-time data on consumer electricity use[4]. HANs serve as the functional entity that permits message transfers with home display devices and access to metering equipment[5]. Users' ability to actively interact with the electrical grid is one of the key characteristics of the smart grid. Users can use AMI to acquire power usage and costs to choose how to charge their electric vehicles, which helps EVs and RESs work together more efficiently.

2.1 Key Technical Issues

The viability and utility of combining EVs and RESs were extensively researched. Electric vehicle charging is given a strong boost by the availability of abundant renewable energy. Reference [5] examined the combined manner and adaptability of RES and EV charging and discharging facilities. They conclude that it is possible to provide the microgrid with the ideal configuration for fusing RESs and EVs. The integrated system's use in microgrids will enable the synergy effect, a win-win outcome. However, due to the intermittent and erratic nature of RESs, numerous issues, including power grid voltage deviation, frequency deviation, harmonic injection, voltage fluctuation, and flicker, would arise when they are all included into the grid at once. The effects of using PV arrays to charge EVs were covered in reference [6]. The findings indicate that PV can only temporarily match the demand for electric car charging. In reference [7], it was suggested that charging stations may use energy storage systems to store excess electricity produced by renewable energy sources so that consumers could continue to receive electricity even when there was not enough generation. Intermittency of renewable energy can be reduced thanks to energy storage technologies, but doing so will require significant investment, delaying the timeline for RESs. By creating intelligent charging, synergistic dispatch, and energy management technologies, the smart grid will lessen the impact that EVs and RESs have on the system. Intelligent

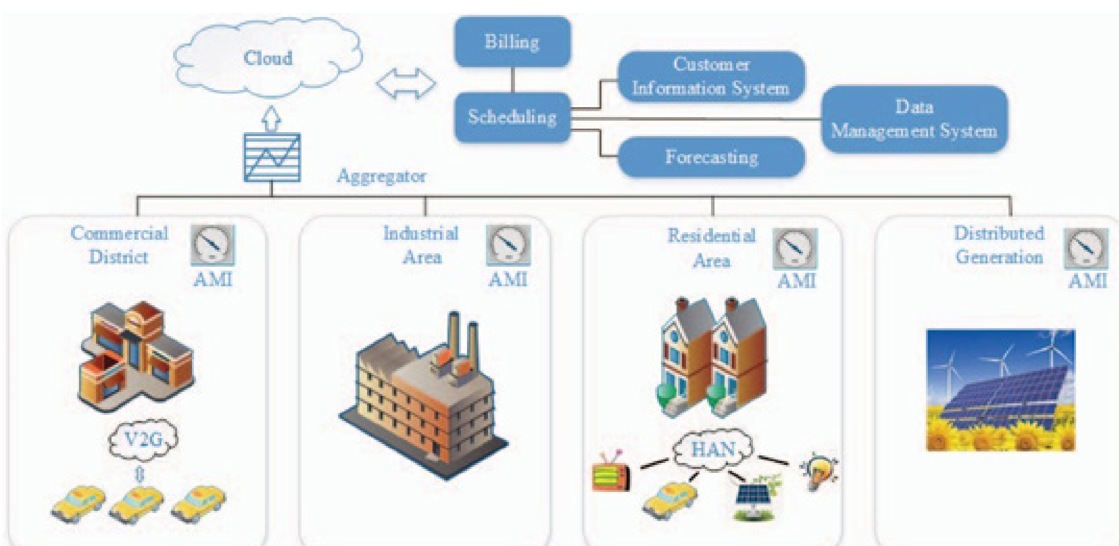

Figure 1. Smart grid architecture.

charging technology. The charging duration and speed are adjusted using intelligent charging technology in accordance with the power supply [8] offers a design for a solar-powered home EV charging station. The authors provide different EV charging control topologies and arrive at the best charging method. In [9], a case was examined. The intermittency problem with renewable energy sources may be resolved using V2G technology, and the results show that intelligent charging technology can effectively reduce the fluctuation issue in the distributed grid brought on by the production of renewable energy. Investigated in [10] are the charging characteristics of EVs and the utilisation status of RESs. Heuristics were used to create an intelligent charging model and lessen the power system's exposure to load instability. The intelligent charging techniques suggested in [10–12] can decrease. In order to reduce the grid-connected wind power's cost of recharging and to maximise the financial gains of EV owners and power companies, policymakers should consider how EVs and RESs interact.

2.1.1 Synergistic Dispatch Technology

When large-scale EVs and RESs connect to the grid, the traditional centralized control is replaced by distributed control. The ability of the power system to respond is faced with additional obstacles due to the erratic charging habits of consumers and the intermittent nature of renewable energy sources. Investigating the synergistic dispatch concerns of EV and RES generation is therefore required. The impact of EVs and solar systems on the demand for electricity was examined in [13]. According to the findings, PV diffusion reduces the grid's overall electrical load by 19.7%. The generated energy from other conventional energy sources can be decreased by the coordinated dispatch of EVs and RESs[14]. explored coordinated energy dispatching in microgrids with wind power generation and EVs. The results show how energy dispatch based on interruptible and variable-rate energy dispatching can achieve better matching between power generation and needs. Grid-connected EVs, wind, and solar energy were all taken into account at once in [15] while setting up a multi-objective coordinated scheduling model. The output volatility of RESs can be efficiently controlled by scheduling the charging and discharging period in a way that benefits both the user and the device.

2.1.2 Energy Management Technology

According to a proposal made in [16], a programmable V2G energy management system might boost the income of providers and owners of EVs while reducing the intermittent nature of solar energy. Described in [17] is a smart charging station. The EV charging is managed so that charging during peak load times has no noticeable effect on the grid. Grid-connected photovoltaic generation, the utility, or both provide the power necessary to charge plug-in hybrid vehicles. In order to maximize the use of available electricity and maintain grid stability, there is a three-way interaction between the grid, EVs, and solar power.

The advancement of the technologies stated above can better match the load and power fluctuation of RESs generation, increase equivalent load rate, and lessen the impact of intermittent RESs.

3.0 Benefit Analysis

3.1 Ecological Benefits

The most efficient strategy to cut emissions will be to charge EVs with RESs because the traditional grid generates the majority of its energy through the combustion of coal. In [18], the carbon emissions of EV charging stations powered by solar energy at work were investigated. According to the findings, solar-powered EV charging can save carbon emissions by 0.6 tonnes per car year, or by 55% less than charging at home at night. Another 0.36 tonnes of CO_2 will be saved if the EVs and PV are dispatched using the best control tactics.

3.2 Economic Benefit

Many researches also focus on the economic benefits for charging providers, EV owners, and power grid businesses. The synergy of EVs with RESs can reduce carbon emissions, which benefits the environment. The cost of operation for charging providers has an impact on the development of EVs and RESs. The Unit Commitment (UC) problem can be used to model the operational costs of the electricity system. The following are examples of UC problems:

$$OC = \sum_{i=1}^{N}\sum_{t=1}^{T}[FC_{it}(P_{it}) + MC_{it}(P_{it})] + ST_{it} + SD_{it} \quad (1)$$

Where OC is the cost of operating the system, FCit(Pit) is the cost of fuel, MCit(Pit) is the cost of maintenance, STit is the cost of starting, and SDit is the cost of shutdown. The operation cost of the system is assessed in [19–21] taking into account the sporadic nature of solar and wind energy as well as the randomization of EVs as load, energy storage, and energy sources. The cost of operation can be reduced. with the grid, RESs, and EVs all working together. The charging cost is what motivates EV owners to charge their vehicles with RESs. EVs can be controlled loads when charging and discharging. Owners of EVs can save 91.6% on charging fees if we can manage their charging behaviour, causing them to be discharged at high electricity prices and charged at low ones[22]. For power grid businesses, producing costs, total life cycle costs, and transmission costs are of particular importance. Energy use and storage costs will go down as EV and RES penetration increases. 20% of the cost of overall generating may be saved[23].

4.0 Conclusion and Prospect

This study reviews and analyses the grid impact, important technologies, economic, and environmental benefits. In the upcoming work, we still need to enhance the performance of the current technologies. The algorithm optimization of control scheduling Most scientists focus on investigating charge control strategies, coordinated dispatch, and energy management using optimisation algorithms. However, the soft computing approach has several flaws, like the EV and RES's insufficient penetration. The control rules algorithm can become very complex and take a very long time to run when there are a lot of sources and EVs.

These problems need to be solved in the future. The utilization of EV batteries to store the extra power produced by RESs and release it to earn revenue when the grid is underutilized, EVs can be thought of as distributed energy storage units. The method described above will, however, result in more battery charging and draining cycles. As is well known, the Li battery's capacity will reach with an increase in charging and discharging cycles, the effect was considerably reduced. Therefore, it is necessary to conduct further research on extending battery life and to present a strategy that balances profitability and battery life.

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