Survey of Electric Vehicle users and prospective buyers in Delhi and the estimated impact on EV charging on the Grid in 2030.

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Transport sector has gained a special attention as it is the world's second-largest emitter of carbon dioxide (CO2). Worldwide it has emitted approximately 8 billion tonnes of CO2 globally in 2018, accounting for 24% of CO2 emissions from fuel combustion. Passenger vehicles accounted for 45% of overall transportation emissions, followed by road freight vehicles at 29%, aviation at 12%, foreign shipping at 11%, rail at less than 1%, and other modes of transportation at 2% (Global EV Outlook, 2020). In India, rapid urbanization in recent years has resulted in critical urban air pollution (UAP) levels in many Indian cities. In response to the environmental issues, the federal and state governments have promoted e-mobility, which results in zero tailpipe emissions and lower operating and maintenance costs.With multiple benefits EVs are getting popularity worldwide. However, transition to EV would require investment planning for the supporting infrastructure like charging facilities and local distribution grids.

One of the important stakeholders in EV ecosystem is the DISCOMs as they would primarily be responsible for preparing the charging infrastructure to support large scale EV penetration. Hence it is important for discoms to plan in advance and estimate the number of electric vehicles that are likely to be in use and their estimated impact on the grid. Keeping this objective in mind, Shakti Sustainable Energy Foundation (SSEF) funded the present study carried out by IRADe in which it has tried to assess the user behaviour and experience of early adopters of EVs in Delhi and estimated the impact of EV charging on Delhi’s power demand and the hourly load on the local grid. For this purpose, primary surveys covering 500 respondents in four distinct segments: current private users of electric-2W and 4W,EV-4W institutional, e-rickshaws and prospective EV consumers (those who are planning to buy a vehicle over the next six months) was undertaken in Delhi from August to September 2020. The survey tried to capture the socioeconomic characteristics, vehicle ownership patterns, transport and charging behaviour of early adopters of EV in Delhi and based on the assessed charging behaviour the study further estimated the impact on the grid of Delhi. In addition, a prospective consumer survey was also undertaken to assess and identify the factors that influence consumer’s choice of buying or not buying EV.

The private consumers include EV-2W,4W users and prospective consumers. The survey results show that the most of early adopters of EV 2W in Delhi belong to lower household expenditure groups in the range of Rs. 7,000 – 40,000 per month with an average expenditure of Rs. 18,506 per month and around 1/3rd already have conventional 2W or 4W. Early adopters of EV 4W are in the higher monthly household expenditure range of Rs. 40,000 – 50,000 per month with an average expenditure of Rs. 44,286 per month and already have conventional 2W or 4W. The early adopters of EV 2W and 4W in Delhi are all aware of air pollution compared to other issues like water pollution, noise pollution and climate change and global warming. Early adopters of EVs and prospective buyers prefer EVs for regular and short distance, mostly to work place.

To assess the charging pattern for EV 2W and 4W, the plugin and plug-out time reported by the respondents to collected in the survey. In this way, a 24-hour charging profile is obtained for a weekday and weekend. The charging pattern for EV 4W is through two modes, i.e., regular charging and top-up charging. In the Private EV 4W case, the respondents do not require to use top-up charging on any day. The regular charging time in weekdays and weekends is from 5 pm to 7 am, considered non-working hours. On average, it takes 9-10 hours in normal charging mode and up to 2 hours in fast charging mode to completely charge an electric 4W vehicle. All respondents have their private charging point at home, which is provided and installed by their EV manufacturers. The regular, once a day, slow charging satisfies their requirements of daily travel. Hence the fast-charging option is seldom used and required by the respondents.

For EV-2W, more than 90% of the respondents charge their vehicles at home on both working and non-working days and office charging and shop charging are almost negligible. Approximately, 39% of the respondents charge their EVs 7 times a week (once a day). This is followed by 17% and 16% of the respondents charging 5 times and 6 times a week, respectively. However, it also means that 55% of the respondents charge their EV 2W less once a day. A small percentage of respondents mentioned that they charge 12 times and 14 times a week. The charging pattern for EV 2W is through two modes, i.e., regular charging and top-up charging. The regular charging time on weekdays and weekends is from 7 pm to 8 am. Generally, top-up charging is not relevant for electric 2W vehicles. On average, it takes 7-8 hours to completely charge an electric 2W vehicle. Therefore, for analysis's sake, charging is assumed to be a top-up if it takes less than the average normal charging of 7-8 hours.

Compared to early adopters among the Prospective Consumers, all women respondents preferred EV over conventional for their mobility needs. The average family expenditure of 2W EV intenders was Rs. 23971 per month and average monthly expenditure of respondents who were 4W EV intenders was Rs 34,230 per month and for The major determinants of prospective consumer to choose or not to choose EV are range, charging time, Operating and maintenance cost, Resale value and Government policy. All EV intenders wanted lower prices, high range and hybrid batteries for their vehicles. Lack of parking spaces emerged as abig hindrance for EV adoption.

The public transportation part of the survey includes E-rickshaws and institutional EV-4W. Both were owned and operated by men only and worked almost seven days a week. These drivers were found to besatisfied with EV 4W, despite issues with range and charging time. Availability of Public charging infrastructure & higher waiting time for charging are the aspects for which respondent drivers are least satisfied and free servicing, maintenance, repair and battery replacement services are high on wish list of the drivers. To increase use of electric vehicles by private and public companies, tax breaks may be considered for those who use electric cars to meet their transport requirements. Electric car use by government can be increased through mandates and policy stipulation. All E-

Rickshaw drivers belonged to low income groups and self-financing is the major source to finance e-rickshaw so some easy finance schemes are required to boost e-rickshaw adoption.

Further, separate analysis of data for weekdays and weekends has been done through an excel basedmodel to arrive at the electric load impact on the Delhi's grid due to EV charging. EVs can be charged through slow AC charging or DC moderate charging and hence impact of slow and moderate charging is kept separate to understand the hourly impact of such charging.

The cumulative hourly impact of all electric vehicles together (3W-122, 2W-123, 4W-20 (private) and 4W-167 (institutional)) on weekdays shows that the major impact and surges was due to the 4W vehicle charging, especially moderate DC charging, in the afternoons and early evenings. These hours are generally of peak load, and hence adds to the load pressure on the grid. On the weekends, the 4W-institutional load is non-existent due to the non-plying of institutional vehicles on weekends *(in the survey, institutional vehicle drivers mentioned that Saturday is working, hence considered Weekday while Off day is only on Sunday)* and thus on these days top-up chargingby vehicles are relatively flat.

IRADe estimated the vehicle count for each mode of vehicles in FY 2019-20 based on Road transport model. It shows that the impact of EVs is minor compared to the average hourly load in Delhi. This is primarily due to significantly lower count of EV-4W, which have comparatively larger battery among EVs. The higher count of e-rickshaws is not putting much load on the grid because of the minimal size of batteries employed in the same. A far lesser impact of EVs is estimated when the charging behaviour of EVs during weekend is analysed.

However, Electric Vehicles is expected to increase substantially in this decade. IRADe estimated that Delhi would have a substantial number of EVs by 2030 i.e.EV population of 3W-1,20,013; 2W-14,93,632; 4W (Private)-6,97,935; 4W (Institutional)-51,862and hence their impact on the grid would also be significant. The Central Electricity Authority (CEA) estimates for the year 2030, the peak load requirement in Delhi would be 11,575 MW.

In 2030, a substantial impact will fall on grids due to the EV-4W and y EV-2W due to its large numbersas shown in Figure A. Comparison between the effect in 2030 with FY 2019-20 shows a significant difference. This is primarily due to the estimated count of vehicles. Another important observation to be made is that the impact of 4W-(Institutional) vehicles is substantially lower in 2030 and the noon charging peaks that were seen during the analysis of surveyed vehicles in 2019-20 is dampened out. This is because EV-4W (private) count is relatively high as compared to the EV-4W (Institutional). The impact of EV charging on the estimated hourly electricity load on peak and lean month shows that EVs in 2030 have the potential to contribute 17% over and above the peak month electricity load requirement. This contribution may increase to 54% of the total electricity requirement in the lean month as shown in Figure B. Hence, it is imperative for the distribution system to plan for EVs coming into the system. On weekends, compared to a weekday, the impact of EV charging on weekend is not as significant but still has the potential to be 4% of the hourly load in peak month and 10% of the total electricity load in the lean month of 2030

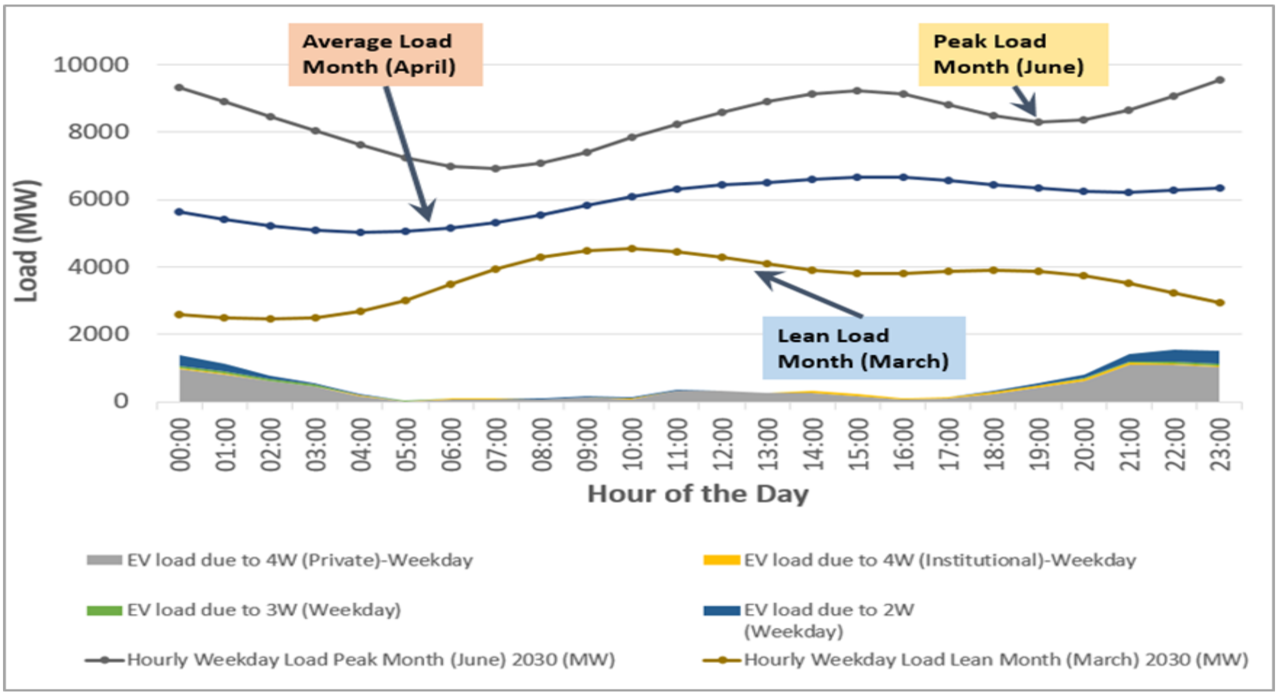
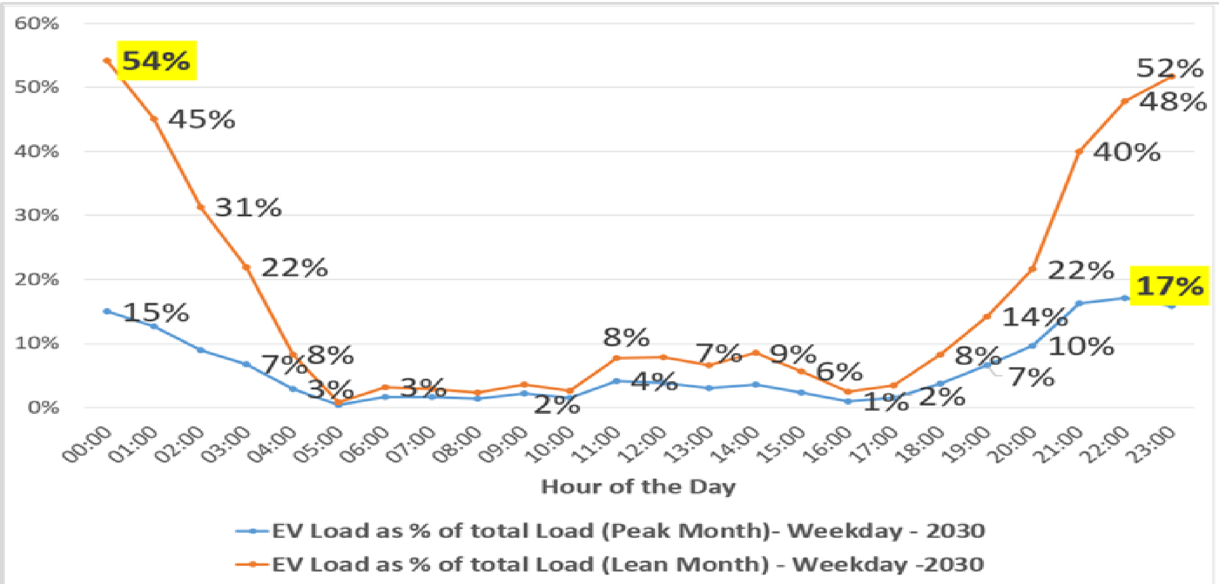


Figure A: Estimated Impact of EV on Delhi on Electricity Load* in 2030 on a typical weekday[1]



[1] The peak load month, average load month and lean load month curve is plotted based on peak load requirement (in MW) available for 2030 (Long term electricity load forecasting, CEA 2019) and offsetting the load based on FY 2019-20 actual data obtained from '*Energy Analytics Lab'- IIT-K CER Website*https://eal.iitk.ac.in/ .

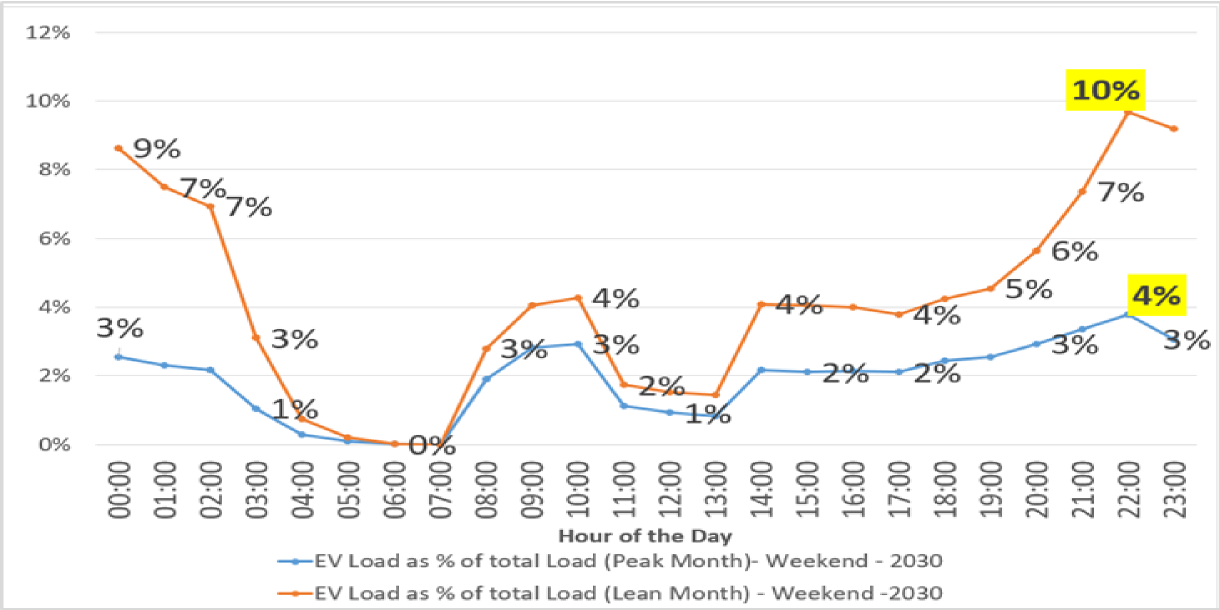


Figure B: EV Charging impact compared to the Weekday and Weekend estimated hourly electricity load in 2030 (Peak Month/Lean Month

Conclusion

The survey highlighted that women, students, salesmen as well as people using public transports have strong preference for EVs. Moreover, given the limited range of current EVs and lack of charging infrastructure, the early adopters as well as prospective consumers prefer it for travelling for short distance. So, these categories can group for the promotional campaigns and Advertisement. There is a lack of awareness about economic benefits of EVs as evident in the prospective consumer survey where 52% of conventional 2W and 15% of conventional 4W opted for EV when shown comparative values of capital cost, operating cost, EMI for a loan period of 7 years, range/mileage for some existing EV and conventional vehicle models. In addition, the advertising campaign for promoting electric vehicles should highlight features such as “new battery-based technology”, “less noise”, “suitability for local travel” and benefit of “less mechanical parts” in addition to new upcoming models for improved impact as these are some important determinants of EV demand.For public transport, it has been observed that most of the e-rickshaw drivers are from low income economic background hence financing their e-rickshaw purchase becomes a constraint. Among the e-rickshaw drivers surveyed, 44% of the owners purchased through their monetary resources, 32% through bank's financing, 11% purchased through private finance and 6% from other finances. Self-financing is the most common source of finance for e-rickshaw drivers hence supporting them through easy finance schemes may help increase e-rickshaw growth. For institutional EV-4W, to increase use of electric vehicles by private and public companies, tax breaks may be considered for those who use electric cars to meet their transport requirements. Electric car use by government can be increase through mandates and policy stipulation

As far as impact on DISCOMs is concerned, the study segregates the vehicular impact of each category of vehicle surveyed along with mode of charging (slow/moderate) wherever applicable. The analysis also estimates the cumulative load due to the EVs in FY 2019-20 as well as 2030, highlighting the major factors affecting the grid load a decade ahead. The study's survey spanned over only two months (Sep-Oct 2020) and hence the seasonal variation in EV Charging behaviour, if any, does not show in the outputs. The study found following impacts.

1. The impact of EVs (individual or cumulative) on the grid is very minimal due to very low number of EVs plying on the Delhi roads in FY 2019-20. Comparatively high e-rickshaw numbers are also not impacting the grid much because of very small batteries used in such vehicles.

2. The impact of EVs in 2030 is profound and is provided below

   a. EV Load share in 2030 estimated hourly Demand (without EV Load) on weekdays
      (i) Maximum of 17% at 00:00 HRS in Peak month
      (ii) Maximum of 54% at 22:00 HRS in Lean month

   b. EV Load share in 2030 estimated hourly Demand (without EV Load) on weekend
      (iii) Maximum of 4% at 00:00 HRS in Peak month
      (iv) Maximum of 10% at 22:00 HRS in Lean month

Interventions for Load Management

A few of the critical interventions that can be undertaken for management of the increasing EV load is discussed below:

1. **Time of Day (ToD) Tariff:**

   Price economics is an essential consideration while deploying Time of Day tariff. ToD is a tariff that is charged based on the time in which load is connected to the system (in this case EV charging time). A higher tariff is charged from consumers if the load is connected during peak time of distribution utility while a rebate is given if the load is connected at lean hours. This is done such that non-essential loads can be shifted to non-peak hours such that load management becomes easy and economical for a distribution utility. As shown in the analysis, the surge loads of EV in the noon and early evening hours can be shifted to off-peak hours of late-night by utilizing ToD tariff for a price-sensitive consumer.

2. **Smart Charging/ Managed or Controlled Charging:**

Smart Charging is another intervention that has been deployed successfully in various parts of the world and in a fast-evolving market like Delhi, may provide an innovative solution to the load management problem. Smart charging involves integration of vehicle with grid and hence also broadly given the name as Vehicle-Grid Integration model. In Smart charging, charging can be initiated, stopped or regulated for an EV or multiple EVs based on remote functionality.

For example, RE generation, especially solar, starts generating substantial power and because of must run status of the same, forces coal generation plants to ramp down and operate inefficiently at partial load. Smart charging may initiate charging of connected EVs and coincide its load drawl in conjugation with the operation of a PV-solar plant. This may lead to better management of the grid and avoid costly system augmentation which elsewise might be needed to support peak load charging of EVs.

Smart charging can be unidirectional or bi-directional. Uni-directional is a case as mentioned above while the bi-directional, in theory, is the usage of charge available with vehicle batteries to support the grid in time of urgency to dampen the load curve of distribution utility. Benefits of Smart charging, non-exhaustive, is listed below:

a. Reduction of bills for consumer by efficiently using time of usage tariff and alternately avoiding high demand charges, which would otherwise be imposed on the consumer
b. Deferral of distribution system upgrades/augmentation costs
c. Better integration of RE
d. Reactive power support in management of energy imbalances

3. Smart Transitioning of EV Load:

Delhi, as well as India, is moving towards a grid with an increasing share of RE in energy mix primarily dominated by solar power that peak during the day. In this upcoming decade, the availability of infirm cleaner power in the grid during the daytime will be higher and cheaper than power in the evenings and nights. Hence, the charging of EVs may need to be accommodated during the daytime using suitable mechanisms that inspire the charging behaviour of EV owners.

Way Forward

This study gives few crucial points to ponder in the expected dominance of EVs in the next decade primarily due to added impetus by the government to promote it as a sustainable means of transport through subsidies and rebates as well as an ever-increasing IC Engine fuel prices burning hole in the price-sensitive customer. Regarding the impact on grid the incoming EVs are expected to bring, the points mentioned below provide an avenue to brainstorm for effective adoption of EVs.

1. Policies for shifting charging time needs to be explored based on the demand-**supply pattern of electricity.**

2. **Sensitivity of charging time with the price of electricity** needs to be explored.

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