Charging infrastructure strategies for roll-out into electric vehicle segment on larger scale in urban areas

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ABSTRACT

In the view of all-encompassing introduction to electric vehicles, policy makers need to take a call on how to build charging infrastructure to match up to demand . The authorities need to decide, design for the charging operational tactics to be followed. The questions need to be answered regarding how many stations, where , which type , capacity be installed. Early developments for roll-out in metro cities is quite promising , while the need for large-scale roll out in urban areas need to be yet answered. The date regarding the rate of charging, charger performance place a major roll while designing the clustered charging hubs. This paper puts an effort to explore the changes which can be brought in to charging infrastructure to solve the peak loading at service stations of urban area. The proposed solution is based on traveling pattern of urban cars. Two distinct ideas which can solve the infrastructure problems are proposed through this paper.

Keywords: electric vehicle ,charging station infrastructure, EV charging Station design ,urban area smart charging

1. Introduction

The major concern in today's scenario is , how to reduce the carbon emission to bring down the global temperature and impact it as on human and other living organism on the earth surface [1]. Carbon emission from I.C.Engine run vehicles is one of the major contributor to Greenhouse gases bringing in climate changes [2,3]. Air pollution levels in densely populated or metro cities are of major concern caused by petroleum based emission of transportation sector as received the greater attention these days [4–6]. Globally, the major source of carbon dioxide- emission is from transportation sector [7] 24-25 percent of the world's CO2 emissions is due to vehicle transportation sector [8]. The shift from traditional petroleum based engines to electric vehicles leads to reduced pollution , increasing health of humans , lesser noise and increasing economics for country like India [9–13]. Thus, the main focus of global automotive segment is moving towards zero-polluting vehicles [14,15]. 2019 onward the increase in electric vehicle globally is exponential [16]. The increase in use age of electrical vehicle pose challenge of developing and maintain of electric charging station, optimizing its location and developing grids [17,18]. The focus need to be on integrating the power grids of renewable and non-renewable sources and also improve the performance of electrical vehicles to match to performance of internal combustion engine vehicles [19,20]. The major concern for general public to switch over to electric vehicles is lack of safety, performance and charging stations and infrastructure, similarly the investors are waiting for increase in vehicles to make business profitable. The public is quite confused regarding choosing between EV or IC engines [21]. To resolve the public concerns, government should step in through policies. There is need for more research and development for improving life of batteries for making EVs attractive [22,23]. Today, the automobile sector is focusing on three different aspects like creation of automatic driven vehicles, self balanced vehicle and electrification of vehicles [24]. So, we need to focus on delivering on the above area of interest while planning for infrastructure for charging station . With increase in number of electric charging stations , load on current grid system increases which need to be addressed or changes need to be brought in to accompy increase in load on grid system otherwise it will lead to power shortage for other domestic requirement like agriculture [25,26]. The changes needed for grid system to meet to demand is largely difficult without integration of conventional power from coal based plants is clubbed with relievable non-conventional resources like solar , it can be presumed such a combination can solve the power shortage problem for large extent [27,].

This paper focuses on designing strategies for large scale roll-out of electric vehicle and infrastructure required for deployment of charging stations . This paper also puts light on need for generation of integrated grid systems empowered renewable energy sources and improving grid flexibility. The problems arising due to fossil fuel run vehicles , its impact on environment and roll out of Charging stations in India, also highlighted in this paper .

Result Discussion

Optimization of battery pack of Charging ports

Slow charging stations as typically 3kw rating and charging time 8-10 hr. Fast charging stations as typically 20kw rating and charging time 3-4 hr. Rapid charging stations as typically 43kw rating and charging time 30-60 min.

The battery pack is spitted into 4 categories and each battery has separately maintained with plug port. Here the 4 plug ports and bunks are done for fast charging and battery gets charged with minimum time.

Conversion of parking lots into charging points

The major concern need to be addressed is lack of available site space in urban area for development of required charging stations for large unit roll out of electrical vehicles this problem can be greatly addressed by converting parking lots into electrical charging centers .

Optimization of Charging Infrastructure Development, Planning and Operation Management

Optimization means planning for size, shape, location, number of charging unit, distance between each charging station. Poor planning will lead to Chaco's and failure of system for roll-out. A localized large charging station with higher number of chargers can serve more EVs at a time but, it will require larger space and higher cost , along with grid integration problems [28]. The various EV vehicles as varying battery capacity and power rating , indicating the infrastructure need to be built to meet the varying need [29]. The EV built vehicles of three kinds namely , Hybrid electric vehicles ,Plug-in electric vehicles ,Fuel cell electric vehicles, charging infrastructure developed should meet the charging types of all. Planning and operation management of charging station depends of frequency of charging which interlinks with rate of roll-out into EV's. Efforts need to be made to optimize level of charging, number of charges, space requirement, type of charging station, and energy storage technologies to be used, grid integration if any, etc. Operation management need skilled workers to manage and support grid operation to minimizing losses of power , waiting time optimisation, smooth charging operation, etc. [30].

. **Development of Fast Charging, Ultra-Fast Charging, and Battery Swapping Stations to Reduce the EV Charging Time**

The revenue generation by deployment of fast and ultra-fast charging stations depends on magnitude of EV adoption rate [31]. The local public are on expectation that Potential Power EV station to perform at the same speed similar to conventional refueling, and for government authorities to focus on fulfilling the public desire by deploying fast charging stations with higher power ratings [25]. Faster charging stations will bring down waiting time and will uphold the acceptance from general public [32]. However, the technology involved for establishment of faster charging stations are to be developed since faster charging stations as negative impact on stability of grid and resilience [33]. A battery swapping system can be worked out at service stations which reduces or removes waiting time for charging of EVs [34].

Strategy-Based Management for addressing Queues at Charging Station

To avoid over loading or ineffective usage of available charging station Google based indicator or an app indicating loads at different charging stations need to be developed , this will lead to avoiding of Queues at service stations during peak loads. An effectual communication system will assist in supervising the queues at charging stations. An agent-based negotiation system was proposed for distribution of vehicles to charging stations [35]. This method will be useful for regulating queues at charging stations**.**

Grid Integration system at Charging units to Maintain Energy Balance

Increasing usages of EVs, will effective bring down atmospheric pollution especially, the carbon levels in atmosphere will be addressed bringing down green house effect but it may lead to emission or pollution from power producing units like coal and also heavy dependency on conventional electricity will put pressure on grid system [36].hence we need to move towards integration systems of clubbing the solar based electricity (which can be generated at service station itself) and convention electricity from grid system to balance the carbon emission and meet load demands.

5. Major Findings

The present work puts light on new developments and challenges in the area of EVs and their charging infrastructure. The major finding from the present work is well elaborated below.

- Updated battery pack of electric vehicles leads to faster charging of battery with minimum time.
- lack of available site space in urban area for development of required charging stations for large unit roll out of electrical vehicles can be greatly addressed by converting parking lots into electrical charging centers.

- The charging stations need to be developed to empower all needs like charging EV vehicles like Hybrid electric vehicles ,Plug-in electric vehicles ,Fuel cell electric vehicles.
- Operation management need skilled workers to manage and support grid operation to minimizing losses of power , waiting time optimization, smooth charging operation.
- Development of Fast Charging, Ultra-Fast Charging, and Battery Swapping Stations to Reduce the EV Charging Time .
- To avoid over loading or ineffective usage of available charging station Google based indicator or an app indicating loads at different charging stations need to be developed , this will lead to avoiding of Queues at service stations during peak loads.
- Moving towards integration systems of clubbing the solar based electricity (which can be generated at service station itself) and convention electricity from grid system to balance the carbon emission and meet load demands.
- The adoption rate of EVs is highly dependent on the availability of proper charging infrastructure with minimized charging time. The battery-swapping station showed its advantage of regulating the charging schedule of EV battery packs in a way to minimize its impact on the main grid. Moreover, it can serve as an energy backup unit and supply energy to the main grid at the time of peak load condition.
- The authorities should forecast the possibility hydrogen energy and fuel cell as replacement for battery energy storage system.

6. Conclusions

The rise in global temperature due to excess use of fossil fuels and rising environmental concerns have compelled for large scale roll-out for electrical vehicles and subsequent need for developing suitable charging infrastructure. In the present study, it is found that the recent trends in researches are more focused on the development of new and fast EV charging infrastructure that can minimize the charging time of EVs, increasing the utilization of available renewable energies for EV charging, minimization of grid dependency for EV charging, and the optimal location of charging stations, which is mainly focused on planning a new location network. The part of reducing emission levels by using EVs and renewable energies for its charging is well addressed by the researches but for developing a fully environmental conscious EVCS infrastructure, it is important to take into account the environmental sustainability concerns that will be raised when new constructions for establishing EVCSs will take place. It may lead to accruing new lands, cutting trees, etc., which will further increase the problems. A solution to this would be the use of present infrastructure like parking lots at workplaces, shopping malls, etc., to develop EVCS. Moreover, acquiring the present refueling station and converting it into EVCS. The idea behind this is as the demand for petrol, diesel, etc., at the refueling station decreases with increase in the number of EVs and their charging demand, it would be more profitable to convert the existing refueling stations into EVCSs. Adoption of new technologies like V2G, Smart Grid, Smart charging technique, etc., for EV charging will be very helpful in maintaining the energy balance of the power system and effective utilization of available renewable energy. It will also help in meeting customer satisfaction and economic charging rates. The development of an efficient network of communication for information exchange, optimization unit for reduced charging time, and prediction unit to help the best possible optimization are the key to the efficient operation of EV charging infrastructure. In the coming future, the development of charging stations will grow at a ramping pace but it is strongly recommended to take into account the environmental burdens and the global warming potential from these developments. To feed increasing electrical loads in form of EVs, whose demand is dynamic, a stable distributed or microgrid system network with maximized energy generation from a renewable energy system needs to be promoted to fulfill the motive of reduced dependency on fossil fuels and zero emission of environment polluting gases.

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