Smart Charging and Electric Vehicles Management Solutions: A Perspective

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Abstract: India is keen to attempt to work towards a low carbon emission pathway, As per goal set up for Intended Nationally Determined Contribution (INDC) by India, India has to reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005. Sustainable green transportation network is one of the measures for achieving this goal. Government of India is undertaking multiple initiatives to promote manufacturing and adoption of electric vehicles in India. However, in India Electric vehicles (EVs) still have a long way to go for making a significant change.

Since, EVs needs charging stations to charge the batteries, the impact of EVs on power system cannot be ignored. The impact of EV charging will be felt first at local hotspots on distribution grids before the other levels i.e. generation, transmission and grid are affected. The effect of load of charging of EVs will be more visible on power system when there is a significant number of electrical vehicle being used by the citizens/people. This papers gives a perspective and insight into that how Smart charging & EV management Solutions may bring various benefits to Network operators and Electric Vehicle owners. As the number of Electric Vehicle grows, the implementation of smart charging will allow EV drivers to charge reliably and economically and will also increase the hosting capacity of EVs in distribution network with reduced/delayed network augmentation. As the EV load penetration increases, smart Charging of EVs may also form EV loads to be managed in flexible manner, i.e their charging times can be coordinated with renewable energy generation. The widespread adoption of EVs and their evolving technologies also allows for envisioning a future in which EVs can feed electricity back into the grid, known as vehicle to- grid (V2G) integration. EV as flexible load and V2G technologies require aggregating large numbers of individual EV loads which could be seen as a large source of generation or load providing ancillary services such as spinning and reserve.

However, the significant number of EVs used by the citizens/people is the essential parameters for all the measures mentioned in the paper.

Keywords: Electric vehicles, Distribution Network, Smart Charging, EV management solutions.

1. INTRODUCTION

India is keen to attempt to work towards a low carbon emission pathway, while simultaneously endeavoring to meet all the developmental challenges that the country faces today. As per goal set up for Intended Nationally Determined Contribution (INDC) by India, India has to reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level and to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030. Thrust on renewable energy, promotion of clean energy, enhancing energy efficiency, developing climate resilient urban centers and sustainable green transportation network are some of the measures for achieving this goal.

Electrifying road transportation through Electric vehicle is one of the measures for achieving the goal for low carbon emission pathway. It has multiple benefits, including the reduction of emissions of local pollutants and noise and the promotion of energy security and decarbonisation.

2. ENABLING FRAMEWORK FOR DEPLOYMENT OF EVS

A supportive policy environment enables market growth by making vehicles appealing for consumers, reducing risks for investors and encouraging manufacturers willing to develop EV business streams on a large scale to start implementing them. Governments across the world are offering substantial direct and indirect incentives to promote EVs. Direct incentives include purchase subsidy for EVs and subsidy for installation of chargers while indirect benefits range from tax breaks to access to reserved lanes and parking spots etc[4][1]. France offers a CO2 emission based “feebate” system, which subsidizes electric vehicle purchase while penalizing higher-emission vehicles [4].

In India, setting long-term vision for EVs & its deployment will help to ensure sustainable penetration of EVs and will also define a roadmap for the industry while giving the industry enough time to prepare and act:

(i) A consistent and stable government policy on emission regulations and well defined

strategic targets on crude oil substitution could offer long-term clarity to the automotive industry, enabling companies to plan in advance.

(ii) Policy support along with suitable regulatory provisions/clarifications from different Government Departments /regulators. Direct & indirect incentives from Government will enable the market growth by making Electric vehicles appealing for consumers, reducing risks for investors and encouraging manufacturers willing to develop EV business streams on a large scale to start implementing them.

(iii) Cohesive focused efforts from Original Equipment Manufacturers, utilities to work together for common standards and devices.

(iv) More funds and work for R&D in the area of charging technology, battery technology, vehicle technology, charging infrastructure etc. Later on the R&D can be expanded for Smart Grid & Smart charging and EV management solutions, information and communications technology (ICT) infrastructure and services for smart charging network extendibility and operational efficiency, power quality, flexibility, V2G etc.

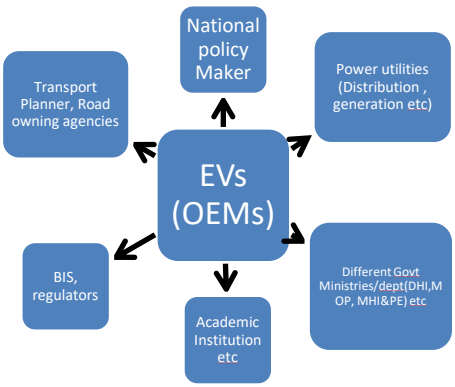

Figure 1: Various stakeholders of EVs

In India, Electric vehicles (EVs) still have a long way to go for making a significant change in oil demand and greenhouse gas (GHG) emissions. The policy support for deployment of market for EVs will lower/remove the barriers towards faster adoption. Government of India is undertaking multiple initiatives to promote manufacturing and adoption of electric vehicles in India. Government of India had announced the National Electric Mobility Mission Plan 2020 (NEMMP) in 2012,along with Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME) guidelines in 2015 to provide incentives to EVs[4].With support of the Government, electric vehicles have started penetrating in the Indian market.

Availability of adequate Charging Infrastructure is another key requirement for accelerated adoption of electric vehicles in India. Recently Ministry of Power (MoP) have issued following clarification/order in this regard.

(i) MoP vide letter dated 13th April, 2018 have clarified that during the activity of charging of battery for use in electric vehicle, the charging station does not perform any of the activities namely transmission, distribution or trading of electricity, which require licence under the provisions of the Act, hence the charging of batteries of electric vehicles through charging station does not require any licence under the provisions of the Electricity Act, 2003[5].

(ii) Further, MoP vide their letter 14 th December, 2018 have issued Guidelines for Charging Infrastructure for Electric Vehicles — Guidelines and Standards [6]. In the guideline , it has been mentioned that private charging at residences / offices shall be permitted. DISCOMs may facilitate the same. Setting up of Public Charging Stations (PCS) shall be a de-licensed activity and any individual/entity is free to set up public charging stations, provided that, such stations meet the technical as well as performance standards and protocols laid down as well as any further norms/standards/specifications laid down by Ministry of Power and Central Electricity Authority from time to time. Any person seeking to set up a Public Charging Station may apply for connectivity and he shall be provided connectivity on priority by the Distribution Company licensee to supply power in the area. Any Charging Station/ Chain of Charging Stations may also obtain electricity from any generation company through open access. The guideline also gives direction in regard to Public Charging Infrastructure (PCI)- Minimum Requirements, Location of Public Charging Stations, Priority for Rollout of EV Public Charging Infrastructure, Implementation Mechanism for Rollout etc.

The above clarification/order of MoP have given direction for setting of Charging Infrastructure for accelerated adoption of EVs in India.

3. IMPACT OF EV'S ON POWER SYSTEM

Since, EVs needs charging stations to charge the batteries, the impact of EVs on power system

cannot be ignored. However, the same would only be visible when there is a significant number of electrical vehicle being used by the citizens/people.

With the rise in sizable number of EVs and its usage patterns, there may have an impact on power system at different levels, i.e generation, transmission, system operator & distribution. Some of the impacts, with the widespread use of EVs, are mentioned below:

(i) Generation: There may have an increase in the energy requirement on all India basis due to charging of batteries of EVs. The increase in All India peak demand may depend upon the charging pattern of Electric Vehicle owners.

(ii) Transmission : There may be change of direction and quantum of power flow on Inter-state and Intra State transmission lines. Although this will depend on weather and behavioral aspects of citizen/people for charging of their EVs.

(iii) System operator : During peak times, the system may require more system services, such as frequency control ancillary services, and the need to maintain reserve power capacity, if EV loads coincides with peak times.

(iv) Distribution level: The DISCOMS would have to procure more power for charging requirement of EVs. The network augmentation may be required to cater the load of EVs and to avoid overloading of lines and transformers. The voltage drop below a statuary limits may also be felt at distribution level. There may have some assets which can experience thermal limits/overloads. The power quality may also be affected. In addition, EVs in contrast with other loads on distribution networks, are not stationary.

The impact of EV charging will be felt first on distribution grids before the other levels are affected. It is, therefore, DISCOMs would have to evaluate how these will be affected by different numbers of EVs. Further, the number of EVs simultaneously charging will depend on multiple factors, including the time of day (morning/afternoon/evening), type of day (weekday or weekend), weather conditions, EV owner's requirement etc[2].

The impact of EVs on distribution side can be minimized by following ways:

(i) Planning and building the charging infrastructure at such locations where the effect of EV load is minimum in the distribution network. Such as in Netherlands, the installation of charging points is tied to residential areas where electric car owners request parking permits[1].

(ii) EVs can offer the dual benefit of RE integration as well as load flattening for DISCOMs. EVs may form a "flexible load," i.e. their charging times can be coordinated with renewable energy generation, to ensure effective uptake of RE in the grid thus allowing DISCOMs to meet their RPOs as well as for load flattening [4].

(iii) The second option is to augment the distribution network with more CAPEX and pass on the costs to consumers through the tariff system. The CAPEX investments can also be capitalized by offering aggressive time-of-day (ToD) tariffs[4].

(iv) Electric Vehicle Management System and Smart Charging are the another ways to minimize the effect of load of charging of EVs on distribution network. They could reduce/delay or avoid the need to upgrade/replace networks for EV loads to some extent [1].

4. WAY FORWARD FOR SMART CHARGING: A PERSPECTIVE

Smart Charging & Electric Vehicle management solution: Smart charging is the intelligent charging of EVs, where charging can be shifted based on network loads and in accordance to the vehicle owner's needs. Smart charging needs an Electric Vehicle management solutions to cater the requirements of network as well as of vehicle owners both. It needs Control signals which can be enabled at the Electric Vehicle Supply Equipment (EVSE) level or within vehicles. These signals would require an information and communications technology (ICT) infrastructure for communicating between charging points and back-end systems[1]

The EV management solution for smart charging may build some of the algorithms as per the requirement of distribution network operators and Vehicle owners. Algorithm which may be built in initial stage for gaining experience are as follows[7]:

- Minimise cost – only charges at lowest cost periods as per ToD tariff structure
- Optimise time – charge starts as soon as the EV is plugged in, ignoring price signals
- Optimise time and cost – avoids charging at the most expensive peak price period
- The algorithm for ensuring that the car gets the required charge (for the next planned journey input by the driver) to optimize the time.
- When a thermal or voltage problem is detected in the network, a control signal for corrective approach to disconnect the EV

charging points may be actuated. On the other hand, while reconnecting an EV, another control signal to reconnect the most suitable EV may be actuated.

EV load as a Flexible load: As the EV load penetration increases, smart Charging of EVs may also form EV loads to be managed in flexible manner. It may also help in demand-response by shifting EV load demand so that it coincides with RE generation or lowers the ramping requirements of the remaining generation fleet or to reduce peak load. Providing price signals & incentivising the consumers could help to achieve this[1]. Signals given to charging stations will have to consider the generation and grid/network constraints as well as enable customers to benefit from price opportunities.

Table-1 Road map and initiatives

Sr No.	Road Map	Initiative
1	Government directives on emission regulations	As per Intended Nationally Determined Contribution (INDC) by India, India has to reduce the emissions intensity of its GDP by 33 to 35 per cent by 2030 from 2005 level and to create an additional carbon sink of 2.5 to 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.
2	Policy support along with suitable regulatory provisions/clarifications from different Government Departments/regulators, direct & indirect incentives from Government	(1) National Electric Mobility Mission Plan 2020 (NEMMP)-by DHI (2) FAME-I (3) FAME-II (4) MoP vide their letter 14 th December, 2018 have issued Guidelines for Charging Infrastructure for Electric Vehicles — Guidelines and Standards
3	Cohesive focused efforts from Original Equipment Manufacturers to work together for common standards and devices.	OEMs in together taking up various R&D projects for electric mobility. Indian Standard for Electric Vehicle Conductive Charging System- Part 1(General Requirements) has been published by BIS as IS 17017(Part 1):2018.
4	More funds and work for R&D	Various R&D projects in the area of charging technology, battery technology, vehicle technology, charging infrastructure & system are under process.

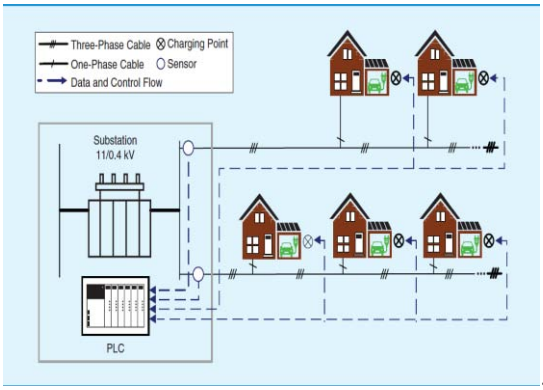

Figure 2: The infrastructure used for deploying the EV management solution [2].

Vehicle to Grid (V2G): The widespread adoption of EVs and their evolving technologies also allows for envisioning a future in which EVs can feed electricity back into the grid, known as vehicle to-grid (V2G) integration. Electricity distribution companies in US, Japan and China are experimenting with utilization of EVs as grid assets, either by using them as a demand response resource or for providing ancillary services through Vehicle-to-Grid technologies [4].

Aggregators: EV as flexible load and V2G technologies require aggregating large numbers of individual EV loads through analytics and local area control [1]. This may bring the concept of aggregators who could be seen as a large source of generation or load, which could provide ancillary services such as spinning and reserve.

While aggregators could operate at grid level, they could also trade with the local DISCOMs/network operator to provide system services. Meanwhile, who should provide these services is a question that is tied to specific systems and regulatory designs – options include public utilities, third parties and e-mobility service providers[1].

Standards: The charging infrastructure for EVs will require common standards and interoperable solutions between charging stations, distribution networks and the EVs themselves [1]. Interoperability and common standards are necessary to ensure compatibility and efficient communication to enable EVs as flexible roaming platforms where consumers can be aggregated as they drive and charge in different local distribution networks. Interoperability is necessary both on the physical-electricity-network side but equally at the ICT interface, where information will need to flow efficiently across the range of stakeholders along the value chain of the charging service. The Technical Committee of BIS is formulating Indian Standards on Electric Vehicles and Charging Stations. These Standards are being formulated

taking into consideration the International standards and also factoring in the local conditions in India. Indian Standard for Electric Vehicle Conductive Charging System- Part 1(General Requirements) has already been published by BIS as IS 17017(Part 1):2018.

Business model: To enable smart charging, regulators and policy makers may have to enable business models that deliver some combination of price signals, control signals and aggregation enabled by data analytics and controls for a large numbers of EV users[1].

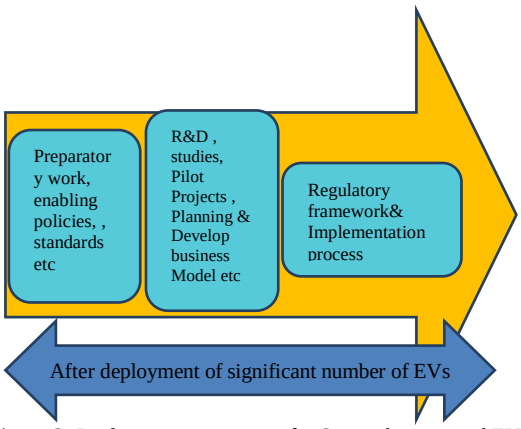

Figure 3: Implementation strategy for Smart charging and EV management solutions, Aggregators, V2G etc.

Road Maps: If the capital costs of EVs are brought down with the help of new technology and efficient pricing of electricity, better integration of intermittent renewables and hence a more sustainable electricity sector from the present BAU would enable a major shift to EVs. The roadmap to achieve this, may include elements shown in fig.3.

5. CONCLUSION

Smart charging & Electric vehicle management solutions may bring various benefits to Network operators and Electric Vehicle owners. As the number of Electric Vehicle grows, the implementation of smart charging will allow EV drivers to charge reliably and economically and will also increase the hosting capacity of distribution network with reduced/delayed network augmentation.

Smart charging and Electric vehicle management solutions would also help in providing different solutions for vehicle to- grid (V2G) integration and EV as a flexible load for demand response. To gain experience over the concept, some pilot or R&D projects in these areas may be taken up in the end of .

However, the significant number of EVs (Fig 3) used by the citizens/people is the essential parameters for all the measures mentioned in the paper.

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