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SHAKTI SUSTAINABLE ENERGY FOUNDATION

Dispelling Myths: Electric Vehicles are expensive and will be a burden on the Indian electricity grid

KPMG Advisory Services Pvt. Ltd. is the knowledge partner for this paper

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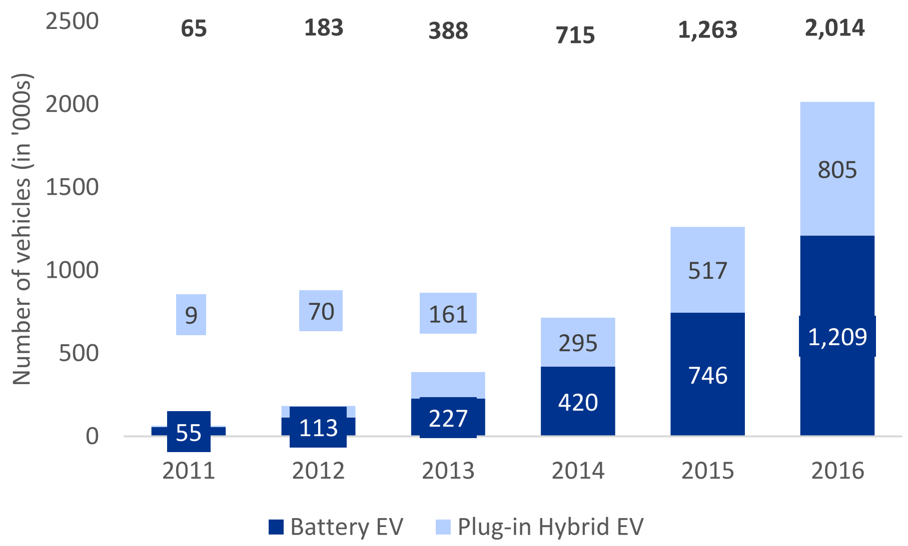
Introduction

Globally, road transportation sector contributes to 16 per cent of global carbon dioxide (CO_2) emissions[1]. The drive towards deploying Zero Emission Vehicles (ZEV)[2] has gained momentum to address the clean energy considerations especially in the urban/city transport. Technology advancements accompanied by subsidy and incentive support[3] has driven the ZEV penetration in the recent past. In fact, the number of ZEVs has grown at 99 per cent CAGR in past five years[4].

Figure 1: Number of ZEVs in the world



Source: Global EV outlook 2017, IEA

Moreover, several countries have also announced plans to shift towards electric vehicles adoption and restrict the sale of petrol/diesel cars.

- Britain has announced ban on sale of all diesel and petrol cars and vans from 2040[5]
- Norway has announced complete ban on petrol powered cars by 2025[6]
- France to ban sales of petrol and diesel cars by 2040[7]
- China is considering to ban sale of petrol/diesel cars in "near future"[8]
- India envisions to be a 100 per cent EV nation by 2030[9].

[1] Understanding CO_2 Emissions from the Global Energy Sector, World Bank
[2] ZEV stands for vehicles which produce no emissions from the on-board source of power (e.g., an electric vehicle) (Source: Glossary of air pollution terms, Air Resource Board, California)
[3] In some Chinese cities, there is a restriction on number of new vehicle registrations. However for EVs, such restrictions are partially or fully waived. (Source: Global EV outlook 2017, IEA)
[4] Global EV outlook 2017, IEA
[5] Guardian Media report
[6] Independent Media report
[7] Guardian Media report
[8] Livemint media report
[9] Economic times media report

Will EVs help reduce CO_2 emissions?

EVs can help reduce particulate matter emission from cities (India has 10 cities in world's top 20 most polluted cities in terms of PM 2.5). Further, powering EVs with renewable energy can help mitigate the vehicle emissions completely. However replacing conventional vehicles with EVs may not immediately lead to reduction in CO_2 emissions if EVs are charged using grid power.

- 1 litre of petrol emits 2.35 kg of CO_2 resulting in 156 g CO_2 emission per km of distance travelled (assuming 15kmpl mileage)
- CO2 emissions from power generation has to be less than 626 g/kWh for EVs to help reduce CO_2 emissions (assuming mileage of 4 km/kWh).
- Currently average CO_2 emissions from power sector in India is 732 g/kWh. By FY 2022 these emissions are expected to reduce to 581 g due to increasing penetration of renewable energy. Hence after 2022, CO_2 emissions are expected to reduce via EVs even if powered with grid power.

Sources: Ambient (outdoor) pollution database, World Health Organization (WHO), May 2016; U.S. Environmental Protection Agency; Draft National Electricity Plan; Understanding CO_2 Emissions from the Global Energy Sector, World Bank; KPMG analysis

Economics of Electric Vehicles

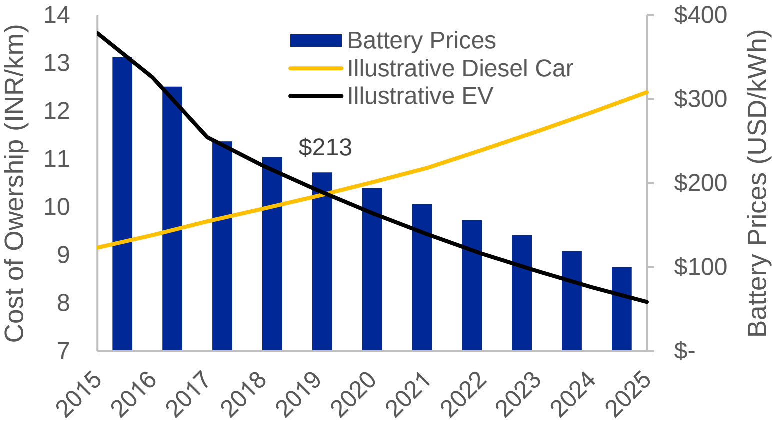
Currently, EVs are expensive when compared to conventional Internal Combustion Engine (ICE) vehicles. However, the total lifecycle cost of EV's are expected to economical to ICE vehicles – driven by the declining costs of Lithium Ion Batteries (LIB)[10].

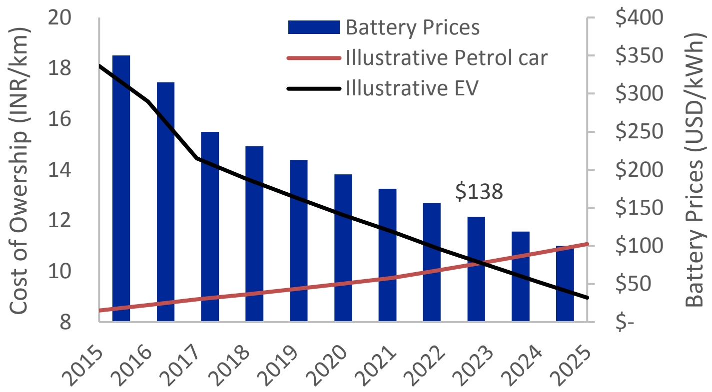
Cost of LIB has fallen by around 75 per cent from USD 1,000 per kWh in 2010 to around USD 273 per kWh in 2016[11]. The price is further expected to drop by 60 per cent to USD 100 per kWh by 2025[12]. Most EVs across different customer segments are expected to be price competitive (in terms of upfront cost) with ICE vehicles on an unsubsidized basis by 2025[13]. Currently batteries contribute around 50 per cent in cost of EV however with declining cost of batteries, the share of batteries in upfront cost of EV is expected to reduce to less than 30 per cent[14].

Our preliminary analysis also suggests that in terms of Total Cost of Ownership (TCO)[15], commercial EVs can become economically viable in early 2020s as shown in below figures. Further, passenger EVs are expected to become economically viable (in terms of TCO) by 2023 (around 50 per cent reduction in TCO by 2023 against 2015 for passenger vehicles levels is due to reduction in cost of batteries)

[10] Significant cost of electric vehicles is contributed by LIB
[11] Bloomberg new energy finance report
[12] Rising Sun, KPMG in India
[13] Electric Vehicle Outlook 2017, Bloomberg New Energy Finance
[14] KPMG analysis
[15] Total cost of ownership is the upfront cost plus the operation cost minus salvage value.

Figure 2: EVs could be more economical than ICE vehicles in early 2020s





Source: KPMG analysis

Due to low operating cost of an EV, commercial and public utility vehicles are expected to become economical earlier when compared with private/passenger owned vehicles.

Operating cost	Illustrative EV	Illustrative Petrol vehicle	Illustrative Diesel vehicle
Fuel	Electricity	Petrol	Diesel
Mileage	6.3 km/unit	25 km/l	21 km/l
Fuel prices	INR 6/unit	INR 67/l	INR 58/l
Running cost	**0.95 INR/km**	**2.7 INR/km**	**2.8 INR/km**

Please note that these calculations are illustrative and done based on various assumptions. The computations and analysis would differ significantly if any assumption is not validated.
Some of the assumptions are given here. *It is assumed that vehicles cover 21,900 km per annum under commercial segment and 14,600 km per annum under passenger segment. It is assumed that loan at 12% per annum would be available for a tenure of 4 years. Corporate tax rate of 30% is assumed for the calculations. Price of electricity is assumed at INR 6 per unit (2015) and expected to increase by 3% per annum. Price of petrol and diesel is assumed to be INR 67 and INR 58 per liter respectively with annual increment of 1%.*

Impact of Electric Vehicles on Indian power sector

Increased adoption of EVs is expected to create a win-win situation for both utilities and power consumers. For utilities, EV create additional power demand which is flexible in nature, thereby helping in better renewable energy penetration and improved utilization of assets. For consumers, there is a potential revenue opportunity arising out of vehicle to grid integration/support.

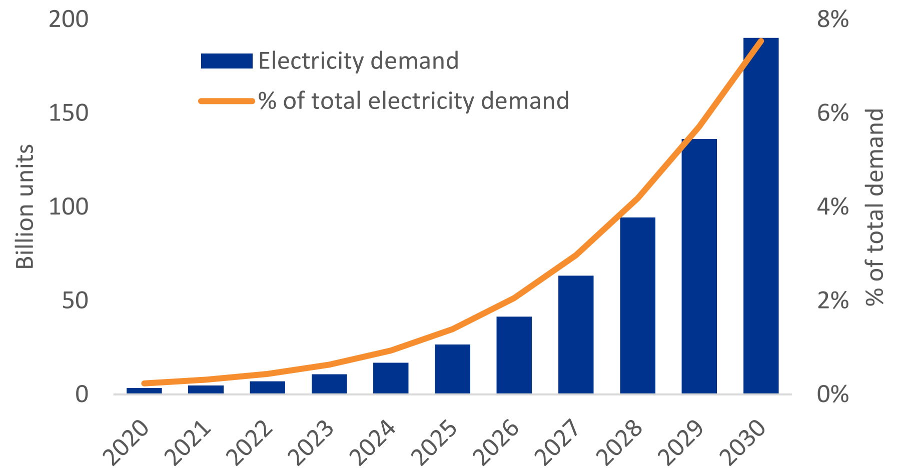
By 2025, it estimated that around 26GWh of used batteries can be re-deployed for stationary energy storage solutions. These batteries are expected to be technically adequate and economical when compared to newly bought batteries.

Source: Lithium-ion battery costs and market, Bloomberg New Energy Finance, July 2017; Clean Technica report

Increased power demand

By 2030, EV's can potentially contribute to around 190 billion units (assumptions mentioned below) of annual electricity requirement- 8 per cent of country's projected annual electricity requirement[16]. Additionally, this will also help improve India's energy security by reducing the import dependency for energy (since past five years, more than 80 per cent of India's oil demand is met by imports[17]. By 2030, 91-93 per cent of India's oil demand is expected to be dependent on imports in a least effort scenario[18]).

Figure 3: Electricity requirement due to EV adoption is set to rise



Source: KPMG analysis

Assumptions:

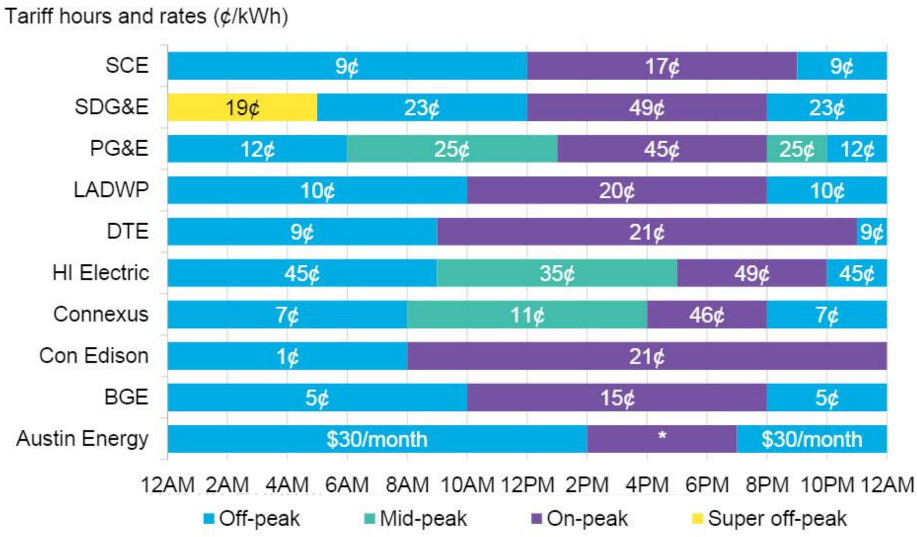
- *By 2020, it is assumed that India will have around 4.25 million two wheeler EVs and 300,000 four wheelers (all taxis) as EVs (for sake of simplicity it is assumed all EVs are battery EVs) – as per Faster Adoption and Manufacturing of hybrid and Electric vehicles (FAME) policy targets*
- *By 2030, it is assumed that 70 per cent of new two wheelers and taxis would be EVs. In between 2020 and 2030, S curve adoption rates are assumed*
- *For passenger cars, it is assumed that market would take off after 2023. Till 2023, only 5 per cent market penetration is assumed with S-curve adoption starting in 2024 and reaching level of 50% market penetration by 2030*
- *6 year CAGR is used to predict future vehicles registrations in India for two-wheelers, Taxis and Passenger cars (Source: Table 20.1-Number of motor vehicles registered in India, Statistical Year Book India 2017, Ministry of Statistics and Programme Implementation)*
- *It is assumed that for two wheelers, 6.5 units of electricity would be required for 100 km and for four wheelers, 25.5 units would be required for 100 km (Based on average mileage taken from FAME policy)*
- *Annual distance traveled: 6,000 km (two-wheelers), 14,600 km (passenger cars) and 21,900 km (taxis)*

Improving utilization of the deployed network

EVs can help in better utilization of the existing network. However, this would require a consequent change in regulatory/tariff structure. Globally certain measures such as Time of Day (ToD) tariffs for EV charging have already been taken up by utilities (refer figure 4).

[16] India's total demand for electricity predicted in FY2027 is 2,131,987 MU in one of the scenario in Draft National Electricity Plan. To predict demand for FY2030, 5.8 per cent CAGR is assumed same as CAGR between 2022 and 2027.
[17] Historical data on consumption and import of crude and products, Petroleum Planning and Analysis Cell, Ministry of Petroleum and Natural Gas
[18] Least effort scenario assumes that little or no effort is being made in terms of interventions on the demand and the supply side (Source: India Energy Security Scenario 2047, NITI Aayog)

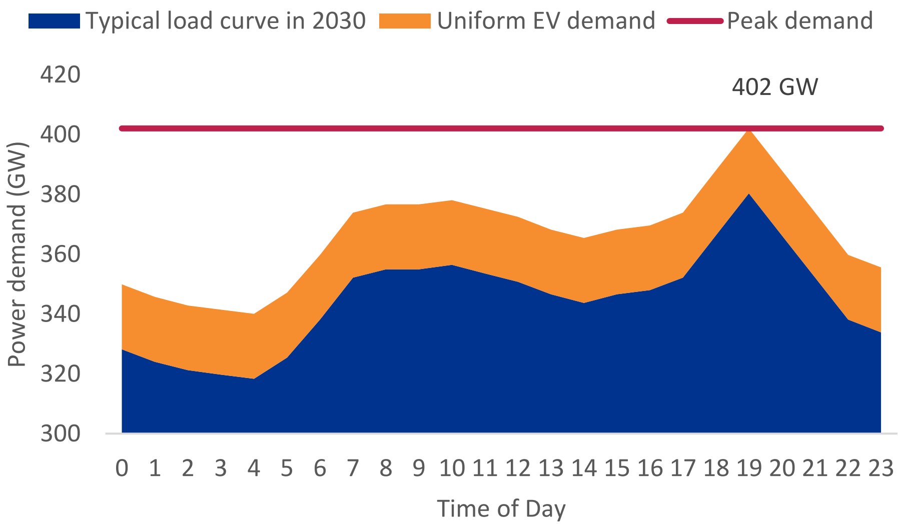
Figure 4: ToD tariffs charged by utilities in USA for EV charging



Source: Bloomberg New Energy finance

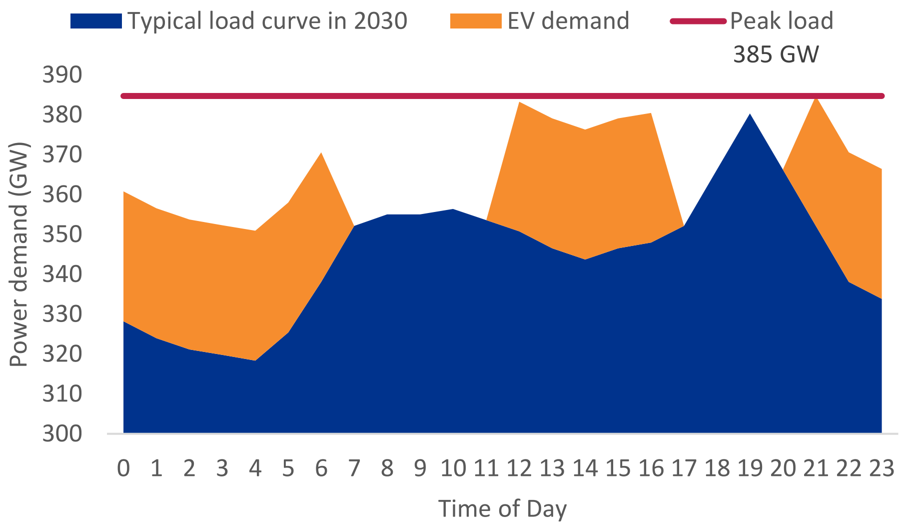
By 2030, India's peak power demand (without considering power demand from EVs) is expected to be 380 GW. Taking into account the EV adoption and unrestricted grid access, the peak power demand is likely to increase to around 402 GW by 2030 (refer figure 5). Right tariff targeting/framework can help avoid the additional EV peak contribution (peak demand expected to increase to 385 GW only, refer figure 6) - thereby saving the capital expenditure for transmission network up-gradation. The right tariff strategy can thus support utilities in managing the EV loads.

Figure 5: Load profile on a typical day with uniform EV load in 2030



Source: KPMG analysis

Figure 6: Load profile on a typical day in 2030 with ToD charging policy in place

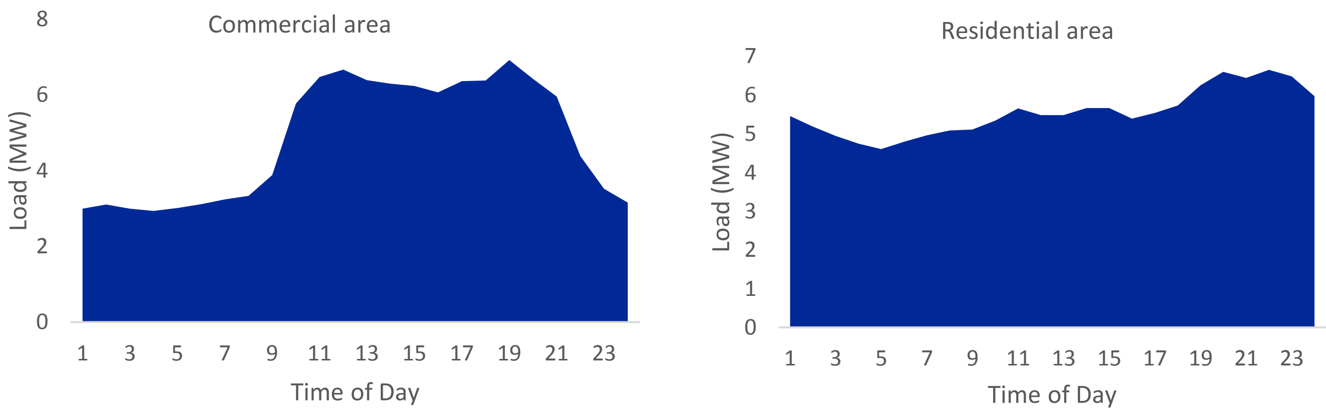


Source: KPMG analysis

Please note that above graphs are for illustrative purposes only. Actual demand curve for EVs can differ significantly. Assumptions: For 2027, the peak load is taken from Draft National Electricity Plan at 317,674 MW. To predict peak load for 2030, 6.2 per cent CAGR is assumed same as CAGR between 2022 and 2027.
India's load curve is projected using typical all India load curve (2015) as given in report titled "Electricity demand pattern analysis" published by Power System Operation Corporation Limited. The load curve for 2030 is projected by assuming the same shape of load curve till 2030.

The tariff structure needs to take into account the difference in load curve of different consumer categories to incentivize the EV charging in local off-peak hours (refer figure 7).

Figure 7: Illustrative load profile of a substations serving commercial and residential areas (selected randomly in a south Indian state)



Source: KPMG analysis

Each city has its own spatial distribution of commercial and residential areas. So each city has to design its own tariff structure to handle the load generated due to EVs.

ToD tariffs have already been implemented for industrial and commercial consumers in few states such as Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra and Telangana. States are yet to design dynamic tariff structure to manage the EV charging. Thus, it is imperative to create awareness among State Electricity Regulatory Commissions to act pro-actively on tariff structures for EVs.

Overall tariff restructuring reforms are already under consideration in India. A committee has been constituted under the Ministry of Power to develop a design framework enabling uniform and homogenous electricity tariff categorization across India[19]. It is yet to be seen how these reforms are implemented across the country and how these incorporate tariff structure for EVs.

Better renewable integration into the grid

EV adoption can help integrate more renewable energy into the grid by:

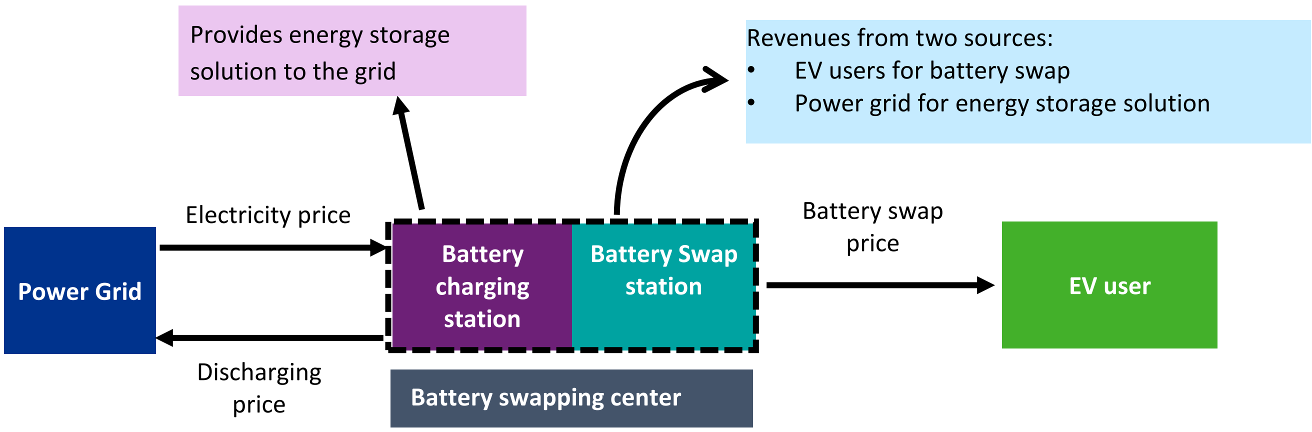
- 1,200 GWh[20] of potential EV/distributed battery storage capacity by 2030 can be leveraged to optimally integrate more solar rooftop at local distribution level itself.
- Other potential ancillary services from EVs to the grid such as peak demand reduction, power back up and demand response can provide additional revenue opportunities for customers.

Key challenges in EV adoption

EV adoption rate is expected to be driven primarily by the evolution of cost effective battery storage technologies. The high upfront battery costs still remains the biggest bottleneck for larger EV penetration. Hence to promote EV adoption, countries across the globe give financial as well as non-financial incentives. Indian government also provides financial incentive of up to INR 1.24 Lakh for electric cars[21] under FAME policy. Apart from direct financial incentives, alternate business model solutions such as battery swapping infrastructure may be explored to reduce the upfront costs.

In battery swapping business model, EV owners pay for batteries on per month/per charge basis instead of buying EV battery upfront. The battery swapping station earns revenue by swapping batteries for EV users and providing utility scale energy storage solutions to the grid.

Figure 8: Illustrative business model for EV battery swapping centers



[19] Conference of Power, Renewable Energy and Mines Ministers of States & UTs, May 2017
[20] EV adoption rates as taken in analysis briefed in figure 3. Typical storage capacity in a vehicle is computed from FAME policy document.
[21] Incentive given for Mahindra E2O T1/T2/T6 and E2O plus P2/P4/P6/P8.

Battery swapping model has been implemented in Israel and China (in china there are ~3,600 battery swapping stations[22]). However these has met with limited success. Several issues such as standard protocols, battery design, safety issues, etc. need to be assessed for ensuring a successful roll-out. This model might be more appropriate for public usage based transport where standardization is easier to achieve. Recently, there has been significant interest among leading EV manufacturers and policy makers to develop this model.

[22] Liang Y., Zhang X., Xie, J. and Liu W., An Optimal Operation Model and Ordered Charging/Discharging Strategy for Battery Swapping Stations, Sustainability, April 2017. doi:10.3390/su9050700

Conclusion

In India EVs are expected to become affordable in early 2020s. Commercial vehicles are expected to become economical earlier as compared to privately owned vehicles (in term of total cost of ownership). Favourable government policies can further help in improving the affordability of EVs. Government needs to come up with clear policy on EV charging infrastructure related investment and tariff policy for EVs to promote EV adoption. Rapid EV scale up can have a positive multiplier effect on Indian economy especially on the power sector.

EVs are expected to add significant power demand. This additional burden on the grid can be managed with minimal network investment with the help of intelligent tariff and pricing solutions. In fact, EV presents a flexible demand on the grid which can help de-carbonize the power grid by helping integration of higher share of renewables in the grid.

Power sector stakeholders (regulators and utilities) however need to act proactively to enable grid integration of EVs. If not managed in a smart way, EVs can also represent a big challenge as they can disrupt the whole power system, adding peaks to the load curve.

About Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation works to strengthen the energy security of India by aiding the design and implementation of policies that encourage energy efficiency as well as renewable energy. Based on both energy savings and carbon mitigation potential, we focus on four broad sectors: Power, Transport, Energy Efficiency and Climate Policy. We act as a systems integrator, bringing together key stakeholders including government, civil society and business in strategic ways, to enable clean energy policies in these sectors.

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