Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market

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Abstract

This paper discusses about the potential need for electric vehicles (EV), charging station (CS) infrastructure and its challenges for the Indian scenario. Battery electric vehicles (BEVs) are promising class of drive trains in the coming years especially in urban regions in order to shift the decentralized exhaust emission in megacities to centralized power plants in rural areas. Up to now the BEV’s bottleneck is in the range of 100km per charge due to limited on board energy which can be optimized by introduction of plug-in hybrid vehicles along with real time road traffic management. With increase in liberalization, privatization and expansion of distributed and renewable power generation of Indian electricity market, transmission and distribution, as well as market processes related to the allocation of energy and energy mix are undergoing an evolutionary development with improved efficiency and reliability. A structured analysis of respective parameters is performed for the commercial scopes of electric vehicles in existing energy market. Market-based and regulatory concerns are considered to outline a scenario where an aggregator controls the charging of electric vehicles and provides ancillary grid services. Searching charging stations for electric vehicles is an important issue for the drivers which need the implementation of smart charging infrastructure network. Charging Station selection algorithms involve the overall information obtained through interactions between the EVs-EVs and EVs-Charging Station selection (CSS) server through the mobile network, delivering information regarding availability of charging slot at nearest CS, thus minimizing individual waiting time and provide improved efficiency.
Keywords: Electric vehicle; Charging station selection; Charge scheduling; Energy mix; Grid-Electric vehicle; smart charging.

1. Introduction
1.1 Potential need for Electric Vehicles
India is one of the top ten automotive markets in the world today and having highly increasing middle class population with buying potential and the steady economic growth. But petrol price has increased more than 50% in 13 different steps in last two years. Here comes the potential need for alternative technologies in automobiles such as electric vehicles (EV) in India. Although the initial investment is around 1.5 times than conventional IC engine, but time has come when cost of environment is now more of concern than the cost of vehicle. National governments are focusing on R&D and consumer incentives, whereas city governments are supporting infrastructure deployment locally through public-private partnerships and other programs. The Global EV Outlook (GEO) finds that global EV sale has increased more than double between 2011 and 2012, exceeding the 100,000 sales milestones. Together EVI countries have deployed about 47,000 slow and 1,900 fast non-residential charging points till 2012, and their governments have spent approximately USD 800 million on infrastructure deployment since 2008. These efforts are beginning to pay off, with battery development costs dropping from $1,000/kWh in 2008 to $485/kWh in 2012. The most successful EV region is the Kanagawa Prefecture in Japan with 2,183 EVs. The second most successful EV city is Los Angeles. Rotterdam is the most successful electric car city in Europe, with 1,100 EVs on road. Dutch city is the electric car hub with 532 EVs per every 100,000 registered vehicles. The IEA study took an in-depth look at the energy infrastructure, travel patterns all over the world. These areas are actively pursuing development goals through different innovative policies and programs. Some of the approaches are for example drivers of electric cars are offered a financial consumer incentives, such as tax credits, purchase subsidies, discounted tolls, free parking, and access to restricted highway lanes.

1.2 Comparison between three different fuel types keeping total expenditure constant
Considering the total cost of transportation as constant i.e. Rs. 5000, the table below shows the range can be achieved by all the three types of vehicles. Unit cost of petrol, diesel and electricity is assumed as Rs. 75/ltr, Rs. 60/ltr and Rs. 5.75/kwh. For EV, Nissan Leaf specification is referred, (121 km/24 kWh) with total discharge up to 20%. For ICE vehicles the mileage is taken as 20 kmpl for both petrol and diesel.

<table>
<thead>
<tr>
<th>Fuel/Data</th>
<th>Petrol</th>
<th>Diesel</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost/Liter</td>
<td>Rs. 75</td>
<td>Rs. 60</td>
<td>Rs. 5.75</td>
</tr>
<tr>
<td>Consumption</td>
<td>67 Ltr.</td>
<td>83 Ltr.</td>
<td>870 kWh</td>
</tr>
</tbody>
</table>
Potential Need for Electric Vehicles, Charging Station Infrastructure

<table>
<thead>
<tr>
<th>Range/month</th>
<th>1333 Km</th>
<th>1667 Km</th>
<th>3623 Km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range/day</td>
<td>44 Km</td>
<td>56 Km</td>
<td>121 Km</td>
</tr>
<tr>
<td>Range/year</td>
<td>16000 Km</td>
<td>20000 Km</td>
<td>43478 Km</td>
</tr>
</tbody>
</table>

With Rs. 5000, 67 liters of petrol, 93 liters of diesel and 870 kWh of electricity can be consumed. From that the maximum range per year can be calculated. Considering diesel range i.e. 20000 km/year as reference, petrol doesn’t even reach that range and the clear winner is electric with an excess range of 23247 km/year, which is equivalent to a saving of Rs. 32700/year. The excess investment in buying an electric car can be easily recovered within couple of years of fuel saving. Otherwise the cost of environment is now more of concern then the cost of fuel.

2. Charging Station

2.1 Requirement of charging station Infrastructure

Charging infrastructure will play a pivotal role on EV deployment, and, in the absence of a proactive plan and schedule, is a major impediment to mass market adoption. Infrastructure limitations are particularly pertinent to BEVs due to their sole dependency on electricity. The charging infrastructure includes all of the hardware and software that ensures energy is transferred from the electric grid to the vehicle. It can be categorized by location, power level and charging time strategy.

Charging locations combined with an acceptable charging time strategy increases BEV functionality and decreases public charging requirements. The approximation of the electric vehicle supply equipment (EVSE) needed at different types of locations (e.g., Home, Work and Commercial Parking) is proposed based on an optimal charging strategy.

2.2 Indian current scenario

Large scale introduction of Plug-in electric vehicles (PEVs), including plug-in hybrid electric vehicles (PHEVs) and Battery Electric Vehicles (BEVs) have the potential to improve Indian energy and environmental landscape of personal transportation. Central government should start enforcing necessary measures to install EV charging infrastructure. Initial step could be to encourage international market players to make case studies on potential locations and adequate quantity of Electric Vehicle Supply Equipment (EVSE). With a projection of EVs, the effects on current, energy production, transmission and distribution scheme, road traffic density, emission level and parking space requirement need to be analyzed. Operation and maintenance of installed infrastructure should be maintained properly. Instead of direct involvement of Govt. body, private players should be tendered in order to maintain the smooth work flow. Central management through Charging Station Selection server (CSS) will play a vital role in information transfer between EVs-Server-Control centres.
2.3 Algorithm for charging station selection
Charging Station Selection server (CSS) traces the instantaneous location of a vehicle and taps the range available with it. It proposes all the charging stations covering the limit. CSS communicates with other vehicles to determine the road traffic and gives an approximate time and charge remaining, until a specific charging station is reached. It also suggests an alternate route to the nearest charging station in case of heavy traffic. The driver chooses the charging type and blocks a slot considering least waiting time. The CSS uses mobile network to communicate with the vehicle and CSs. It also proposes the current metering scheme at particular CS and compares with other CS price. It also can be done through a demand based metering system where EVs will be charged according to peak time and peak load.

3. Integrated power and transportation network
Electric Vehicles face different challenges with respect to the power grid. The charging problem starts with the vehicles flux at the power consuming location, where the power flows from the grid into the batteries. The electric energy is transferred only via the distribution grid, which limits the energy flowing in the transmission lines - transportation network. The other problem is that to know whether the road vehicles flux and the power available at the charging station network are in real time balanced. This increases the difficulty of EVs charging management. Grids, with flexible control characters, have the potential to successfully manage the load. Thus communication network, no matter what type it is, is indispensable to be the information exchange bridge between the transport network and the power grid. Therefore future power distribution grid with large amount of EVs charging load, will interact among the transportation network, power grid and the communication network.

3.1 Requirement for Smart Grid
One way of enhancing the power grid is to increase renewable energy production. But Indian power sector is yet to meet the demand completely. Other way is to utilize the available resources smartly. Increasing the Supply, by installing new power plants is a systematic process and it will take time. Here comes the need for smart grids. Smart grids introduce a two way dialogue where electricity and information can be exchanged between the utility and its customers. Its developing network of communication, controls new automation technologies and tools working together to make the grid more efficient, reliable, secure and greener. Smart grid enables other technologies to be integrated thus making the grid autonomous and efficient. The major aim of smart grid in India is to optimize the demand side management rather than generation side. Each home should have a smart Energy Management System which will help managing the electricity consumption more efficiently. Smart devices
and appliances will adjust their run schedule to reduce electricity demand on grid at critical time and lowering energy bill.

4. Grid to Electric Vehicle
4.1 Impacts on electricity supply and the grid
Impact of high level of penetration of EVs on the electricity grid would mainly be on the low voltage (LV) distribution grid, and would depend on characteristics of grid as well as on the timing, location and rate of battery recharging required. However, demand-side management is achieved by using smart metering systems, variable electricity tariffs and off-peak battery charging. This gives a potential to significantly reduce the need for grid reinforcement and the costs associated with it. Moreover, this could also increase the utilization factor of existing low-GHG power generation assets such as Hydropower plants and wind farms, thus improving their economics. The charging schedule of EVs has very important implications on the well-to-wheel (WtW) CO₂ emissions.

Here is a study on the energy demand for a residential apartment having 1000 homes. Consider the peak load of a single house to be 5 kWh at night. Thus total load including common amenities will come up to 5050 kWh. Taking factor of safety as 1.5, the required transformer rating will be 7.5 MVA (10x750 kVA). Suppose 50% of the houses are having EVs. If all the EVs are charged at a time with 3.45 kWh, the charging load comes up to 1725 kWh. Total load is revised to 6775 kWh. The required transformer capacity will rise to 10.1 MVA (14x750 kVA) giving rise to an additional investment of around 70 lakhs.

4.2 Smart Chargers
According to studies, India will have close to 1 lakh EVs by 2020. To support this huge network, there is a requirement for smart chargers. Apart from public charging stations, India needs to work on mass charging stations at work places and parking towers. To minimize peak load charging, smart chargers have to cut off power to particular vehicles once it reaches a 70%-80% of charging and divert the same to other cars. Most of the offices in India are small and distributed. So we can have a common parking tower for all the offices at a particular zone where smart charging can be implemented, which will otherwise minimize the individual implementation cost.

5. Result and Discussion
From the fuel comparison table we infer that the cost of fuel i.e. electricity for EVs is 45% cheaper than petrol and diesel. But still it requires a large charging station infrastructure to be installed throughout the country before encouraging the society for adapting it. Government subsidy, public awareness, instant technical support and extended manufacturer warranty are the key measures to attract Indian customers. Instead of solely depending on local OEM, India should encourage more and more
foreign direct investment to serve a faster, better and greener charging infrastructure. For India, to save the large financial investment of large scale grid enforcement, load balancing by variable electricity metering tariffs will be a smart move. Proper information transfer between CSS and EVs should be ensured for smooth traffic flow.

6. Conclusion
India should invest in small scale reinforcements to manage the load issues locally instead of going for a massive change. Home charging should be encouraged for long battery life and grid balancing. Proper planning of place, population, traffic density and safety should be taken into consideration before implementing the large scale charging infrastructure for the second largest populated country of the world. Consortiums of companies in the transport, energy and power electronic sectors which are working on projects connected with the initiation of commercial charging terminals for electric vehicles, as well as fast-charging stations. It seems, however, that the most important question in the building of an electric vehicle market, and the EV vehicle charging system, is the integration of activities in the energy and transport fields. Only systematic development of both systems will provide stable and reliable electrical power system, especially at the level of limited power and sustainable development of the Indian electric vehicle market.

References
[3] Indian Passenger Vehicle Industry, An ICRA Perspective