Smart Charging Stations for Vehicles

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ABSTRACT: The charging methods for plug-in hybrid electric vehicles (PHEVs) as part of the energy system are investigated in this article. When the total charging power at each workplace is subject to severe restrictions imposed by the energy grid, the goal was to improve the aggregate all-electric mileage (total distance travelled using just the traction batteries in each PHEV). Different input factors, such as state-of-charge, battery size, trip distance, and parking duration, were evaluated in order to distribute this power optimally. A new agent-based model that explains the spatiotemporal movement of individual PHEVs was used to create the necessary vehicle mobility. The findings indicate that, in the instance of Helsinki (Finland), clever management methods may result in a 5 percent improvement in all-electric mileage when compared to no control. The advantages of smart charging diminish away when the forecast error is significant, or when the battery is especially tiny or big. When applied to the optimum distribution of limited charging power amongst the vehicles in a vehicle fleet, smart PHEV charging methods seem to offer just a small improvement in all-electric range. Thus, a simple charging approach based on equitably distributing electricity to PHEVs may be adequate. This discovery may be significant for smart grid design in the future, since grid limitations may necessitate restricting the charging power of bigger PHEV fleets.

KEYWORDS: Electric Vehicles, Charging Stations, Public Charging Infrastructure, AC Charging, DC Charging.

INTRODUCTION

E-mobility is quickly becoming one of the most efficient modes of transportation since it produces zero emissions and does not need the use of fossil fuels. Cleaner, greener transportation will also assist to decrease CO2 emissions in the atmosphere and therefore global warming. However, one of the most important goals in order to accelerate the growth of e-mobility is to improve power generation and management. The charging techniques and infrastructure are the most important demands of electric vehicles.[1]–[3] Most individuals like to charge their car first thing in the morning as part of their regular routine. Charging stations are more likely to be found near their homes or at their workplaces. Aside from that, charging stations in public areas will be quite popular. The time it takes for the cars to charge is also a significant factor. The majority of individuals do not want to stop for 2-3 hrs to charge their cars. As a result, charging station techniques will need to be deployed in an organised way so that people may charge in the shortest time feasible.

In intercity circumstances, charging demand will almost always be extremely high. As a result, delivering optimal power to all stations at a rapid pace is a difficult job. Although demand may not be as strong on the outskirts of the city as it is in the city centre, implementation of the public charging interface at such places must be done with great care. The creation of Charging Structure Infrastructure is one of the three key components responsible for speeding up EV adoption. Figure 1 depicts a conceptual path for electric vehicle development. It shows that there will be a variety of changing stations.[4], [5]

ELECTRIC VEHICLE CHARGING STATIONS

The charging infrastructure is the most essential component of EV transportation. The platform that provides energy to the vehicle's battery in order for it to remain mobile on the road. The charging stations may take many different forms, such as wall charging, grid charging, and so on. It also allows for effective communication between the vehicle and the platform, allowing for a two-way communication connection to be established.

Residential charge is the most frequent term for this kind of charging. The solar panel placed on the house grounds provides the majority of the power for the home private charging facility. The car may be charged using a single phase 230V/15A socket with a maximum power of 2.5KW. The billing system is linked to the home-metering system.For the home charging facility, a separate EV Charging policy has been established. Public Charging: For charging outside the house, EV Charging Stations are either directly connected to the grid network or powered by a separate PV solar panel system. They're particularly prevalent in locations like retail malls, movie theatres, and office buildings.[6], [7]

Load Management at Charging Stations

NREL is also looking at ways to reduce the power system's effect from shared, autonomous EV charging. Researchers are developing distributed control systems for controlling the energy loads of EV-charging station clusters using consensus-based power-allocation algorithms. Charging stations in the same cluster interact with one another using consensus-based algorithms to achieve optimum power sharing and reduce peak demand on the power transmission bus.

Electric vehicles may be charged in one of two ways: AC or DC.

AC Charging: This kind of charging is designed for charging stations that are located across long distances, particularly along highways. An EVSE (Electric Car Supply Unit) converts AC electricity into DC current and provides it to the vehicle. A 15 Amp socket is used for charging in vehicles like the Mahindra E2O and E2O+.

1) Standard AC Charging: Two-wheelers and four-wheelers use this kind of charging facility, which has a charging rate of 2.5kW to 3kW. Charging period for this kind of vehicle may take up to two hours for bigger cars and an hour for lighter duty vehicles.

2) AC Fast Charging: The charging rate for this kind is usually between 7kW and 22kW. With a boost mode, the quicker option just reduces the charging time. DC (Fast) Charging: The main way of charging is to charge the car battery directly via the DC Charger connector. For heavy-duty trucks, the charging capacity may range from 10kW to 50kW or even more.The voltage rating at which DC charging takes place is usually between 48 and 72 volts. Dc Charging is available in Indian electric cars like as the Mahindra e2o, e-Verito, and Nissan Leaf.[8]

1) Level 1: Have a 48V to 72V output voltage, a minimum current of 200Amp, and a power output of 10kW to 15kW.

2) Level 2: DC Fast Charging is a voltage level that serves up to 1000V and has a power output range of 30kW to 150kW.[9], [10].

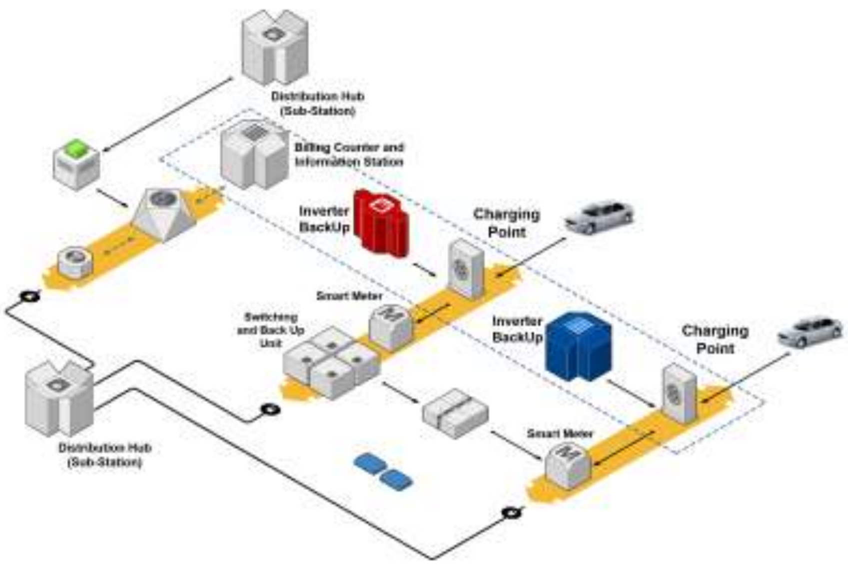

Figure 1: Smart Charging Stations for Vehicles

DISCUSSION

Smart charging is safer since smart gadgets verify the connection between the vehicle and the device before beginning the charging process. If there are many charging stations on the same site, dynamic load management may improve safety. If necessary, charging events may be halted remotely. Connecting the charging device to a charging service, which automatically gathers consumption statistics, may resolve neighbourly disagreements over your increasing energy use. EV owners are directly invoiced for charging expenses in this manner. To assist corporate vehicle drivers, the service may automatically report the expenses of both pubic and residential charging to the employer. Timing may be improved using smart charging depending on the pricing at the local energy market, such as Nord Pool Spot. As prices reflect energy demand, this saves money while simultaneously benefiting the environment and the electrical system. EV charging balances the supply and demand of energy and reduces the requirement for electricity production via charging time optimization.It helps in reducing the noise pollution. Figure 1: Smart Charging Stations for Vehicles Figure 2: Smart Charging of Vehicles

Figure 2: Smart Charging of Vehicles

Smart EV charging or intelligent charging refers to a system where an electric vehicle and a charging device share a data connection, and the charging device shares a data connection with a charging operator. As opposed to traditional (or dumb) charging devices that aren't connected to the cloud, smart charging allows the charging station owner to monitor, manage, and restrict the use of their devices remotely to optimize energy consumption. With cloud-based solutions, only sky is the limit (pun intended). Smart EV charging service can be modified: it is effortless to add and remove features and create a system that suits your needs. New features can also be added and updated to existing charging stations. This is why smart EV charging is also future-proof. Changing demands and hopes will be turned into new features, and added into the smart system as the world keeps changing. Electric cars connected to the grid with smart charging create a symbiosis with the power grid, they support each other. Without smart charging, this connection wouldn't exist and EVs could become a burden on the grid. Psst! We recently worked with Eurelectric and BBC StoryWorks Commercial Productions to put together this handy video that illustrates how smart charging works.

The transportation sector of the world is in the transformation stage, shifting from conventional fossil fuel-powered vehicles to zero or ultra-low tailpipe emission vehicles. To support this transformation, a proper charging station (CS) infrastructure in combination with information technology, smart distributed energy generating units, and favorable government policies are required. The motive of this paper is to address the key aspects to be taken care of while planning for the charging station infrastructure for electric vehicles. The paper also provides major indagation and developments in planning and technological aspects that are going on for the enhancement of the design and efficient management of charging station infrastructure. The paper addresses the present scenario of India related to electric vehicle charging station developments. The paper specially provides a critical review on the research and developments in the charging station infrastructure, the problems associated with it, and the efforts that are going on for its standardization to help the researchers address the problems.

In the present scenario, global warming and climate change are the major concerns that can severely affect the environment and life on earth [1]. Greenhouse gases (GHGs) are the prime factors that are responsible for climate change [2,3]. Air pollution and GHG emissions from the fossil fuel-based transportation sector in recent years have received the greatest ever attention, especially in large, dense cities [4–6]. Globally, in 2016, 7.87 billion tonnes of carbon dioxide-equivalents of GHG emissions were from the transportation sector [7] and it increased to 8.04 billion tonnes of carbon dioxide-equivalents of GHG emission in the year 2017. According to an estimate, 24 percent of the world's CO2 emissions are due to the transportation sector in which 3/4th of these emissions account for road transportation [8]. In India, 291 Mt of CO2 equivalent emission was from the transportation sector in the year 2017 [8] and it accounts for 18% of total energy consumption [9]. The use of electric vehicles plays an important role in improving the traffic and helps in maintaining a healthier living environment by zero or ultra-low tailpipe emissions and much lower noise [10–13]. Thus, the global automotive industry is shifting towards zero-emission vehicles [14,15]. In 2019, globally, almost 4.8 million battery electric vehicles (BEV) were in use and about 1.5 million new BEVs were added to the worldwide fleet [16]. The development of an electric vehicle charging station and its optimal location is very important for easier adoption of electrically-propelled vehicles and the use of cheap and clean electrical energy from grid and renewable energy resources [17,18]. A proper charging station network will help in alleviating the range anxiety of owners of electric vehicles (EVs), assuring the similar performance of EVs compared to that of the internal combustion engine vehicles [12,19]. To lay more emphasis on continuous improvement in recharging technology, the share of electric vehicles in the market must be increased. The present problem with the adoption of EVs can be related to the "chicken or egg" theory [20]. The consumers are waiting for proper charging infrastructure to get full assurance of successful trip completion with no or minimum delay in charging time. Moreover, the investors of charging infrastructure are waiting for enough EVs on the road to make the business profitable. The stakeholders also differ in opinion on the choice between fast charging or smart charging (SC) for EV charging stations [21]. To solve all these issues, government policies also play a very important role. Another important factor that plays an important role in the adoption of EVs is the lack of suitable batteries that can deliver a sufficient amount of energy for a longer duration of time to enhance the range of EVs [22,23]. At present, the transportation sector is going through three revolutions, i.e., autonomous driving, shared mobility, and electrification [24].

So, when planning for the charging infrastructure for the electric vehicles, it is crucial to take into account the synergies and potential interactions among these three emerging revolutions. With the increase in the adoption of electric vehicles, a new emerging significant electrical load is introduced to the power grid, which will require changes in the infrastructure [25]. The transfer of electrical energy is done only via the distribution grid, which limits the energy that is flowing in the transmission lines [26]. The large-scale reconstruction of the distributions grid to meet the EV's charging requirement is difficult. It is crucial to accurately assess the possible impacts of large grid-connected renewable energy generation (REG) system and electric vehicle charging stations (EVCS) on the network performance. Such analysis will help the power utilities to become efficiently equipped so that the potential operational issues can be solved [27]. Figure 1 describes the basic charging infrastructure for the electric vehicles with the level of charging at each charging station [28]. Figure 2 shows the charging infrastructure for EVs with different charging station configuration. According to a study in [29], which was done on owners of battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV), residential charging is found to be the most important and most frequently used location. The major challenges in developing an efficient charging infrastructure are to have an effective communication network for information exchange, an optimization unit to reduce the charging time at the charging station, and a prediction unit to help the optimization unit to make the best possible decision [30].

CONCLUSION

We developed a smart charging technique for a PEV network in this study, which provides several charging possibilities at charging stations. Charging stations, like regular petrol stations, can have several capacities and pricing options, and the recharge price for each option might vary from one station to the next. In such a circumstance, it is critical to implement a charging strategy that finds the most appropriate charging station for a PEV user, allowing the user to recharge for the least amount of money while still arriving at his or her destination on time. The research problem was represented as a multi-objective optimization problem with the goal of lowering charging time, trip time, and charging cost. To estimate the latency at various charging stations, we employed a queuing model. We also added the concept of partial charging to address the issue of lengthier charging durations and potential overlap between peak PEV and residential demand periods. We demonstrated how pricing could be utilised as a motivator for PEV drivers to choose partial charging during high load hours. We solved the study topic by presenting an ACO-based meta-heuristic approach due to the optimization solution's high temporal complexity. The simulation results show that the proposed technique reduces the average charging latency (by up to 25%) and cost significantly (up to 15 percent). In the future, we'll look into the best dynamic pricing model for minimising the overlap between peak PEV and residential usage.

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