Electric Vehicle Charging Infrastructure Planning and Security Measures in Indian Urban Centres

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Abstract Electric Vehicle penetration in India could reach 30% by 2030 and this will generate an estimated savings of about 474 Million tons of oil import and 846 Million tons of CO_2 according to a study by NITI Aayog and Rocky Mountain Institute. Research shows that 83% of the consumers globally are hesitant to adopt EVs because of the battery life and range anxiety. The extreme price sensitive Indian customers are skeptical about siting charging infrastructure in the road network. In the past few years, researchers worked on the optimal deployment and sizing of charging stations using objective functions and different optimization algorithms. But most of the works have taken the European and other Western cities into consideration. This paper proposes a methodology to calculate the number of charging stations for EVs considering extensive environmental elements in designing the charging infrastructure in Indian Cities. Though there is a strong push for EVs, currently we are in the nascent stage of market development in India and thus it will be difficult to lay down a detailed plan. In this paper, the security factors that are to be prioritized for the installation of EV charging infrastructure in Indian Urban areas are also identified. Finally, the feasibility and viability of the methodology are applied in an Indian City as a business case.

Keywords Component · Formatting · Style · Styling · Insert

1 Introduction

The transportation sector profusely depends on the fossil fuels and contributes to almost one fourth of the total EU-28 greenhouse gas emissions. EVs have been found

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to be the most efficient and viable option to control the emissions currently [1]. EV adoption has reached its inflection point and EV penetration in India is predicted to reach 30–50% by 2030 generating about 846 Million tons less CO_2 [2].

Smart grids are carrying the power from the generating stations and information to control, monitor and automate the entire grid [3]. EV adoption put huge stress in the existing grid infrastructure. In this paper, we will discuss on the impact of EV adoption in the energy systems, measures to reduce the risks and the future planning of the infrastructure.

2 Charging Infrastructure Use Cases

Home Charging: EV Supply Equipment (EVSE) installed in the customer premise lets customers use it as per their convenience mostly during evenings and night.

Commercial Charging: The facilities available to the customers at the work locations, stores and restaurants.

Public Charging Stations: These stations are generally fast recharge stations, where the customer can recharge the battery in a short time. The public charging stations are a de-licensed activity in India and any individual can set up these stations once they meet the technical and performance standards.

3 Impact on Energy Systems

The rapid adoption of EV have great impacts in the existing energy systems testing the grid robustness, grid security, volatility, power quality as well as grid cyber security.

3.1 Data Security

As the number of endpoints increase with the increase in the nodes/charging stations the data is exposed to more risks (Fig. 1).

However, the prudent way to secure the data stored/in-transit is to adapt to cloud infrastructure to avail High Speed, Scalable Storage, Interconnectedness, Low Maintenance, Scalability with added features of security while allowing the users ‘access from anywhere’.

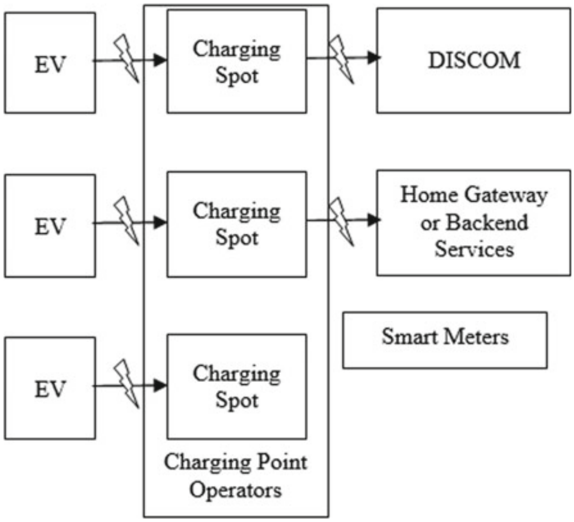

Fig. 1 EV charging endpoints

3.2 Grid Infrastructure and Security

The most pronounced effect of EV adoption is the increase in evening peak loads, as people plug in their EVs after they return home. The variation in the load curve has huge ramifications in the quality of the power supply.

One of the significant challenges the DISCOMs face is to continuously upgrade the infrastructure in the urban centers to cater to the increasing load demand locally. This has become even more important in the light of the recent regulations which provides for load shedding compensation.

4 Econometric Model

The econometric model analyzes the amount of energy, power, number of chargers required with growth in EVs and estimates its impact on the distribution grid. The model can be used to predict the infrastructure requirement in any city/region (Chandigarh in this study) while having the ability to aggregate with a vision of decentralized urban planning.

4.1 Assumptions

- Vehicles are categorized into 2, 3, 4 and 6Wheelers.
- EV adoption follows the technology adoption curve [4].

- Electricity usage per km is assumed as constant for each category based on the current industry benchmarks.
- Daily average distance travelled by cars, rickshaws and motorcycles are assumed.
- Utilization rate is assumed to be 30% for the charging station [5].
- Public Chargers are rated 50 and 10 kW.
- 70% of the vehicles registered in the city are used in Chandigarh, People from neighboring states purchase the vehicles from Chandigarh because of the lower taxation.

4.2 Methodology

- Number of vehicles sold for 2019–2030 is estimated based on CAGR and national growth rate
- Number of EVs are estimated using penetration rates
- Cumulative distance travelled by each EV Category is estimated
- Equivalent Electric Quantity (EEQ) [6] is determined based on per km electricity usage
- Power required for public charging, peak load and the number of chargers needed are estimated using the utilization rate [5].

4.3 Analysis

It is evident from Table 1 that the EV consumption, in the projected optimistic case, makes only 4% of the total energy consumption of 2030. Though 2Wheelers attribute 80% of the EVs, the biggest contributor to the consumption is 4Wheelers.

Figure 2 shows that dependence on residential charging may increase the peak load by 30%. The utilization period for residential charging is skewed towards the peak hours in an uncontrolled grid, whereas the public charging infrastructures are used ~16 h/day [5]. As the city depends more on residential EVSE, load in the peak hours increases significantly. Thus, it is always better for the grid to deploy more public charging stations for effective load management than the decentralized residential charging, especially in densely populated cities. Also, the utilities should

Table 1 Energy consumption in Chandigarh

	Year	Pessimistic	Average	Optimistic
Total EV consumption (MU)	2025	4.65	7.59	18.92
Total energy consumption (MU)	2025	1751.83	1890.04	2050.48
Total EV consumption (MU)	2030	34.54	53.13	93.73
Total energy consumption (MU)	2030	1888.41	2247.50	2702.20

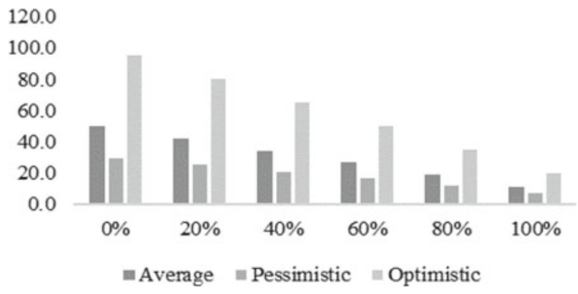

Fig. 2 Public charging versus peak load

have flexible transformation capacity to cope up with the power fluctuations resulting from excessive load (Fig. 3).

The peak load due to increased EV usage in the grid is enhanced by 5–15%, calling for a radical change in energy management of SLDCs, PPA structures and energy banking (Table 2).

NITI Aayog proposes to have at least one charging station in 3 × 3 km grid. However as per our analysis, in Chandigarh, there should be 19 charging stations, one in every 2 × 2 km grids in order to build a healthy grid.

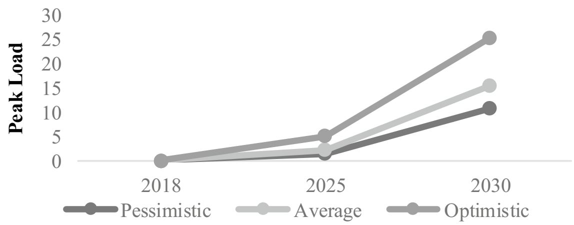

Fig. 3 Peak load

Table 2 Projected charging stations

Year	EV	Projected No. of charger stations		
		Average	Pessimistic	Optimistic
2025	Cars	3	1	8
	2 W	6	4	10
	3 W	1	1	3
2030	Cars	19	10	38
	2 W	38	30	53
	3 W	9	5	19

5 Mitigation of Security Threats

5.1 Role of Urban Planners

The industry experts expect a boom to the DC Fast Charging Stations only by the end of 2030. Urban planners, real-estate players and the EVSE suppliers should collaborate through the infrastructure planning, with increased focus on security to make it affordable, accessible and reliable.

5.2 Smart Charging

Smart Charging minimizes the load impact in the grid by attenuating the peak load and reduces the curtailment. Various methodologies are [7]:

- Time of Use Pricing
- V1G- Reduce, stop or start charging based on the communication from the grid
- V2G- Bidirectional, supply power to grid
- V2H- Supply power to home
- Dynamic Pricing.

5.3 Cyber Securiity

Connected systems across the world are vulnerable to hackers. Certain practices and tools which can reduce them are [8]

- Adopt best IT practices and Physical security
- Unidirectional Gateways
- Two Factor Authorization.

5.4 Remedies

The exigent measures that need to be adopted in security and infrastructure planning are:

- Incorporate the EV Charging requirements in the Grid Expansion Plans
- Innovations in making the infrastructure flexible and secure
- DISCOMs' role in residential EVSE setup
- Building competence for EV charging station O&M
- Strategic placement of fast charging stations for low grid impacts
- Increase storage capacity planning and deployment to deal with DER penetration.

6 Conclusion

Utilities are trying to find new ways to deal with power demand fluctuations arising out of EV usage and predicting the consumption pattern. The impacts and challenges remain in the decentralized grid, but the effect is amplified in densely populated developing economies like India. Innovations around deployment of public charging stations and EV data handling are paramount to brace for the future.

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