E-Mobility Integration

Electric Mobility, like wind and solar energy, has finally arrived on the scene where it is challenging nearly a century old fossil fuel powered mobility option. It is often branded as step towards cleaning our transport system with high carbon footprint, meeting climate goals and improve air quality in urban spaces.

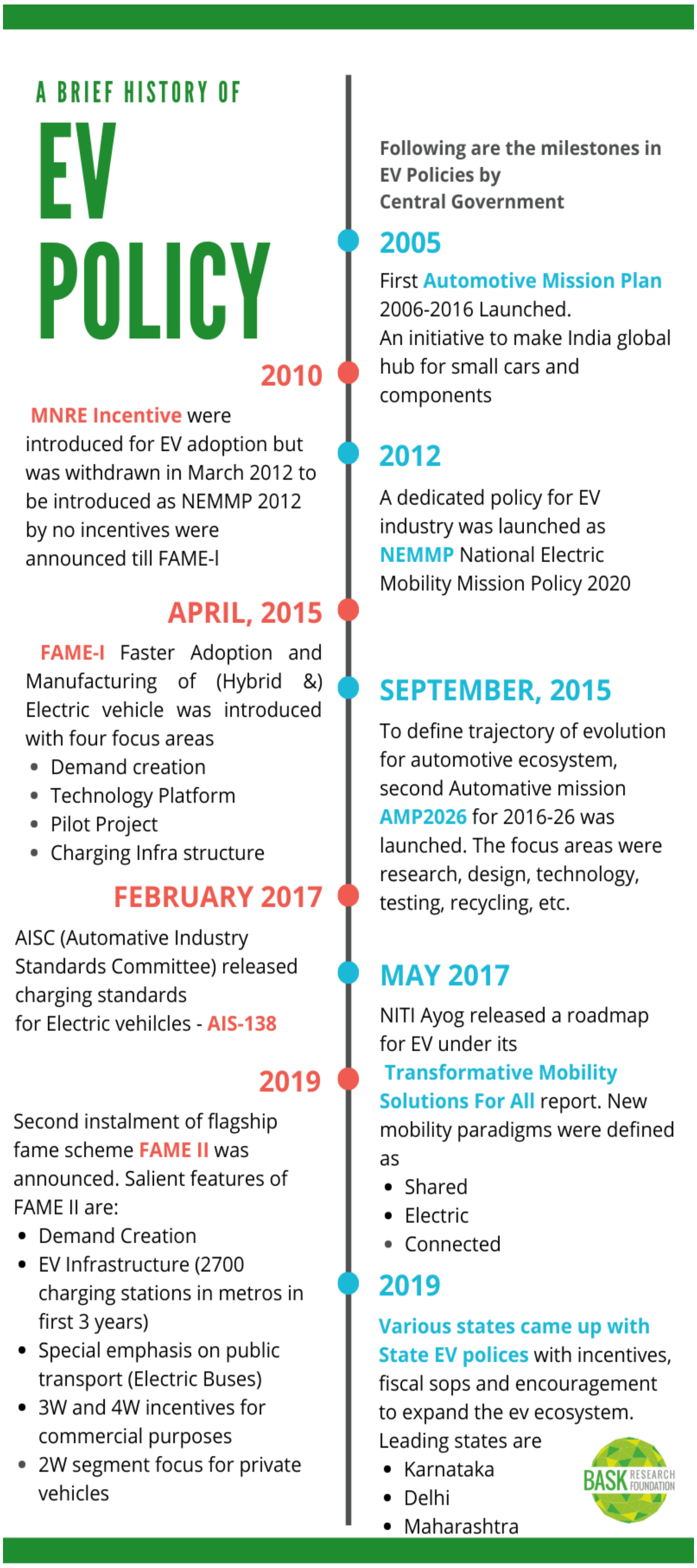
Complexity of electric mobility transition does exceed the complexities and challenges inherent to low mobility planning, even though later is just an additional dimension to the former. First and foremost, e-mobility poses a threat to traditional automotive industry, along with livelihoods and investments linked to it. Secondly, it requires for significant upfront capital investments required for setting up charging infrastructure and procuring electric vehicles. Lastly, for a city to build an ecosystem for electric mobility transition, other than the traditional institutions linked with urban mobility, role of electricity distribution companies and state electricity regulator becomes very crucial.

Electric mobility ecosystem is an amalgamation of three distinct value chains - Energy Supply, Charging Infrastructure and Add-on Services. Customers mobility and providing access to charging is the requisite for building an e-mobility eco-system. The eco-system of E-mobility starts with goal setting, mobility planning and evaluating the current augmentation needs within departments/authorities. It is imperative to foremost address challenges and possible solutions to ensure a seamless E-mobility integration for the city.

Electric Mobility Trends

Indian transport sector is the fifth largest in world and with introduction of EVs, it is set for a major disruption. Recognizing this, Central and state governments are coming up with policies to make the transition swift and conducive for every stakeholder.

One of the most celebrated programs for EV was FAME-1 launched in 2015 under National Electric Mobility Mission Plan. Recently FAME II was launched on 19th March 2019. Though sequel of this flagship scheme does not have any incentives for private



vehicle owners, it has demand side incentives for public transport and commercial fleet. With an outlay of 10,000 Crores for three years (2019-22), this scheme will provide incentives for E-Buses, 3W and 4W to be used for commercial purposes.

FAME II plans to augment the charging infrastructure by

1. Setting up of new charging stations by central govt. in association with PSUs and private partnerships.

2. It envisages to install one slow charger for each E-bus and a Fast charger for a cluster of 10 E-buses.

3. FAME II also encourages the integration of RE with charging infrastructure.

Electric Mobility Trends in Rajasthan:

Rajasthan state has envisaged an EV research and manufacturing zone in new draft industrial policy of Rajasthan.

In addition to this JCTSL (Jaipur City Transport Service Limited) is in process to release tenders for procurement of first lot of E-bus fleet. These buses will have a capacity of 55 passengers and a range of 150 Km on full charge. The buses can be charged to 100% in two hours by fast charger. JCTSL is also planning to install charging infrastructure in the city.

Appointment of JVVN as state nodal agency for EV, tariffs approved by RERC.

REIL (Rajasthan Electronics and Instruments Limited) signed an agreement[1] with Jaipur metro to install three charging stations at 5 metro stations. Each charging station can charge three EVs simultaneously.

Goals for Electric Mobility

While national and state governments are working on targets for electrification of transport sector, it is imperative that a city defines its own goals for electric mobility transition. This shall ensure that electric mobility serves as a tool for larger urban design and sustainability goals for the city.

Following goals are proposed for electric mobility transition for Jaipur city.

Mobility Efficiency

Preference towards mobility solution is a function of ease, comfort, last mile connectivity and speed of mobility. Effectively, choices are often inclined towards fastest solution available for connecting 2 points. While designing mobility solutions, transit speed, along with cost, is the most critical parameter dictating the competitiveness of the mobility solution. Efficiency of a mobility solutions is a function of speed of transit, end to end connectivity, transition time between connecting mobility options and ease of transition.

Hence, while integration of electric mobility solutions, emphasis should be given to improving overall mobility efficiency of public infrastructure.

Carrying Efficiency

Electric mobility transformation holds the potential for creating a smart, connected and efficient mobility infrastructure. However, this shall not be achieved by simply replacing fossil fuel power vehicles with electric vehicles. It is pertinent that special attention is given to decongesting the city by introducing solutions which ensure that public transport and shared mobility solutions are preferred over individual vehicles.

Passenger Safety

Passenger safety is defined as physical and mental safety during the duration of commute via an available mobility option. While this obviously includes road safety and

[1] http://www.reiljp.com/prel139.html

accident free mobility, it lays equal emphasis on safety of different genders and age groups within the mobility environment. Although, relative and subjective, it shall also include a minimum comfort level acceptable to majority of local population.

Capacity Utilisation

Public transport entities have been consistently working with operating losses. Poor capacity utilization, non-sustainable tariffs, competition from private operators are amongst the key reasons for poor state of public transport infrastructure. Electric mobility transformation provides an opportunity to re-think and re-design mobility ecosystem. Prerogative should be towards demand-based mobility solutions, ensuring better capacity utilization as well low stand-by time for mobility assets. This shall pave way for affordability as well as commercial viability.

Air Quality Index

Air quality and emissions in urban areas is increasingly recognized as a critical problem and leading cause of health-related issues, especially among vulnerable age groups. While air quality of a city is a function of many other variables along with vehicular emissions, a study conducted by International Council on Clean Transportation (ICCT)[2] revealed that 76% of air pollution deaths in India are linked to IC vehicle emissions. Given the increasing consciousness around emissions related issues, an electric mobility transformation plan which has the potential of measurable impact on air quality is likely to find support across multiple stakeholders.

Understanding Electric Mobility

A traditional an ICE vehicle is powered by burning fossil fuel in its internal combustion engine and producing toxic exhaust gases and particulate matter in the process. In comparison, a fully electric vehicle uses one or more electric motors or traction motors for propulsion. These motors are in turn powered either by energy stored in chemical batteries or through electric traction lines, the former being more popular globally.

The energy storage unit in an electric vehicle is often based on Lithium chemistries, and it can account for 20-25% cost of the vehicle. The storage unit is either permanently housed within the vehicle in which case it needs to be charged by an external charger. The other alternative is that the storage unit is designed to be swappable, wherein a discharged unit can be replaced by a charged unit at a battery swapping station.

[2] https://www.ccacoalition.org/en/resources/global-snapshot-air-pollution-related-health-impacts-transportation-sector-emissions-2010

Both the technologies have their pros and cons, and the choice may be dictated by end use application, frequency and availability supporting infrastructure such as land and power distribution grid capacity. Further, charging infrastructure offers a choice between two popular standards and different charging rates, the requirement for which is again determined end use application, usage etc. Charging standards and charging rates are briefly discussed in Section x and Section y, respectively.

Finally, electricity tariff is critical parameter which dictates viability of electric vehicles for fleets and other commercial applications. Section z discussed scenarios for 2W, 3W and 4W vehicle segments for Jaipur city.

Charging Infrastructure

Charging level

Charging infrastructure is defined by International Technical standard they follow, charging capacity or rate, and type of current (AC or DC). Table x describes charging standards as issued by Ministry of Power. The table also maps electric vehicles available in the Indian market and charging options they comply with.

Charger Type	Charging Standard	Capacity	Vehicle
Slow Charger	Bharat AC – 001	Up to 10kW	Ather 450, Ather 350, Tata Tigor EV, Mahindra e2o, Mahindra e2o Plus P6, NEO, Mahindra e-Supro Cargo Van, Mahindra E-Supro, TREO HRT, TREO SFT.
	Bharat DC – 001	Up to 15kW	
AC Level II Charging	Type II AC	>22kW	Mahindra e2o Plus 8, Nissan Leaf, Renault Zoe
AC Fast Charging	CCS	> 50kW	Volvo 8400 B5RLEH 4x2 and Hyundai Kona
	CHAdeMO	> 50kW	

Ministry of Power (GoI) has laid out recommended guidelines for setting up Charging Infrastructure and opening the segment for private investments. This includes directions for setting up both CSS and CHAdeMo based chargers for public charging stations based on market demand and notifying it as a de-licensed activity.

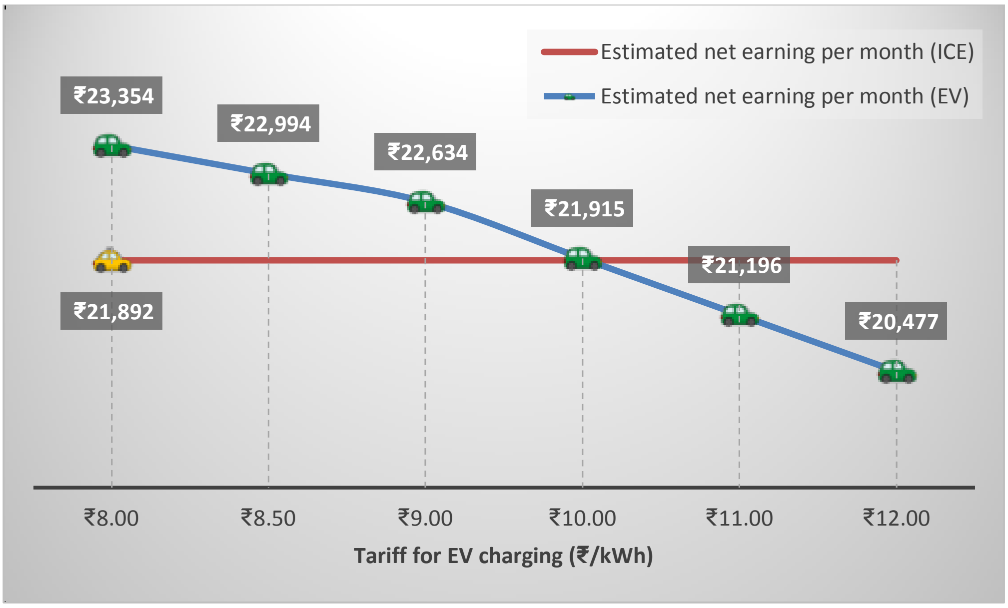
Charging Rates

Many States have announced have already announced EV tariffs to promote electric vehicles. While Maharashtra, Jharkhand, Haryana, Karnataka, Gujarat and Chandigarh have used conventional two-part tariff structure; Delhi, Punjab, Andhra Pradesh, Uttar Pradesh, Telangana, Chhattisgarh and Madhya Pradesh have adopted consumption-based billing mechanism. Delhi, Maharashtra, Uttar Pradesh and Telangana have introduced "TOD" (Time of Day) incentives for better demand response. Annexure x highlights EV tariffs introduced by various States. Rajasthan in its ARR[3] for 2019-20 has kept EV in bulk supply category with proposed tariff of 8.05 Rs/kWh, which is comparatively higher than other states.

Apart from public transport segment, Electric mobility transition is likely to pioneered by fleet operators and freight companies. The decline in cost of vehicles (particularly storage) and advancement in technology is projected to disrupt the mobility sector. However, the disruption does not happen without a strong foundation, and seed for transition need to be laid and fostered. In the short term, electricity tariffs for charging electric vehicles is a key parameter which can be manipulated through policy intervention and ensure economic viability of electric vehicles, at least for stakeholders which are likely to lead electric mobility transition.

Table below estimates projected average net monthly earning of cab drivers for electric car (TATA Tigor EV) for different tariffs for EV charging viz-a-viz a diesel sedan (Swift Dzire). The analysis assumes an average daily run of 250 kms for diesel sedan, and 200 kms daily for electric vehicle. A lower run is assumed for electric vehicle considering down time of a little over 2 hours for charging the electric vehicle once in a 12 hour shift. In the current scenario, it is evident that electric vehicles are viable for city fleet operations for an effective charging tariff of INR 10 per kWh or lower.

[3] http://energy.rajasthan.gov.in/content/dam/raj/energy/jaipurdiscom/pdf/tariff/2019-20/petition%20in%20english%20tariff%20petition%20FY%202019-20.pdf



Business Models for Public Transport

This section discussed potential business models that may be adopted for integrating electric mobility for public transport. Further a SWOT analysis is performed for Jaipur city to understand suitability to Jaipur city.

BM I: JCTSL procures electric buses and sets up charging Infrastructure.
BM 2: JCTSL procures electric buses and partners with Distribution Utility for setting up and managing charging infrastructure

BM 3: JCTSL partners with private operator, where the later procures, operate and maintain the electric buses and the charging infrastructure.

BM 4: Partnership between JCTSL, Distribution Utility and private operator for distribution of investment needs and operational responsibilities.

	Strength	Weakness	Opportunities	Threat
BM 1	• Full control over routes, fare, schedule • Easier access to VGF • Less dependence on market signals	• Impact on public spending budget • Lack of expertise and experience of JCTSL	• Seeding electric transition in absence of private players • Electric transition as an opportunity to strengthen existing operations and balance sheets	• High capital and operational risk • Ability to keep pace with market and technology disruption • System inefficiencies

	Strength	Weakness	Opportunities	Threat
BM 2	• Full control over routes, fare, schedule • Easier access to VGF • Less dependent on market signals • Streamlined execution of charging infrastructure	• Impact on public spending budget • Lack of technical expertise and experience of JCTSL • Absence of coordination channel between JCTSL and JVVN	• Seeding electric transition in absence of private players • Electric transition as an opportunity to strengthen existing operations and balance sheets • Better resource planning by distribution utility	• Poor fiscal health of JVVN • Poor coordination between the agencies • High capital and operational risk • Ability to keep pace with market and technology disruption • System inefficiencies
BM 3	• Mitigation of operating and technical risks • Access to private investments for scaling • Less impact on public spending budget • Leverages expertise in spheres of planning and operations	• Absence of regulator or capacitated public body to monitor quality of services delivered • Access to VGF in a fair, transparent and efficient manner.	• Creating platform for private investment and scalability • More receptive to market and technology innovation • Better standards for mobility services • Demand oriented planning	• Release of dues in a transparent and timely fashion • Collusion between parties • Performance and financial viability of private operator
BM 4	• Mitigation of operating and technical risks • Access to private investments for scaling • Less impact on public spending budget • Leverages expertise in spheres of planning and operations • Streamlined execution of charging infrastructure	• Absence of regulator or capacitated public body to monitor quality of services delivered • Access to VGF in a fair, transparent and efficient manner. • Absence of coordination channel between parties	• Creating platform for private investment and scalability • More receptive to market and technology innovation • Better standards for mobility services • Demand oriented planning	• Release of dues in a transparent and timely fashion • Collusion between parties • Performance and financial viability of private operator • Poor coordination between the agencies

Both JCTSL and JVVN are suffering from poor fiscal health and they are limited by existing operational challenges to lead the electric mobility transition. Further, JCTSL does not have the operational or technical expertise to manage the electric fleets. Based on the above SWOT analysis and existing scenario of public mobility and related institutions in Jaipur city, participation of private players is pertinent for electric mobility transition of the city.

Charging Infrastructure | Charging Rates | Range Anxiety

Charging Rate

Table below shows the range offered by electric cars currently being offered in the Indian market. Majority of the vehicle offer a range of 120 – 140 kms on full charge. This is significantly less that range offered by fossil fuel vehicles, with easy access to refueling stations almost every few kms at least. While the range offered by electric vehicles is projected improve with improvement in energy storage technologies and reduction in its cost, it is unlikely that most electric vehicles shall be able to compete with fossil fuel vehicles. Under these circumstances, it is often assumed that a comprehensive charging infrastructure is necessary for electric mobility transition for any city.

Table 1 Range offered by electric cars in India

Hyundai Kona Electric	Mahindra e-Verito	Mahindra e2o	Tata Tigor EV 2019
452 Km	110-140 Km	120 Km	142 Km
39.2 kWh	13.91-18.55 kWh	11-16 kWh	16.2 kWh
			

As evident from section xx.xx, charging infrastructure involves pertinent complexities. ChAdeMo and CCS being 2 popular charging standards globally, it is not very clear which standard is going to become more universal. Ensuring that charging facilities are available in compliance with both international standards shall almost double the cost of setting up the charging infrastructure.

Further, charging technologies are evolving at a significant pace. Charging rates have increased significantly in the last 3 years, and they are predicted to increase further. This has a significant implication on current investments and number of public charging stations requited to meet the demand. Lastly there is a growing debate between viability of charging infrastructure vs battery swapping stations.

Recommendations

- Range anxiety is often over-hyped because of accustomed practices rather than real world issues. Seeding electric mobility transformation shall focus on identifying early adopters and building tailored charging infrastructure for those consumer segments. For example, range is rarely a concern for white collar worker who is travelling less than 80kms per day in the city. The concern is even less for individuals who own a second vehicle, as they can use that for long distance travel needs. Hence, it can be assumed with high confidence that most personal mobility needs can be through slow charging stations installed at over-night or day-time parking spots.
- BIS is in the process of releasing its own standards for charging infrastructure in India. Looking at the precedence, it is likely going to be a mirror of one of the popular charging standards, CCS or ChadeMo. Until then, standard of charging technology may be adopted based on preferred choice of Indian OEMs and popular choice of International suppliers currently present in India. Inputs of experts from technical organisations such DISCOMS, EESL etc. shall also be taken into account along with industry stakeholders.
- It is important that charging infrastructure plan is tailored to meet the needs of early adopters. The trends and economics suggest adoption of electric vehicles is likely to be pioneered by freight aggregator, along with public transport. Hence, aligning plans for charging infrastructure with investment plans of local fleet operators is likely to yield better utilization and economics.
- Lastly, like any transition, it is unlikely that electric mobility transition shall be smooth. Hence it is crucial that there is a strong focus on pilots, with a platform for institution and public learning. Multi-stakeholder partnerships involving public, private, academic and civil society institutions is crucial for same.

Energy Storage

Lithium ion technologies have largely become the industry standard for electric mobility applications. Despite trends of falling prices and increasing storage density, energy storage typically accounts for about 25% of total cost of the vehicle. Because of limitations of high capital cost and offered range, a few interesting business models have evolved in the last few years. These includes models like battery leasing and battery swapping, along with popular business models such as *Wet-Lease* model.

Lithium ion chemistries, especially for fast-charging applications, pose a significant safety risk as they are highly flammable. These risks are further aggravated by exposure to harsh sub-tropical climatic conditions.

Recommendations

- Strict compliance and safety guidelines need to issue for battery handling,
- Develop and execute training programs for people likely to engaged with electric vehicles and energy storage handing. This may include agencies such as traffic police, fire control unit, electric utilities, emergency response teams, and others as deemed necessary.
- Given that EV ecosystem is in its early stage, business models which limit the technology and operational risk are more suited for public procurement. This shall facilitate a low risk learning environment while the support ecosystem for electric vehicles and energy storage is at nascent stage of development.
- Strategic pilots may be designed and sanctioned to understand their complexities, benefits and suitability for Jaipur city.

Reorientation of Safety Protocols

Though EV is generally a low maintenance vehicle due to fewer moving parts, it has its own safety hazards similar to the characteristic of high-power electric equipment. Automobile Maintenance and service industry may need a complete reorientation for their procedures as the existing mode of ICE vehicle servicing/washing cannot be implied on electric vehicles. In addition to this, presence of any electrical infrastructure above 400 V near fuel pumping station is considered as a safety hazard and a charging station operates at around 500 V. Policy and technical solution for these issues is likely to cause major sectoral disruptions and should be analyzed properly.

Risks pertaining to emergency response:

- Electrical shock (up to 400 volts).
- Extremely high temperatures and thermal runaway.
- Toxic fumes.
- Lithium burns (respiratory and skin reactions).
- Toxic runoff.
- Reignition up to 24 hours after initial extinguishment.

Maintenance	Activities	Risk
First Line Maintenance (By User)	Vehicle Washing, Windscreen top-up	Low risk of direct contact
Second Line Maintenance (By Mechanic)	Battery top-up, routine mechanical maintenance, etc.	Exposure to high voltage

Maintenance	Activities	Risk
Third Line Maintenance (In the manufacturer's workshop)	Major electrical repairs	Exposure to inflammable material and high voltage levels

Recommendations

- Training and capacity building
- Issuance of strict guidelines for installation and operation of charging infrastructure
- Emergency response protocols

Grid Infrastructure and Supply of Electricity

Electric mobility transition is Electric mobility transition is projected to have very little impact on transmission grid infrastructure in short to medium term. But same is not true for distribution infrastructure. Depending on rate of penetration, continuous augmentation of distribution infrastructure may be required. This shall include LT transformers, sub-stations and cabling.

Other aspect is electricity tariffs for vehicle charging. Electricity tariff can account for more than 50%[4] of *total running cost* of the vehicle. This is critical parameter which can significantly impact the viability of the electric vehicles in the short run while in the long run same shall be dictated by economies of scale and fall in price for batteries.

Recommendations

- While electricity tariffs for EV charging do need subsidization in the short term to seed the transition, but same shall not come at the cost of low-income groups. Industry and commercial institutions in Rajasthan are also suffering very high tariffs compared to many other states, and hence there is very little scope for cross-subsidies. However, excess capacity currently available with JVVNL under long terms contracts may be appropriately monetized by offering attractive tariffs for EV charging. The positive bias in the electricity tariffs can work as a benefit for DISDCOM, early electric mobility adopters and electricity consumers at large.
- Penetration and growth of electric vehicles need to be closely monitored to ensure that appropriate infrastructure augmentations may be made in a timely manner. DISCOMS may also interact with concerned public institutions and private players in electric mobility to map their investment plans and prepare capacity augmentation plans in a more efficient manner.

[4] https://www.pluginindia.com/electricvehiclecosts.html

- Pilots such as innovative tariff structures to regulate charging demand may also be initiated for demand management or peak shifting. Similarly, pilots may also be initiated to map the value and roadmap for Vehicle to Grid integration.

Planning

Electric mobility transition demands significant upfront investments, for both public and private mobility. Hence it is critical, that demand-based planning is done to ensure better capacity utilization and sustainability of assets deployed. This shall include setting up charging infrastructure as well as deployment of vehicles.

Recommendations

- With a focus on end to end connectivity, deployment of electric vehicles shall be tailored to route needs based on capacity and frequency. Suitable arrangements shall be made to cater to mobility needs during peak and off-peak hours. Use of mid and small sized vehicles may be considered for same, along with heavy capacity vehicles.
- Deployment of charging infrastructure shall be planned in consultation with concerned public and private stakeholders. Framework may be created to map penetration and movement of electric vehicles across the city.

Financing Electric Mobility Transition

Public mobility services in Jaipur city are largely operating at financial losses, and they are often unable to compete with private service providers who under pay their drivers, flout safety norms and blatantly overload their vehicles. Penetration of app-based cabs has considerably changed passenger behavior, moving them away from public transport services by providing on-demand mobility with much better quality of service.

Recommendations

- A comprehensive public mobility infrastructure is critical for a sustainable. It is critical to build an ecosystem with fair minimum standards of performance which ensure movement of goods and people in a safe, efficient and accountable. Hence, standards of performance as guiding principles shall be drafted and executed to ensure a fair and sustainable competition environment for public and private service providers.
- Demand based mobility planning, along with integration of public and private mobility services for end to end connectivity shall allow for a viable and sustainable infrastructure,

- Current incentives for electric mobility may be leveraged to reform financial health of public mobility by introducing appropriate vehicles on strategic routes
- Premium public mobility services may also be considered for white collared worked on strategic routes for better revenue opportunities.
- Tariff rationalization and competition shall be carefully studied to improve the financial status of public transport institutions.
- Along with reforms initiative, more efficient funding such as municipal or green bonds may be explored for financing electric mobility transition.

Annexure: I

Electric Tariff for Electric Vehicles, as declared by different States in India.

State	Category	Energy Charges	Fixed Charges	TOD
Delhi (16.03.18)	Separate Category	Supply at LT – Rs. 5.50/kWh Supply at HT Rs. 5.00/kVAh	No fixed charges	Yes
Punjab (27.05.19)	Separate Category	Rs. 6.00/kVAh	No fixed charges	No
Maharashtra (12.09.18)	Separate Category (HT&LT)	Rs. 6.00/kWh	Rs. 70/kVA/Month	Yes
Jharkhand (28.02.19)	Commercial	Rural - Rs. 6/kWh Urban - Rs. 6.25/kWh	Rural - Rs. 40/Conn/Month Urban – Rs. 150/Conn/Month	No
Andhra Pradesh (22.02.19)	Non-Domestic (LT-II) HT Category-II(E): Electric Vehicles (EVs) / Charging Stations	Rs. 5 /kWh	No fixed charges	No
Haryana (01.11.18)	LT & HT	Rs. 6.50/kWh and Rs 6.40/kWh respectively	Rs. 160/kVA/Month	No
Karnataka (30.05.19)	LT & HT	Rs. 5/kWh	LT – Rs. 60/kW/Month HT – Rs. 190/kVA/Month	
Uttar Pradesh (07.03.19)	LMV-1b and HV-1b LT and HT (metered consumers of LMVs and HVs to be charged as per respective category tariff)	LMV-1b - Rs. 6.20 / kWh HV-1b - Rs. 5.90 / kWh LT - Rs. 7.70 / kWh HT - Rs. 7.30 / kWh	No fixed charges	Yes
Gujarat	LT & HT	LT – Rs.	LT - Rs. 25 per	

(24.04.19)		4.1/kWh HT – Rs. 4/kWh	installation HT - Rs. 25/- per kVA per Month, upto contract demand HT - Rs. 50/- per kVA per Month, for demand above contract demand	
Telangana (15.11.18)	LT & HT	LT – Rs. 6/kWh HT – Rs. 6 + TOD Charges	No fixed charges	Yes
Chhattisgarh (28.02.19)	LV-2.1: Non-Domestic LV-2.2: Non-Domestic Demand Based Tariff (for Contract Demand of 15 to 112.5 kW) Supply Voltage HV- 3	Rs. 5/kWh	No fixed charges	No
Madhya Pradesh (03.05.18)	LV – 5 and HV – 4: Electric Vehicle/ Rickshaw charging installations	Rs. 4.08/kWh	No fixed charges	No
Chandigarh (20.05.19)	Electric Vehicle Charging Station	Rs. 4/kWh	Rs. 100/kW/month	No