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Load Management Strategies of Electric Vehicle Charging Station

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ABSTRACT

Load management of electric vehicle charging stations (EVCS) plays a crucial role in the development of electric vehicle charging infrastructure, as global environmental pollution is drastically increasing electric vehicles (EVs) penetration into the market. Although EVs are pollution free, consumers are affected due to low charging facilities, long periods of charging time,rapid changes in peak load demand. and voltage fluctuations. These problems make EVs less efficient. In this paper, we present load management strategies for charging stations that offer battery swapping models, energy storage systems, queuing-models, and multi-objective optimization so that we can design a charging station with a minimum charging time, charging cost, and more efficient.

Keywords: electric vehicles, charging station, load management strategies, electricity demand, power consumption, demand response, load management, charge points.

1. Main text

Electric vehicles (EVs) offer a sustainable transportation option. EVs produce comparatively little air pollution compared to cars with combustion engines. The environmental advantages of EV use can be increased if the power supply is sourced from sustainable sources [1]. Increasing demand for electric vehicles contributes to more significant electricity consumption. The US Energy Information Administration states that world energy consumption will grow by almost 50% between 2018 and 2050. As an important part of renewable energy utilisation and smart distribution, the increasing penetration of electric vehicles (EVs) and battery swapping stations (BSS) accounts for the rapid growth in load demand.

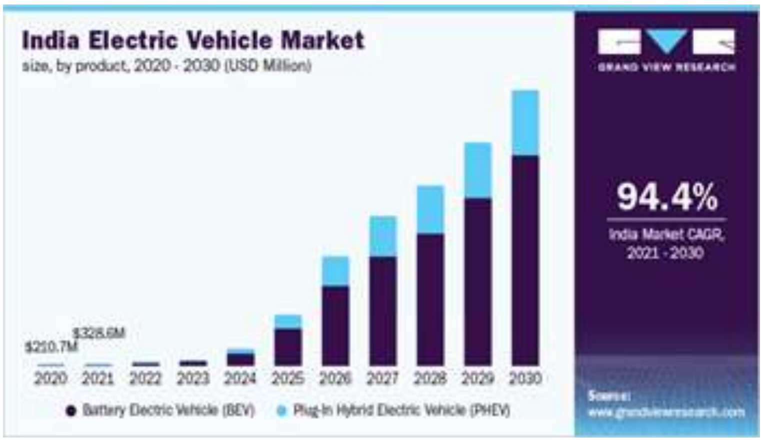

Fig. 1. India EV market

As the demand for electric vehicles rises, the power grid must contend with new issues like uneven power distribution, a lack of charging stations, higher construction costs, longer charging times even when charging stations are already in place, and voltage fluctuations, which occur when energy from the distribution network does not reach the consumer's device in a timely manner [2] [3]. Since there would be less demand for EVs as a result of these issues, it is crucial to build a charging infrastructure and distribution system. Load management is necessary to distribute the EV charging load and prevent the power system from overloading during peak hours. We should follow some load management strategies to reduce the above mentioned challenges like battery swapping model, energy storage system and queuing-model [2][3][4].

2. Literature review

An electric vehicle uses a battery to store electrical energy. It includes a charging station and a distribution network The energy demand is affected by a variety of factors, including the number of hours in the day, the days of the week, holidays, seasons, and locations, as well as the weather. Electricity demand levels are the foundation for electricity supply. When there is plenty of electricity available because demand is low. When demand for electricity peaks, there is not enough supply and the cost of electricity rises. EV To accommodate consumer demand, manufacturers create cars with larger battery capacities. Client requirements. These elements contribute to the requirement for additional charges. The stations put on the property to meet demand even at peak times. Load management attempts to avoid the peak in electricity consumption by effectively allocating capacity to the charging stations. It offers the opportunity to add more electric vehicle charging stations without increasing the charging station connection capacity.

Fig. 2. EV charging Station

3. Queuing-model

Each charging station provides three charging options in a queue.

1) Fast DC charging
2) Charging at AC Level 2
3) Battery swapping options.

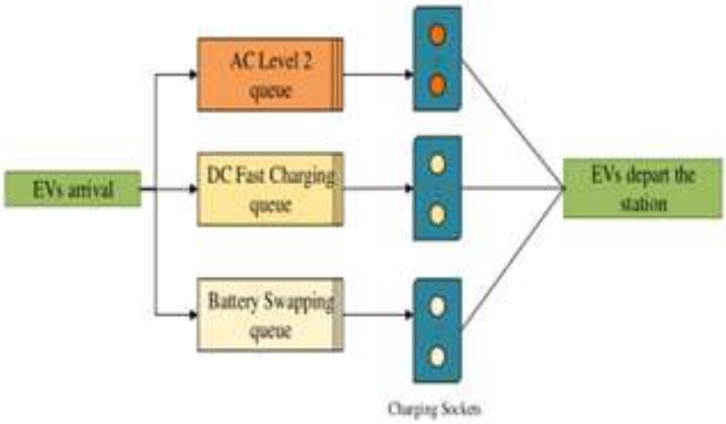

Fig. 3. Queuing Model

The overall journey time is dependent on the distance to the charging station, the length of time spent in line for the selected charging method, the service/charging time, and the distance to the final destination [2][3]. When a vehicle approaches a charging station, there are three stages it might go through: quick DC charging, AC conversion, and another procedure called battery switching or battery exchanging. This model is more efficient due to three-level charging and longer travel time. The disadvantage is the charging process takes longer.

4. Battery Swapping

It is utilised to provide details on reduced lithium levels of charging power based on the needs of electric vehicles [3]. It is necessary to switch batteries when a battery has to be changed, repaired, or when a power source is overloaded in order to prevent interference with the electric vehicle power distribution model's charging infrastructure [2]. When a vehicle enters a charging station, information about the electric vehicle's charging needs is abstracted and sent to the distribution network, which then distributes the needed energy to the appropriate location [4]. This information explains how to distribute energy to various loads using power supplied by the power system and microgrid. Due to the fact that the needed load was met without any deviations, the performance of the electric car was unaffected. The disadvantage is the weight of the extra battery.

Fig. 4. Battery Swapping

Manual: Batteries are manually inserted and removed from the separate slots in the battery swapping station, which is a stand-alone machine. Manual changing stations are modular and take up very little room. These are utilised in applications requiring 2W and 3W batteries since they have smaller battery packs and can be lifted by one or two people [7].

Autonomous: These battery replacement facilities employ a robotic arm, and the procedure is partially or entirely automated. For 4Watt and e-bus applications, robotic swapping is required because the battery packs are larger and heavier and need mechanical help. These exchanging stations are also more expensive and take up more space [7]. The advantages of battery swapping are Recharging an EV takes only a few minutes. Batteries can be charged remotely from the swapping point, giving facility designers more flexibility. EVs will cost less up front since battery leasing will replace battery ownership. Improves battery life predictability owing to controlled charging conditions Even so, there are some barriers Because EV battery standards are not uniform for the same number of EVs, more batteries are required.

5. Energy storage system

It helps to lessen the negative impacts of electric vehicle fast charging and also increases economic effectiveness. Electric vehicle characteristics are utilised to determine the power and charging requirements, and a driving probability configuration model is used to evaluate the investment cost, maintenance cost, and discharging benefits. When a distribution system fault occurs, an energy storage system ensures that the charging station is unaffected [9]. There are fewer power fluctuations and no energy shortages at charging stations. The disadvantage is that, when compared to not having an energy storage system, the cost of charging is higher.

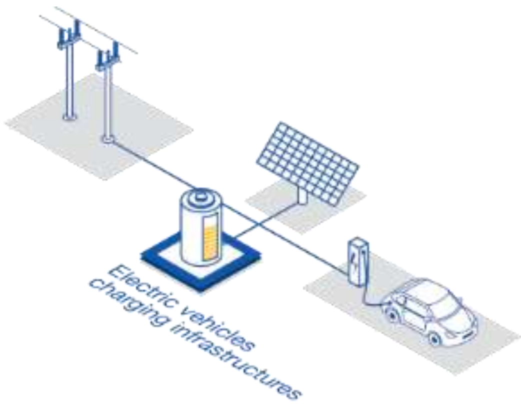

Fig. 5. EV charging infrastructure

6. Markov decision process

Markov decision process (MDP) will develop a control strategy that eliminates the conventional problem of immediate recharging of energy storage units after each electric vehicle charge by setting a target state of charge (SOC) level. This maximizes the use of photovoltaic power for electric vehicle charging and minimizes the impact on the grid [5] [6]. The energy management system aims at minimizing the peak load demand on the grid and maximizing the energy generation for electric vehicle charging. The control strategy is implemented through the Markov decision process for identifying the operation of the system and projecting the future requirements of the charging station [5], and the battery optimal charging strategy This method is applied as the previous information of the vehicle when it is charged by considering its present energy requirement. If the vehicle is charged, then the charging requirement information is stored and shared throughout all locations and distribution network [6]. This process reduces global costs and improves battery performance. The disadvantage is that this strategy only concentrates on one issue until it is totally resolved, which could affect how well the load is distributed overall.

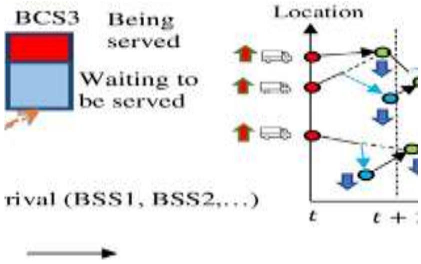

Fig. 6. Markov decision process

7. Results and Discussion:

In this paper, load management strategies of electric vehicle charging stations are studied. The purpose of load management is to reduce the effects of unbalanced power distribution, low charging facilities, and long charging times. To reduce these effects, we are using several methods first. The queuing –model is used to make charging infrastructure more efficient, but the long process charging time is too long. Second, there is a battery-swappable model. The new battery is replaced when the battery is discharged, so charging will be fast, but the only disadvantage is that EV battery standards are not uniform. For the same number of EVs, more batteries are required. Third, Markov decision process. In this process, the vehicle information is stored at the distribution network and charging station so that charging will be fast but it is not very efficient. Finally, in my opinion, out of all these methods, the battery swapping system is the most effective and has the fewest drawbacks, but when an extra battery is carried, more load is applied, which could reduce speed. Therefore, if a battery of low capacity is designed, this will help to boost sales of electric vehicles. Each method has some disadvantages. If there was further research on fast charging, low cost, and long travel time, then demand for electric vehicle consumption would be increased.

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