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Assessing The Impact of Electric Vehicle Charging on Power Procurement Costs: Implications for India's Energy Utilities

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Abstract: Electric transportation is still in its infancy in India. The electrical industry is at the intersection of this potential market upheaval. While increased energy sales from electric vehicle (EV) charging e.may assist an electricity distribution company boost income, charging demand may exacerbate the service area's peak load and have an impact on the distribution utility's power procurement costs. As a result, it's critical to assess the increased power demand resulting from EV adoption, as well as its potential pattern and contribution to base and peak load.This would allow DISCOMs to efficiently run their distribution networks and State Power Regulatory Commissions to use suitable mechanisms to minimize any negative impact on electricity supply. This study calculates the influence of EV charging on the cost of power procurement for energy utilities in a state by modeling the peak and off-peak contributions. The study discovered that charging electric vehicles boosts energy use from 12 to 6 a.m. The amount of EVs that might possibly affect the average cost of supply differs between DISCOMs, according to the report.

Keyword: Peak Load; Energy Demand; DISCOM; Tariff; Electric Vehicle.

Introduction

The growing Electric Vehicle (EV) sector in India differs significantly from the electric mobility scenario in developed nations. Unlike other countries, India is seeing great progress in electrifying the two-wheeler (2-W) and three-wheeler (3-W) sectors, which account for a large portion of the existing vehicle mix [2]. In actuality, 2-Ws and 3-Ws account for around 61 percent of petrol sales and 28 percent of diesel usage, respectively [1].The adoption of electrical technology in the 4-wheeler (4-W) category have been gradual, with EVs (including battery electric cars (BEV) and plug-in hybrid electric vehicles (PHEV)) accounting for only 0.06 percent of the automotive market until 2017 [3]. However, as governments increasingly encourage e-mobility, more electric 4-Ws are expected to be seen on the road. Apart from that, with the launch of the FAME-II (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India) initiative, numerous Indian town regions are intending to adopt electrical buses for inter-city transportation [4][5][6].

The backbone of e-mobility is charging infrastructure. Scaling up EV adoption requires the availability of appropriate charging stations or terminals. Public EV charging stations or private charging can meet the charging need. To fulfil this charging demand, energy distribution companies (DISCOMs) must guarantee that their capacity can handle the increase in electricity demand from EV charging. While increased energy sales from EV charging would help a distribution utility boost income, charging demand might exacerbate the service area's peak load and have a major impact on the distribution utility's power procurement costs. Apart from that, network upgrades may incur additional costs. As a result, estimating the increased power demand from EV adoption, as well as their likely symmetry and distribution to core and peak load, becomes critical. This will allow DISCOMs to run their distribution networks more effectively and stimulate public adoption of electric vehicles. This effort is also critical for building frameworks that would allow India to determine tariffs for EV charging.

This assessment begins with an understanding of the EV pattern in charging and its contribution to peak and off-peak load. The study predicts the increased energy consumption and peak demand in several electrical vehicle charging situations, taking into account the charging requirements across EV segments, after conducting a thorough analysis of the current literature (2-Wheeler, 3-Wheeler, 4-Wheeler and bus). Following that, the influence of DISCOMs in a state on the cost of electricity purchase is assessed and given as a case study.

1. Charging Electrical Vehicle

A. Energy Demand

The electric power sector will face both possibilities and problems as a result of widespread EV adoption. In terms of obstacles, charging electric vehicles might result in a rapid surge in peak demand, placing strain on local distribution systems. Thus, in utility resource planning procedures, it is critical to account the future electricity and power demand from EV adoption.This necessitates a forecast of when, where, and how much an electric vehicle will charge, allowing utilities to change their load predictions to account for the extra load from EV[7]. Only a few studies have looked at the influence of electric vehicles on peak and energy consumption in India. According to a research conducted by Lawrence Berkeley National Laboratory (LBNL), if the Government of India accomplishes its goal of 100% electrification of cars by 2030, the additional demand from BEV charging will be just 82 TWh/yr (about 3.3 percent of total energy consumption in India) [8].By 2030, the contribution of EV to peak demand is expected to reach 23 GW, or around 6% of total peak load (402 GW). The total range for BEV energy consumption in 2030 is 64–105TWh/yr (2.5–4.5 percent of non-EV energy load) and for peak load is 20–40 GW (6–11 percent of non-BEV peak). They also predicted that, assuming a marginal pricing of INR 9/kWh, BEV charging may earn utilities an extra Rs 70,000 Cr ($10 billion) per year by 2030. The analysis makes the important assumption that travel demand would stay constant until 2030, and that all BEV owners will have access to public charging infrastructure.

According to a research by the Forum of Regulators (FoR), a 50 percent filled commercial feeder can withstand up to 22% more EV load from fast charging [9]. Similarly, the residential feeder can safely accommodate a 60:40 load split between residential and EV (rapid charging) loads. In the event of peak co-incident billing, they predicted that the threshold should be set at 20%. On both feeds, the effect of sluggish charging was minor. According to the study, if all users share in the cost of EV charging stations, rate increases range from INR 0.0007 kWh to INR 0.0040 kWh. If simply passed on to EV customers, the impact on tariffs is significant, ranging from INR 0.1792 kWh to 0.2815 kWh. Between 2017 and 2030, Ali and Tongia found that electric vehicles might add up to 50% to peak demand and 3% to peak demand increase. Under 33 percent and 100 percent penetration of EVs in sales by 2030, total power consumption for EVs might range between 37 and 97 TWh, based on primarily intra-city (urban) passenger transport [10]. If all PHEVs consume the same amount of power as BEVs, total demand will be less than 9 BUs. Electricity usage by vehicle type in 2030: 2W has a range of 5TWh to 16 TWh with a mileage of 54.6 km/kWh; 3Wheeler has a range of 9TWh to 17TWh with a mileage of 19.5 km/kWh; 4W Car has a range of 10TWh to 27TWh with a mileage of 9.4 km/kWh; and Taxis has a range of 10TWh to 28TWh. 5TWh to 12TWh with a 9.45 km/kWh mileage, whereas buses range from 12TWh to 30TWh with a 0.85 km/kWh mileage.

The three studies analysed the Government of India's electrification aims and produced outcomes from a macro viewpoint based on EV target accomplishments. The electric bus has been misrepresented in studies of peak and energy consumption, with the exception of Ali and Tongia (2018) [10]. The battery capacity of electric buses ranges from 110 to 355 kWh, which might result in a rise in peak demand [4]. As a result, categorical contributions to energy and peak demand are critical. This is mirrored in Ali and Tongia's research (2018). The report, however, does not give a detailed approach for estimating the contribution of other EV types per category. It is necessary to assess EV charging on a micro level, taking into account the contributions of main EV segments.When compared to the macro level, EVs represent a huge increase in demand [7]. As a result, it seems sense to investigate the impact of EV adoption at the DISCOM level.

B. Charging Patterns for Electric Vehicles

The Salt River Project (SRP) service zone in Arizona was evaluated by the Electric Power Research Institute (EPRI) [11]. In their investigation, they looked at both BEV and PHEV automobiles. To get minute-level, high-resolution data, 100 EVs were tracked using vehicle data logging devices during driving and charging activities. Approximately 81 percent of charging took place at home, with only 3% taking place at public charging stations. Driving patterns and ambient temperature both effect EV charging, affecting battery composition and the supplementary power required for air cooling and heating. Temperature fluctuations had minimal influence on load shapes, they observed.

Only one research, released in 2019, by OLA Mobility Institute to evaluate the operational problems faced by an electric mobility project in Nagpur [12], discusses India's EV charging pattern. According to their findings, cab drivers' power use at charging stations peaked around lunchtime (12pm-4pm) and at night (8pm-12am), with 63.5 percent of charging occurring during these times. However, EV charging was restricted to the cab fleet. In terms of EV charging patterns per category, there isn't much precedent.

2. Case Study

A case study at the DISCOM level is done since electric vehicles (EVs) add considerably to load and energy demand at the distribution level compared to the transmission level [1]. The purpose of this case study is to assess the impact of EV adoption at Delhi's distribution businesses (DISCOMs). The four biggest DISCOMs in Delhi, namely BSES Yamuna Power Limited (BYPL), BSES Rajdhani Power Limited (BRPL), Tata Power Delhi Distribution Limited (TPDDL), and North Delhi Municipal Corporation, were chosen due to the simplicity with which data was available (NDMC).

A. Concept

The 2018-19 electrical data has been compiled. The State Load Despatch Centre in Delhi provides DISCOMs with load curve data. Other information comes from the DISCOMs' tariff order for 2018-19. The Ministry of Power (MoP) and Faster Adoption and Manufacture of (Hybrid and) Electric Vehicles (FAME) criteria were used to determine the rated charger power and battery capacity. The excel-based model is being used to investigate the EV charging pattern and assess its influence on Energy requirement,apex Power, and supply to actual price of Supply (ACoS) [5][6][13][14][15][16][17].

B. Assertions

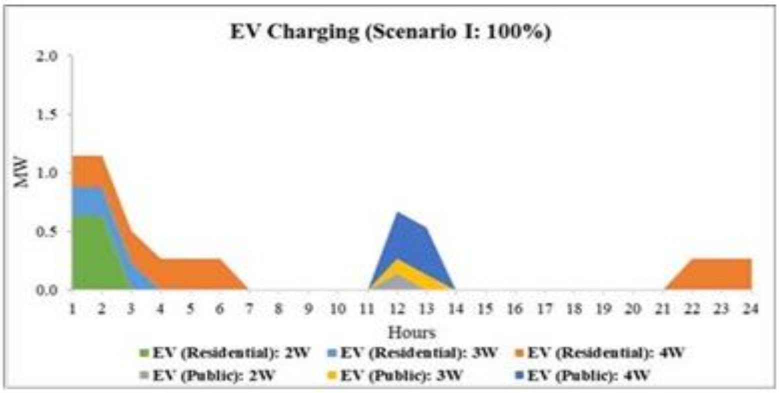
To analyze peak and energy consumption, the study used a baseline of 1200 EVs, of which 200 are electric buses. Using the proportions from the NitiAayog-RMI research [18], the remaining 1000 EVs are classified into two-wheeler (2w), three-wheeler (3w), and four-wheeler (4Www) categories. Bus pricing for intra-city transportation is expected to take place at the depot at night [4]. Other EV classifications take into consideration both daytime and overnight charging.A portion of the budget has been set up for daytime public charging and nighttime home charging, with the assumption that the bulk of charging will occur at home. The battery's depth of discharge is considered to be just 70%, and the equivalent charging energy need is calculated using a 95% efficiency factor. The battery sizes and charger capacities are assumed based on market standards and regulatory guidelines where relevant, and are listed in the appendix.

C.EV Charging Cases

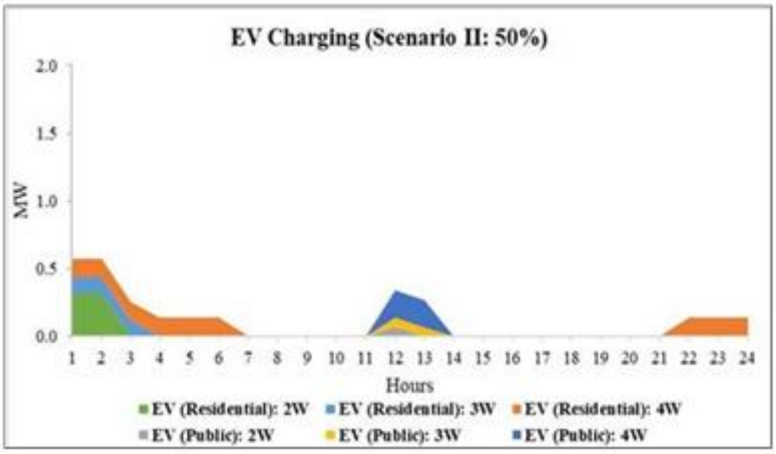
The charging schedule of an electric vehicle may vary depending on the user's preferences. To analyse the EV charging pattern, three EV charging scenarios were explored, based on the most severe, most likely, and average charging power requirements.

- case 1: If all vehicles are start charging atthe sametime.
- Case 2: If 52% of vehicles are start charging at the parallel time.
- case 3:If33%ofvehiclesarestartcharging at the mean time.

In Case 1, 2, and 3, Figures I, II and III depict EV charging for 2W, 3W, and 4W categories at public charging stations as well as at houses. Due to the slower charging procedure of bigger batteries, 4W charging takes longer in households than 2W and 3W charging. Under all three circumstances, 4W contributes the most to power demand at public charging stations. In all three scenarios, the charging power and energy consumption climb the most at night.



FigI.Case I: 100% EV Charging (eliminating Bus)



FigII.CaseII: 52% EV Charging (eliminatingBus)

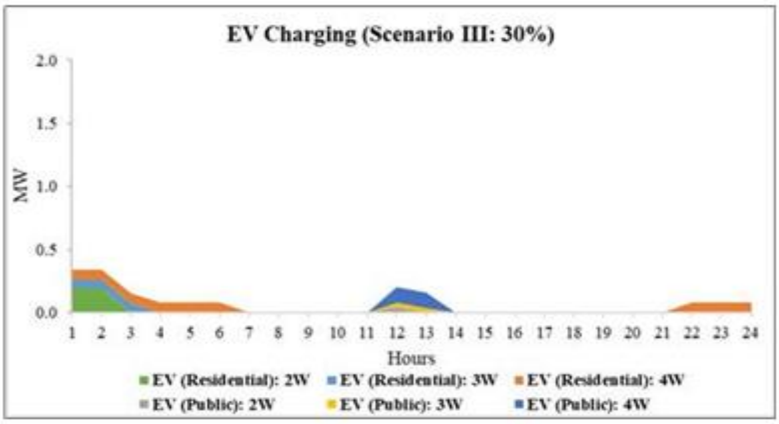
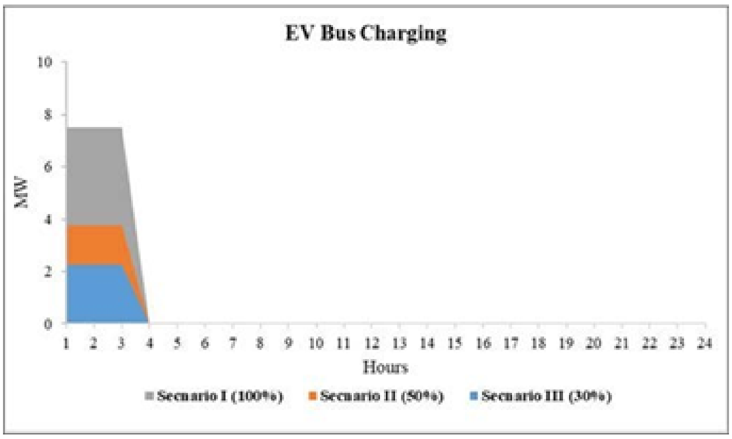


Fig III.Case III: 33% EV Charging (eliminating Bus)

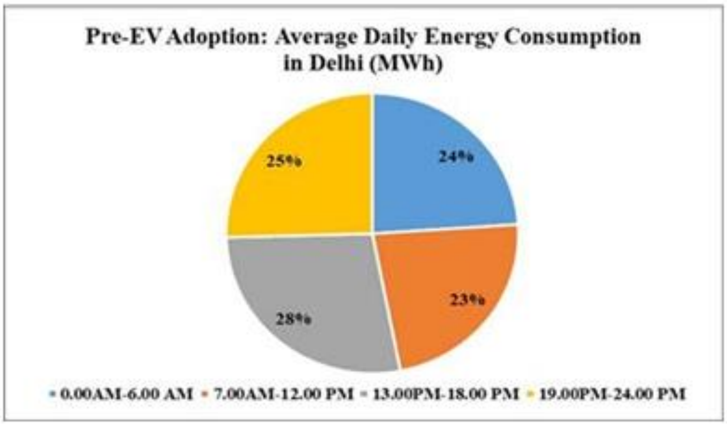
Electric buses, unlike other vehicle types, have a substantially larger battery capacity; hence their charge is tracked individually. As illustrated in Figure D, bus charging creates a dramatic spike in energy and peak demand at night, with the greatest impact if all buses charge at the same time.



FigIV.Three examples of electric bus charging

C. Impact on Delhi's Energy Demand

The increase in energy consumption caused by EV charging in Delhi is presented for the most extreme scenario, in which all EV charging begins at the same time and each EV is charged at least once a day. The energy requirement for the full day is split into four 6-hour intervals. Figures 5 and 6 depict the impact of EV adoption before and after adoption. Between 12 a.m. and 6 a.m., energy usage increased by 24% to 31%. The majority of the energy used for EV charging occurs at home.



FigV.Average Daily Energy Consumption Prior to EV Adoption

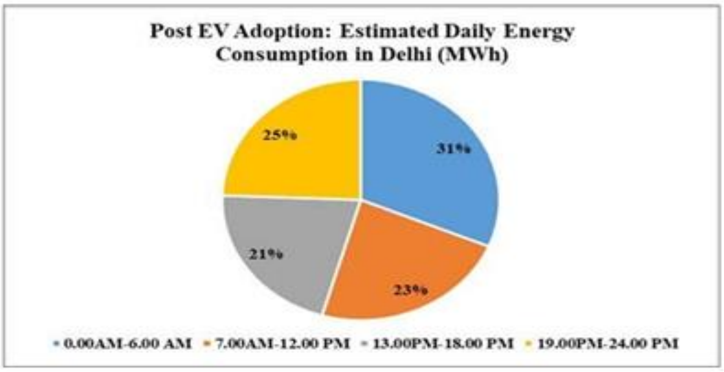
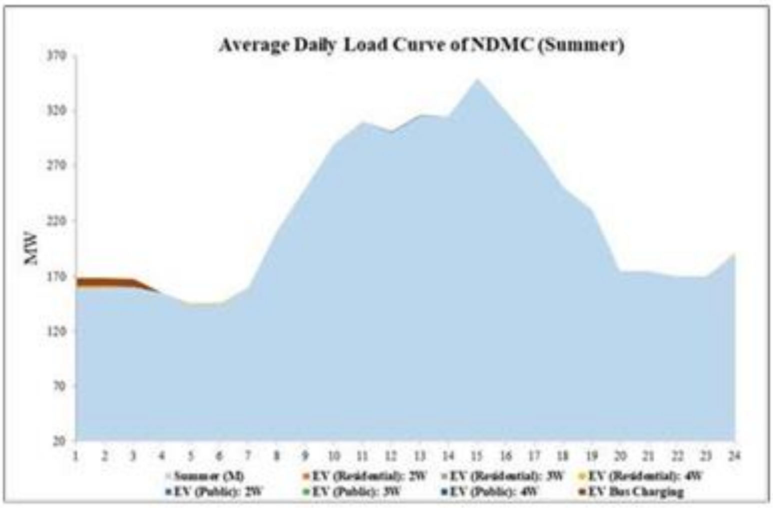


Fig VI.Average Daily Energy Consumption After EV Adoption

D. Impact on Delhi's DISCOMs' peak and energy demand

The next phase is to assess how EV charging affects electricity and energy consumption in each DISCOM. For all four DISCOMs, the load profiles chosen encompass 24 hours and were taken on a random day during the summer. Other than NDMC, the load curves show that DISCOMs suffer evening and night peak demand. The highest demand for NDMC comes in the middle of the day. Figures 7, 8, 9, and 10 show the influence of EV charging on the adoption of 1000 EVs (including 2W, 3W, and 4W) and 100 electric buses.

Among other EV types, the contribution from electric bus charging is the largest and most evident on the load curve. Around 12 a.m., the peak increases dramatically. The charging contribution from the other 1000 EVs is not visible on the load curves since it is such a minor percentage of the aggregate demand of all DISCOMs. The impact of 1000 electric cars is bigger in NDMC than in other DISCOMs, and electric bus charging is the major contributor. Even while EV charging raises energy and peak demand for all other DISCOMs, the impact is minor.



FigVII.The impact of electric vehicle adoption on the NDMC load curve

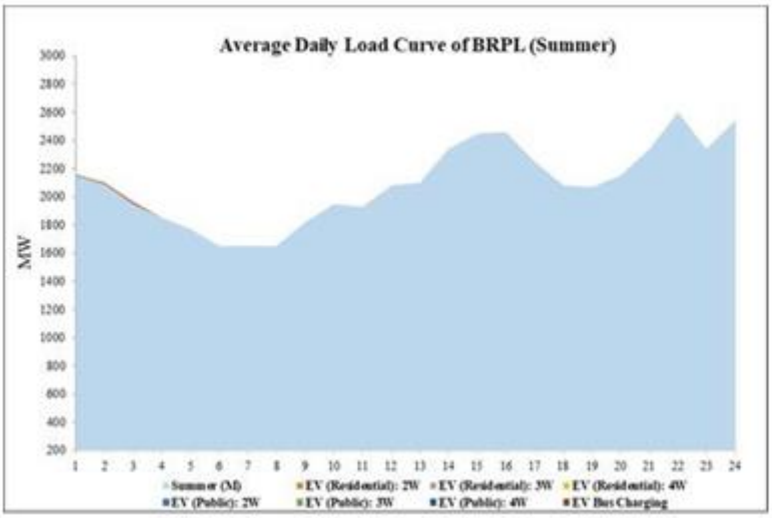


Fig VIII.The impact of electric vehicle adoption on the BRPL load curve

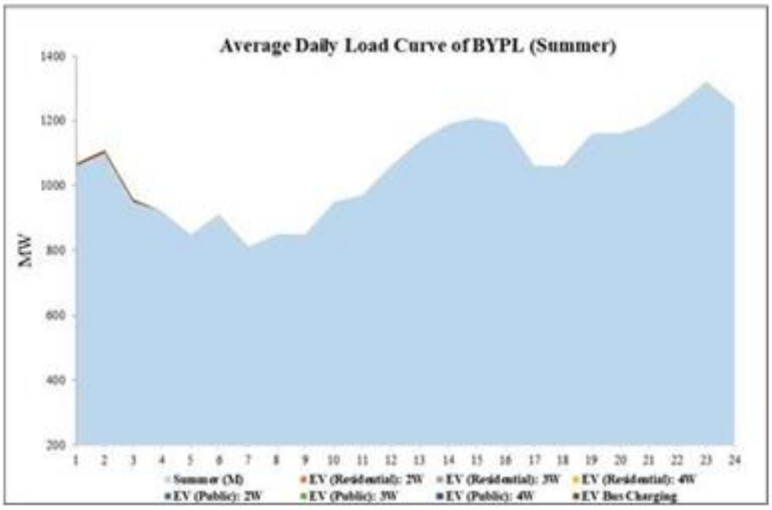


Fig XI.The impact of electric vehicle uptake on the BYPL load curve

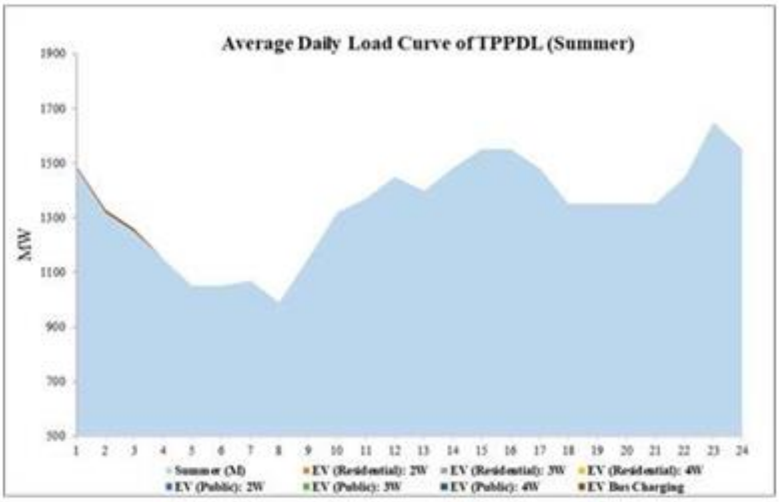


Fig X. The effect of electric vehicle adoption on the TPDDL load curve

3. Discussion

According to the report, electric vehicle adoption will change Delhi's energy consumption pattern and raise energy demand at night from 25% to 33%. At the level of DISCOM. The main contributor to the increase in load from EV charging would be electric bus charging. When both depot and home charging are included, the highest demand for EV charging occurs between the hours of 12 and 6 a.m. Under all charging circumstances, 4W charging contributes the most to power requirements at public charging stations.

DISCOMs must acquire extra electricity to fulfil the increased demand from EV charging. For DISCOMs, EV charging leads in an increase in additional energy sales. The influence of electric vehicles on supply costs is minimal at low levels of adoption. The number of EVs that will have an impact on the ACoS has been approximated using data from tariff orders, as shown in Table 1. In the instance of NDMC, 0.25 million EVs result in a 2% increase in ACoS, resulting in an extra 451 MW of electricity and 1020 MWh of energy consumption.While a 1% increase in ACoS prompted 2.78 million, 1.44 million, and 2.08 million people to leave BRPL, BYPL, and TPDDL, respectively. EV adoption is expected to have a significant influence on NDMC ACoS in comparison to other DISCOMs. The impact of EV adoption on increased average supply costs varies per DISCOM in the same state.

Table I. Peak and energy demand effects of EV adoption

DISCOM	No of EVs	Extra Power need for EV Charging (MW)	High in Energy Consumption from EVs (MWh)
New Delhi Municipal Council	242	450	1022
BRPL	2,762	5023	11344
BYPL	1,425	2589	5848
TPDDL	2,062	3747	8475

4. Conclusion

Small level research is necessary to realize the significance of EV charging in a DISCOM region, according to the research. The quantity of cars and the method of EV charging have an influence on power and energy consumption on a DISCOM load curve. Electric buses, among other EV categories, require specific consideration, especially for DISCOMs with peak power consumption at night. The penetration level of EV has an influence on the average cost of supply for a DISCOM. However, at the same penetration level, the impact is not consistent between DISCOMs.

Because load curves vary in winter, monsoon, and summer, further research is do to regularity in energy usage should be taken into account. The results might be modified further when additional information about the pattern of EV charging becomes available. Accounting contribution from renewable power, which might contribute to daytime pricing, is also crucial.

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