Compendium of Papers & Presentations

CONFERENCE
ON
TECHNOSPHERE OF EVs

CHARGING INFRASTRUCTURE, POWER DEMAND ESTIMATION & PRICING ISSUES

Organized by

UP ELECTRICITY REGULATORY COMMISSION

ON

04th February, 2019

Compendium of Papers & Presentations

CONFERENCE
ON

TECHNOSPHERE OF EVs

CHARGING INFRASTRUCTURE,
POWER DEMAND ESTIMATION & PRICING ISSUES

Organized by

UP ELECTRICITY REGULATORY COMMISSION

ON

04th February, 2019

UP ELECTRICITY REGULATORY COMMISSION

Message from Chief Minister

मुझे यह जानकर अत्यंत प्रसन्नता की अनुभूति हो रही है कि उत्तर प्रदेश विद्युत नियामक आयोग द्वारा दिनांक 04 फरवरी, 2019 को लखनऊ में विद्युत चालित वाहनों के संबंध में विषयक एक संगोष्ठी का आयोजन किया जा रहा है।

उत्तर प्रदेश देश के ऐसे प्रदेशों में से एक है जहां बिजली की अत्यधिक ग्रिड क्षमता का संचालन किया जाता है। प्रदूषण मुक्त राष्ट्र के निर्माण के लक्ष्य की पृष्ठ भूमि में भारत सरकार द्वारा सभी सार्वजनिक यातायात व्यवस्था को पूर्णतः विद्युत चालित बनाये जाने का संकल्प किया गया है।

इस दृष्टि से तकनीक में परिवर्तन के साथ ही ऐसे वाहनों को चार्ज करके के आधार रूप ढांचे के विकास, बिजली की अधिक मांग के लिए ग्रिड क्षमता में वृद्धि तथा इस क्षेत्र में विद्युत की दरों के निर्धारण एवं विनियमन की आवश्यकता होगी उस पर अभी से विचार विमर्श के लिए संगोष्ठी का आयोजन अत्यंत महत्वपूर्ण है।

इसके दृष्टिगत आयोग द्वारा संगोष्ठी का आयोजन किया जाना एक सराहनीय प्रयास है। मुझे आशा है कि संगोष्ठी में विद्युत चालित वाहनों के संबंध में विशेषज्ञों द्वारा सार्थक विचार-विमर्श किया जाएगा। इस अवसर पर विषय के विशेषज्ञों तथा अन्य प्रतिभागियों द्वारा जो महत्वपूर्ण प्रस्तुतिकरण होगा उसका संकलन एक पुस्तिका के रूप में प्रकाशित भी किया जाएगा। उ.प्र. विद्युत नियामक आयोग द्वारा की गयी यह पहल अत्यंत सराहनीय है।

संगोष्ठी के सफल आयोजन तथा पुस्तिका के प्रकाशन के लिए मेरी हार्दिक शुभकामनाएं।

(योगी आदित्यनाथ)

मुख्य मंत्री, उत्तर प्रदेश

UP ELECTRICITY REGULATORY COMMISSION

Message from Energy Minister

हर्ष का विषय है कि उत्तर प्रदेश विद्युत नियामक आयोग दिनांक 04 फरवरी, 2019 को विद्युत चालित वाहनों के संबंध में "Technosphere of EVs, Charging Infrastructure, Power Demand Estimation & Pricing Issues" विषय पर एक संगोष्ठी का आयोजन किया जा रहा है, जिसमें पूरे देश से इस विषय के विशेषज्ञों के साथ ही अनेक प्रदेशों के विद्युत नियामक आयोगों के पदाधिकारी भी सम्मिलित होंगे।

प्रदूषण मुक्त राष्ट्र के निर्माण के लक्ष्य की पृष्ठ भूमि में भारत सरकार द्वारा वर्ष 2030 तक सम्पूर्ण सार्वजनिक यातायात एवं 30 प्रतिशत निजी यातायात को विद्युत चालित जाने का जो संकल्प व्यक्त किया गया है, उसके परिप्रेक्ष्य में तकनीक में परिवर्तन के साथ ही ऐसे वाहनों को चार्ज करने के आधार रूप ढाँचे के विकास, बिजली की अधिक मांग के लिए ग्रिड क्षमता में वृद्धि आदि जो महत्वपूर्ण विषय होंगे, उन पर सभी से विचार विमर्श के लिए इस संगोष्ठी का आयोजन अत्यंत महत्वपूर्ण है। मुझे बताया गया है कि इस अवसर पर विषय के विशेषज्ञों तथा उन प्रतिभागियों द्वारा जो महत्वपूर्ण प्रस्तुतिकरण होगा उसका संकल्न एक पुस्तिका के रूप में प्रकाशित भी किया जायेगा।

मैं इस अवसर पर प्रकाशित होने वाली पुस्तिका एवं इस संगोष्ठी के आयोजन के लिए सफलता की शुभकामना के साथ ही इस अभिनव कार्य के लिए उ.प्र. विद्युत नियामक आयोग को अपनी हार्दिक बधाई देता हूँ।

श्रीकान्त शर्मा

(श्रीकान्त शर्मा)
ऊर्जा मंत्री, उत्तर प्रदेश

UP ELECTRICITY REGULATORY COMMISSION

Message from Chairman

The biggest challenge and accomplishment for a regulator is to look into future and manage the technology disruption in a planned manner through a regulatory oversight by bringing in various stakeholders in a seamless discussion.

Today, power sector is moving towards "waves of disruption". These waves used to happen every over a very long period of time. Now we live in an era of permanent disruption. Just as soon as the disrupting companies start celebrating their triumph over the former incumbents, they become the targets of the next wave of disruptors through either better digitalization or efficient enforcement of environmental norms. The topic of "Technosphere of EVs & Charging Infrastructure along with Pricing Issues & Power Demand Estimation" has been chosen as Indian power system is also moving towards D-3 i.e. "Decentralization", "Digitalization" and "Decarbonization" and Electric Vehicles are representing Decarbonization in order to achieve environmental objectives.

The age of film photography did not run out of any of the components needed to make film or film cameras. Film photography was destroyed by rapid movements in digital imaging and information technologies, disruptive business models with which industry leaders Kodak and Fujifilm simply could not compete. The energy and transportation industries have a similar business model. Every time one flips a switch to turn on a light, more cash is paid to the utility. Similarly, every time one presses the gas pedal in car, he gives cash to the oil industry. Substituting natural gas or ethanol for gasoline doesn't change the business model. Every time you press the gas pedal you still burn fuel and give cash to the energy industry.

Solar and wind power change the energy equation in the same way that digital cameras changed the film camera equation. After a solar roof top or wind power installation representing decentralization and decarbonization, the marginal cost of each additional unit of energy drops essentially to zero because the sun and wind are free. Flipping a light switch burns nothing and means zero cash for the utility because solar and wind have a marginal cost of zero.

Similarly, the electric vehicles which represent decarbonization are environmentally friendlier than the internal combustion engine vehicles. Electric vehicles (EVs) are also cheaper to operate and maintain. An electric vehicle is still more expensive to purchase upfront, mainly due to battery costs. However, like other technology products, the technology cost curve, of EVs points to a disruption soon; innovative business models will only accelerate the transition from gasoline vehicles to electric vehicles. Internal combustion engine car companies will have their challenge moments sooner than they think. The disruptive wave brought about by Electric vehicles (EVs) may wipe the last vestiges of the gasoline car and oil industries.

Electric vehicles can be tightly integrated into the electric grid and provide two-way energy flow as well as cash flow. Electric vehicles can play a role on the grid similar to the role that computer nodes play in P2P architecture. Electric vehicles can store energy when there's excess energy production and then can release energy during these peak demand times. In a competitive energy market every EV owner could participate in energy auctions and sell energy to the highest bidder.

Deployment of EV charging infrastructure needs to be in a phased manner so that the infrastructure is timely placed to cater to EV adoption program. Charging behavior of EV-users' needs to be managed by introducing ToD tariff mechanisms so that consumers are incentivized to charge EVs during peaking hours of RES. In future, batteries of EVs parked and during charging process can be used as grid storage media that could immensely reduce burden on exchequer to create grid storage infrastructure to address issues of intermittency of RES. Distribution utilities will have to play an instrumental role in deployment of EV charging infrastructure by enabling charge point operators with reliable supply of power. Discoms can even play the role of charging point operator as well. However, they have to empanel network service providers to host location of charging stations and give visibility to EV users. Network Service Provider will provide seamless pricing, billing and payment options as well.

The most critical issue that needs to be addressed for viable operations of charging infrastructure is cost incurred towards land in urban areas. The other critical issue is access to power. EV would require 24x7 reliable supply of power. Further, there might be surge and dips in power system apart from swings due to addition of huge load. For instance a use of high power DC fast chargers for charging batteries of EVs can add stress on the existing infrastructure. Hence, the Distribution Transformers (DTs) must have sufficient margins to allow such vehicles to be charged and should create adequate capacity to meet the surge demand due to EVs.

While the impact of EVs on power grid may become crucial in a period between 7 to 10 years from now, it has enormous potential and in order to effectively regulate the EV market, policy makers should first invest in understanding the comprehensive dynamics of EV along with inter-linkages of transport sector and power sector. It is with this view that UP Electricity Regulatory Commission is conducting this workshop to remain ahead of the technology curve. With this spirit, I welcome all the participants in this workshop with expectation of having a fruitful dialogue to find likely solutions for the challenges, identified so far, in implementation of EV as per national ambition.

(Raj Pratap Singh)
Chairman

UP ELECTRICITY REGULATORY COMMISSION

Message from Member Shri S. K. Agarwal

I am immensely happy that the Commission is organizing a Conference on **"Technosphere of EVs - Charging Infrastructure, Power Demand Estimation & Pricing Issues"** on 4th February, 2019 and a souvenir is being brought out to commemorate this occasion.

Vehicular pollution is one of the main issue of concern globally, and in India this menace need to be tackled on an urgent basis. The invent of new technologies has made it possible to gradually shun the use of fossil fuel for vehicular movement. E-mobility is the buzz word in the field of transportation.

Since e-mobility is largely dependent on electricity, the Commission thought it appropriate to deliberate on various issues concerning different stakeholders in order to create a consumer friendly atmosphere alongwith sustainable infrastructure for charging of e-vehicles.

I convey my best wishes for the success of the Conference.

(Shri S. K. Agarwal)
Member

UP ELECTRICITY REGULATORY COMMISSION

Message from Member Shri K K Sharma

I am extremely glad that the Commission is organizing Conference on "Technosphere of EVs - Charging Infrastructure, Power Demand Estimation & Pricing Issues" on 4th February, 2019 and a souvenir is being brought out to commemorate this occasion.

Many initiatives are being taken for faster adoption of EV mobility in the Country. Currently there are several challenges associated with the adoption EV for them to bring in meaningful impact. For the regulator there are a no. of aspects to consider like planning of Ecosystem, demand and load forecasting, tariffs & pricing, cost of storage, impact of peak demand and regulations etc. Niti Ayog playing pivotal role for driving the growth of EV in Country in larger interest of Economy, Environment and public at large.

Today's conference is a step in rapid adoption of EVs especially for U.P. wherein various issues will be deliberated by the experts and stakeholders in various field.

I convey my best wishes for the success of the "Technosphere of EVs".

(K K Sharma)
Member

UP ELECTRICITY REGULATORY COMMISSION

CEO & Managing Director, The Tata Power Company Limited

Praveer Sinha is the CEO & Managing Director of The Tata Power Company Limited (TPC, Mumbai), India's largest power Integrated company with a significant International presence. The Company has its presence in all the segments of power sector viz. Fuel & logistics, Generation, Transmission, Distribution and Trading. It is one of the largest renewable energy companies in India and has developed the country's first 4000 MW Ultra Mega Power Project at Mundra (Gujarat) based on super-critical technology.

Mr. Sinha has nearly 34 years of experience in Generation and Distribution sector. He has been responsible for developing and setting up Greenfield and Brownfield Power plants in India and abroad. Apart from this, he has actively contributed in bringing about huge socio-economic development and empowerment programs for youth and children in these project sites. Prior to becoming the CEO & Managing Director of The Tata Power Company Limited, he has served as the CEO&MD of Tata Power Delhi Distribution Limited (TPDDL), a Public Private Partnership (JV) of Tata Power and Government of National Capital Territory of Delhi from April'2012 to April'2018.The company has a registered consumer base of 1.68 million and reaches out to 7 million consumers in North and North West part of Delhi through its services.

Apart from ensuring operational excellence, Mr. Sinha is extremely passionate towards the inclusive growth of the society and has implemented numerous sustainability programs focusing on women empowerment, skill development for youth and children, which has resulted in the multifold increase in the number of beneficiaries to nearly 1.1 million people in the National Capital.

(Praveer Sinha)
CEO & Managing Director

List of Papers

List of Presentations

CONFERENCE
ON

TECHNOSPHERE OF EVs

CHARGING INFRASTRUCTURE,
POWER DEMAND ESTIMATION & PRICING ISSUES

Papers

Investigating Demand for EVs and related Electricity in Uttar Pradesh on time horizon of 2030

Profile

Tanya Batra: She is Assistant Manager at Grant Thorton in the Public Sector team. She's has extensive experience in renewable energy. She has pioneered and created an online one-stop shop for Solar vendors, Buyers and Enthusiasts called IndiaGoesSolar.com which allowed easy communication between the stakeholders. It aggregated 2000 stakeholders from the market in just 3 months. Spearheaded development of online B2C portal & Sunkalp Partner App (on Google Play) as tools to aggregate the industry stakeholders: Manufacturers, EPCs and customers. She has done extensive policy and regulatory analysis in the rooftop solar domain and published insights in industry magazines and blogs. Awarded among the 50 Most Impactful Green Leaders, World CSR Day. Awarded among the 50 Most Influential Solar Energy Leaders, Thought Leaders International.

Abstract

Estimating the electricity requirement for Electric Vehicles is dependent on first estimating the demand for electric vehicles, and thereafter their power requirements. The reasons underlying the uptake and hence, the demand for electric vehicles can be broadly categorized into three- government enforced measures, economic viability of using electric cars, technical feasibility (charging infrastructure, fast charging stations, characteristics comparable to conventional vehicles). In the supply side, the factors that would determine production would be dependent on profitability and technical capability for production. The paper investigates three scenarios of Electric Vehicles demand in accordance with the targets that the government has set. It first estimates the total number of electric vehicles sold in 2030 in India and accordingly, calculates the estimates for Uttar Pradesh for all the three scenarios. Then it estimates the demand of electricity as a result, for charging the electric vehicles and what additional capacities would be required. The paper concludes that charging of EVs will hardly affect the grid owing to the miniscule electricity required by them compared with total energy requirements. Then it compares economic viability of using an Electric Car vs. Petrol Car. It concludes that, when costs (including capital cost of the car) of an electric car are compared with that of a petro car, then beyond 5 years, electric car becomes more viable to use. However, operational costs for running an Electric Car is already lower compared with that of Petrol Car.

Estimating the electricity requirement for electric vehicles is dependent on first estimating the demand for electric vehicles, and thereafter their power requirements. The reasons underlying the uptake and hence, the demand for electric vehicles can be broadly categorized into three- government enforced measures, economic viability of using electric cars, technical feasibility (charging infrastructure, fast charging stations, characteristics comparable to conventional vehicles).

In the supply side, the factors that would determine production would be dependent on profitability and technical capability.

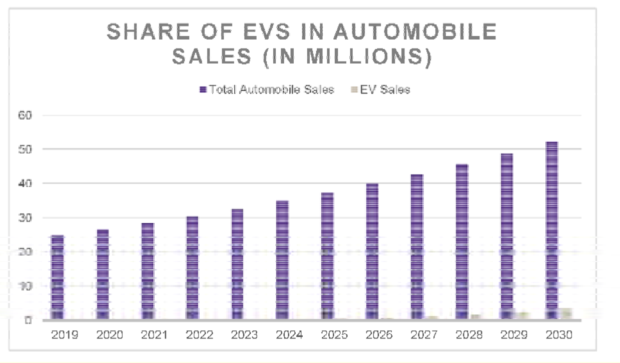
Demand-side estimation

The government of India has come up with the FAME (Faster Adoption and Manufacture of Hybrid and Electric Vehicles) India Scheme under National Electric Mobility Mission Plan (NEMMP) 2020. The incentives available are as highlighted below:

- Electric Scooters: Rs 1800 to Rs 29,000.
- Three-wheelers: Rs 3300 and Rs 61,000 and
- Electric and Hybrid cars: Rs 13,000 to Rs 1.38 lakh
- The total outlay available for the NEMMP is 14,000 crores

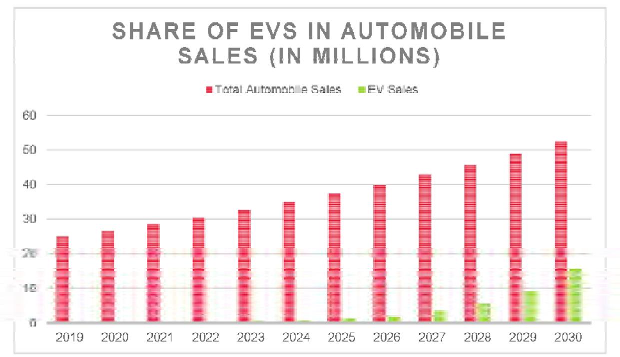
Through this scheme, NEMMP plans to have an impact on 'demand creation' as one of the factors. By 2020, the sales of Electric Vehicles are expected to be at 6-7 million units. The current EV sales stands at a mere 56,000 units.

The EV industry annual growth stood at 124% in the last year and the sales of EVs was 56,000 units in India (mainly contributed to by electric two wheelers. The total sales however of automobiles in India stood at 24.9 million. Hence, EVs constitute a mere 0.2% of the automobile sales in India. This would grow to 7% of the total vehicle sales by 2030 as per conservative estimates (BNEF).



Considering a CAGR of about 7% of automobile sales in India (refer), as witnessed between 2013-2018, the automobiles sales will grow to 3.6 million, realistically (if the growth in share of EVs, compounds by about 38% every year).

However, looking at the ambition of the Prime Minister, the share of EVs should rise to 30% by 2030 (refer). In such a scenario, the graph would look something as shown below. In such a case the growth in the share of CVs should be 57.7% a year CAGR until 2030. At the end of 2030, the expectation of sales would be of 15.7 million units.



Initially, the target of the government was to switch to 100% Electric Vehicles, in such a scenario 52.41 million Electric Vehicles would be sold in the year 2030. Conservatively, assuming that the demand for charging would be for 52.4 million vehicles, calculating the relevant figures for Uttar Pradesh.

EVs in Uttar Pradesh

Uttar Pradesh vehicle sales in 2016-17 accounts for about 10% of the nationwide sales at 2.3 million (refer). In this, if we consider that the same proportions as considered for the nation, then the sales of the Electric Vehicles in the most conservative growth scenario will amount to 3 lakh units (scenario 1), 15.72 lakh units (scenario 2) and 52.41 lakh units (scenario 3).

Now, coming to the electricity requirement for the electric vehicles. On average, let's assume that vehicles travel an average of 25,000 km annually in India. And for every 100 km, 10 kWh (units) of charge is required. In such a scenario, the total requirement from the grid would be as follows (annually).

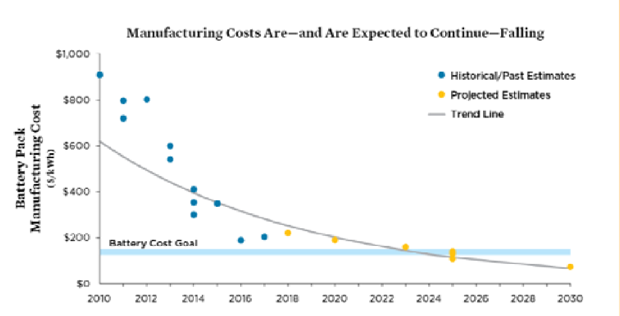
This is energy requirement thus attained as shown above, is equivalent to installing a 45 MW solar power plant which produces 4.5 units of electricity through the year.

This additional capacity required to for electric vehicles will need to be addressed in demand forecasting done by CEA (Central Electricity Authority), based on Uttar Pradesh's plans to scale up EVs in the state. However, looking at the current requirement in Uttar Pradesh (refer), 750 million units of demand form a miniscule percentage of the additional electricity requirement. 3,930 million units is about one-third of one month's demand in Uttar Pradesh. Similarly, 13,102 million units is a little above one month's demand in Uttar Pradesh.

Hence, looking at all the scenarios, it is evident, that the electricity demand would not be a major burden on the grid in order to supply to charging stations. Also, with 'peak demand' not met reducing historically from a whopping 11% of the times to a mere 2% in 2017-18, introduction of EVs seem like hardly a threat in terms of their electricity demand being met (refer).

Operational Economic Viability

Looking at the table below, it can be concluded, that the savings over a lifetime of an electric vehicle is significant as compared with that of a petrol vehicle. The initial cost of an EV may be slightly higher compared with petrol vehicles, however, costs are decreasing as the battery costs continue to decline (refer to figure below the table). The cost will reach optimal levels by around 2023 which is when, the capital cost of producing an electric car will become even cheaper.



Source: Union of Concerned Scientists

Hence, affordability, a factor in determining demand, is also currently there over a period of five years with capital cost on a higher side. However, even the capital cost will decrease by 2023 or even earlier depending on technological advance and efficiencies of manufacturing batteries.

Supply-side estimation

Among the electric car providers, Tata & Ola are already partners in government of India's mission 2030 electric India. Hyundai and Maruti Suzuki already plan to launch a range of electric cars by 2020 (refer). Mahindra plans to have an annual capacity for electric vehicle production of 70,000 by 2020.

In order for the forecasted demand/ target to be met, 50 such facilities will need to be setup with will match the annual consumption of 3.6 million electric vehicles by 2030. This is assuming all vehicles bought are from the country's production and not elsewhere. Hence, if Uttar Pradesh were to have dedicated plants in the state, the number of units of production it would need to meet its production is equal to 5 (10% of the total electric vehicle production in India).

	Electric Car (Mahindra e2o plus)	**Petrol Cars**
Mileage	120 km	620 km (approx)
Energy Consumption	12 units	40 litres (approx)
Energy Usage	12/120= 0.10 unit	3.125 litres per day
Cost	Rs 7.30 per unit for 400-800 units	Rs 71.19 per litre
Cost per km	Rs 7.3 X 0.10 units= 0.73 paisa	Rs 4.59 per kilometre
One day expenditure (50 km average travel)	50 km X 0.73 paisa= Rs 36.50	50 km X Rs 4.59 = Rs 229.6
Monthly expenditure (25 days travel)	Rs 912.5	Rs 5,511

Source: Data Quest

Bottlenecks in uptake of EVs

- Lack of EV Charging Infrastructure: No charging station available for it
- The capital cost of an electric car is higher
- Current lack of options/ variety in electric cars

Way Forward

- Demand estimation of the Electric Charging needs to be done in coordination with the central electricity bodies in order to effectively forecast and cater to the increase in demand of EVs
- Building of Electric Vehicle Charging infrastructure in phases in order to allow for Uttar Pradesh's EV targets to be achieved
- For faster adoption, integrating app based payment for using charging stations

Coordinated energy management for grid integrated electric vehicles

Profile

Dr. V.S.K.V. Harish is currently working as an Assistant Professor at Pandit Deendayal Petroleum University, Gandhinagar. Prior to this, he worked as a Post-Doctoral Fellow at TERI School of Advanced Studies, New Delhi under the Netherlands government sponsored collaborative project titled "Developing and implementing smart grids for India" with Eindhoven University of Technology as partner. An Electrical and Electronics graduate, Dr. Harish received his Ph.D. from the Indian Institute of Technology Roorkee in 2017 and masters with Gold Medal from Jadavpur University in 2012.

He was nominated for the prestigious YOUNG ENERGY RESEARCHER AWARD - 2018 at World Sustainable Energy Days, one of Europe's largest annual conferences supported by the European Commission. He is also the recipient of international travel award from the Department of Science and Technology, Govt of India in 2014 and 2018 and from Soft Computing Research Society, India in 2017.

He has publications in journals of international repute and presented his works in several conferences organized by ASHRAE, ELSEVIER, and IEEE in India and abroad. He has one BOOK publication on Green Buildings with Elsevier which is scheduled to be released by Dec 2018. His research interests lie in building energy systems, micogrids and rural electrification.

I. Introduction

In a classical traditional power system network, electrical energy is produced in big power plants which are either coal-based, oil-based, nuclear-based or large hydro-based. The power levels of generation is decided based on techno-economic optimization studies being carried out with a view to meet the forecasted demand and supply. The generated power is dispatched as per the power purchasing agreement and transmitted over long distances at very high voltage (HVAC/EHVAC and HVDC) levels (and at low currents). Power at appropriate voltage levels is then distributed to industries, commercial usage, transportation and domestic purposes (fig. 1).

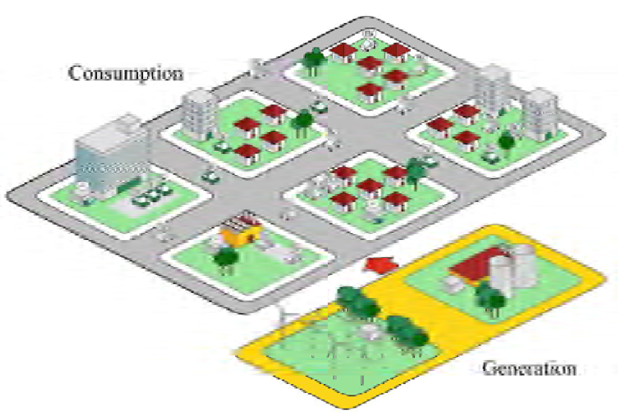


Fig. 1 Conventional Power System [1]

With the advent of improved semiconductor devices and information and communication technologies, electrical power systems are gradually evolving with time. A modern power system consists of various devices and equipment installed both at the centers of power generation and end-use consumption. These devices coordinate with supportive and compatible information and communication technologies to increase system reliability and transparency. Other researched advantages include reduced losses, increased system's resiliency, low-payback period, increased efficiency, reduced commercial losses and environmental friendly operation and control of electrical power generation and consumption. Renewable energy sources, both at micro and macro level, are installed at the distribution level (both at primary distribution voltage level and secondary 3 voltage level) and such installations have been very actively encouraged by governmental sustainable energy policies with an aim to reduce the nation's carbon footprint.

Renewable energy based decentralized energy systems (DESs), off-grid and on-grid based microgrids (MGs)/ home-based solar products are being considered as an optimistic solution to the rural electrification problems in under developed and developing economies like India. Non energy storage home based products, though cheap face the problem of unreliable supply of electricity due to intermittent nature of solar or wind generation. Problem of intermittency is solved by implementing a distributed storage unit which increases the cost and suffers energy loss while power transmission due to degradation of battery while charging and discharging processes. Energy storage technologies which are easy to handle and design, lower in cost, capable of handling voltage and current gradients are being included in a modern power system network. Robust communication infrastructures, and transportation systems with or without embedded energy storage capabilities (plug-in electric and hybrid electric vehicles) are also included in a futuristic modern power system network (fig. 2).

II. PLUG-IN ELECTRIC VEHICLES

Electric Vehicles (EVs), in the present study, include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs) and fuel-cell electric vehicles (FCEVs). As per International Energy Agency (IEA), more than 1 million EVs were sold in 2017, leading to a 54% of growth in new EVs sale in comparison to 2016. In Norway, 39% of the cars sold in 2017 were EVs, thereby, making it the world's most advanced market of EVs with Iceland and Sweden to follow. China encountered the maximum number of EVs sale with a market for EVs of 2.2% in 2017. This is more than half of the EVs sale for the year 2017, worldwide and almost double the amount of EVs delivered in the United States of America (USA) in 2017. USA is the second largest EV market, worldwide. Not only electric cars, but electric buses and two-wheelers are also seeing a rapid growth in the EV market, the vast majority of sales being in China. Apart from China, USA and Norway,

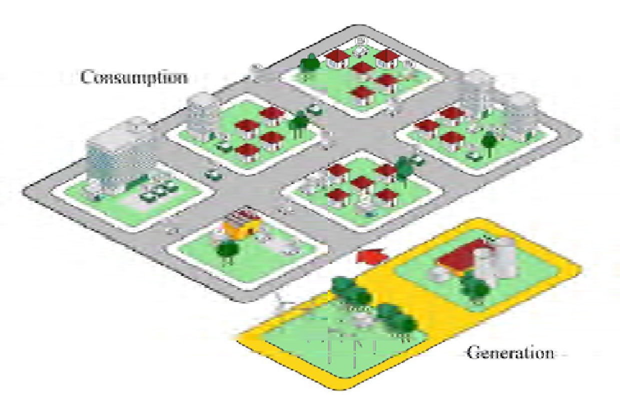
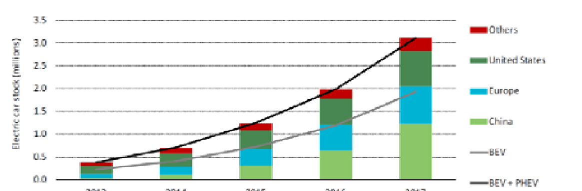


Fig. 2 Futuristic Modern Power System [1]

countries like Netherlands, Japan, France and Germany are laso in the EV market through the Electric Vehicle Initiative (EVI). EVI is a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide with India being one of its members. EVI countries have set a goal to sell 20 million PEVs and PHEVs by 2020, worldwide.

Apart from EVI group, several nations around the globe have set individual goals to create and sell million units of EVs by 2020, as the COP countries have engaged themselves with a decarbonisation goal of the vehicle market, and a global deployment of 100 million PEVS and PHEVs by 2030 (fig. 3).

The rapid increase in stocks and sales of EVs has been due to the growth of charging infrastructure as any supply equipment refers to chargers and charging infrastructure for EVs. Charging infrastructures installed at residential buildings and at workplaces (parking area) were most widely used in 2017. The estimated number of the EV charging installations were almost 3 million worldwide in 2017 (fig. 3). Such Charging installations were also utilized by electric buses in China. Apart from private chargers, generic charging stations for public use weredeveloped by the respective governmental organizations which complemented the



Notes: The electric car stock shown is primarily estimated on the basis of cumulative sales since 2005. Where available, stock numbers from official national statistics have been used (provided that the data can be shown to be consistent with sales evolutions).

Fig. 3 Evolution of the global electric car stock, 2013-17 [3]

role of privately owned charging installations and thus, were regarded as a significant component of the EV supply infrastructure.

Under the context of Smart Grid, Plug-in electric vehicles (PEVs) and plug-in hybrid electric vehicles (PHEVs) are considered as dynamic mobile energy storage structures serving as carriers of energy in both time and space. Integration of EVs into the modern electric power system network is critical. Technical implications in terms of voltage sags, load unbalance, harmonics, and other power quality issues exist, from a local point of view. Other implications such as power system stability of the network, frequency regulation, transmission and distribution infrastructure expansion, upgradation of technologies for coordinated management, demand-supply matching, also exist from a global point of view. Most likely, domestic load for EVs is expected to be supplied from the residential electrical distribution system. Hence, proper approaches and strategies are significant to handle and schedule the charging and discharging activities and patterns of EVs as a high EV penetration rate with the grid shall introduce several adverse impacts, especially on medium to low voltage transformers, if not addressed properly.

III. COORDINATED ENERGY MANAGEMENT

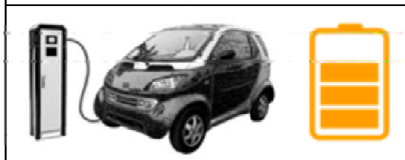
During recent years, several EV energy management problems have been formulated and solved using Artificial Intelligence techniques (Table I).

System model for P2P energy trading among the EVs in a smart parking station is shown in fig. Proposed power sharing algorithm has been developed for a set of rural households, few of which are equipped with solar panels. Conceptual schematic of the proposed power sharing mechanism is shown in fig. 2.

There are a number of EVs, parked in the Smart Parking Station connected together with power lines and to the main grid at the point of common coupling (PCC). Out of the connected EVs, few of them are regarded are SEVs with more than 80% of SoC of their battery and are represented as energy providers. Another set of EVs is regarded as Buyer EVs (BEVs) with SoC less than 80% of their battery. The dashed lines, represent the flow of information from one parking spot of the EV to a centralized P2P station. The main purpose of this communication is to enable

TABLE I. LITERATURE STUDY

Methodology	Remarks	Source(s)
Centralized-Decentralized	Optimal load scheduling topology Dynamic programming being used for de-centralized approach	[2]
Vehicle-to-Grid (V2G)	V2G phenomena applies when plug-in EVs are considered as movable energy storage devices which can inject energy	[3]
	into the grid during the discharging period and thereby providing ancillary services.	
Vehicle to Building (V2B)	V2B is when mobile EVs can be plugged into an buildings' electrical infrastructure which can inject energy into the grid during the discharging period and thereby providing ancillary services to an individual building.	[6]
Unidirectional—Bidirectional	Depending on the possibility of discharging PEV batteries, the methodology can be classified as unidirectional or bidirectional	[5]
On–Off—Idle	This is considered when the EVs are either fully charged or being full discharged depending upon the type of chargers used.	[4]
Heuristic—Rule Based	This label is given to the methodology if an approach without guarantee of reaching optimal solution is applied	[7]
Impact—Economic Assessment	This label is given to the methodology if it considers the analysis of the impacts on the electric infrastructure, or if it includes theeconomic assessment of services provided to the grid	[9]

EV Symbol	Classification	Status
	Seller EV (SEV)	Surplus power and represent energy producers
	Buyer EV (BEV)	Deficit power and represent energy consumers
	Idle EV (IEV)	Do not participate in the P2P trading at that hour but take up the parking space

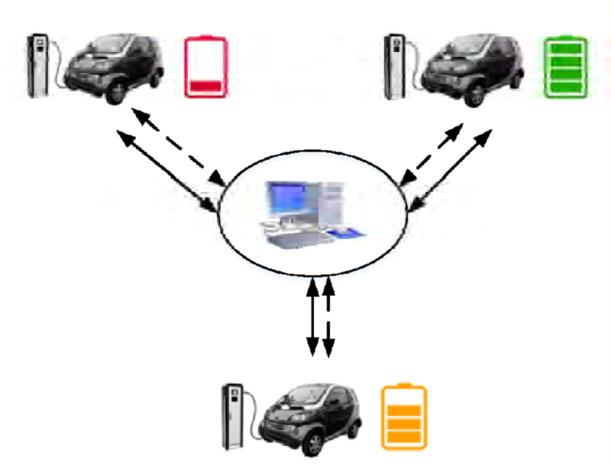


Fig. 2. Peer to peer energy sharing model

transparency of information on any transaction and sharing that would happen at any instant of time between EVs. This information can only be READ by the EVs and can be edited only at the centralized P2P smart Parking Station with administrator privileges. Communication protocols, rules and strategy of communication is beyond the scope of this paper. Solid lines represent power flow from one EV to the other. Every EV is equipped with a meter box capable of saving the transactions, history of energy sharing, thereby facilitating energy management.

IV. PROBLEM FORMULATION

A linear based approach is made use of to calculate the nodal voltages for a lov voltage (LV) distribution system. The nodal voltages are calculated taking into account the number of EVs connected to the nodes and the nodal load profiles. A centralized based approach is presented in this paper which serves as a benchmark to compare the coordinated energy management problem through P2P energy trading among EVs in a smart parking facility, in terms of technical benefits and can be compared to any other developed approaches as well.

Let us consider a set of ***V*** EVs in the smart parking station, given by eqn. (1). 8

$$V := \{EV_E : e \in Z\}$$

where,

$Z := \{1, 2 \ldots V\}$ = index set of EVs connected to the nodes

$$\min_{\substack{d^i \in D^i \\ s^i \in S^i}} \sum_{i=1}^{V} \sum_{t=1}^{K^i} c_i \tau \left(d^i - s^i\right) \tag{2}$$

s.t.

$$0 \le d_t^i \le p_{nom}^i \quad \forall i = \{1, 2, \ldots, V\} \tag{3}$$

$$0 \le s_t^i \le p_{nom}^i \quad \forall t = \{1, 2, \ldots, K^i\} \tag{4}$$

$$soc_{lower}^i \le soc_{t-0}^i + \tau \sum_{t=1}^{k} \left(d^i - s^i\right) \le soc_{upper}^i \tag{5}$$

$$v_{\min} \le v_i^n \le v_{\max} \quad \forall t - \{1, 2, \ldots, N\} \tag{6}$$

Primary objective is to minimize cost of energy consumption of PEVs connected to the nodes. An objective function is formulated as the sum of costs of energy consumption values of all the PEVs connected to the respective nodes of the LV distribution network.

V. SIMULATION RESULTS

The optimization problem formulated is solved using Newton's method with equility constraints, and the Barrier method []. The problem is applied and tested on an IEEE Radial connected residential LV distribution grid (fig. 3).

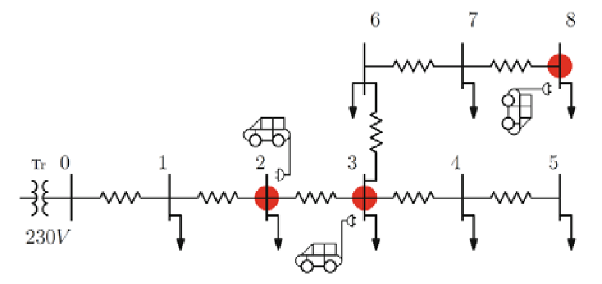


Fig. 3. IEEE LV Residential Distribution test case

As shown in fig. 3, three PEVs have been assumed to be connected to node numbers 2, 3 and 8. It has also been assumed, that all the three PEVs will be connected at the same time 18:00 hrs and are being disconnected to 06:00 hrs, 04:00 hrs and 04:30 hrs connected, respectively next day.

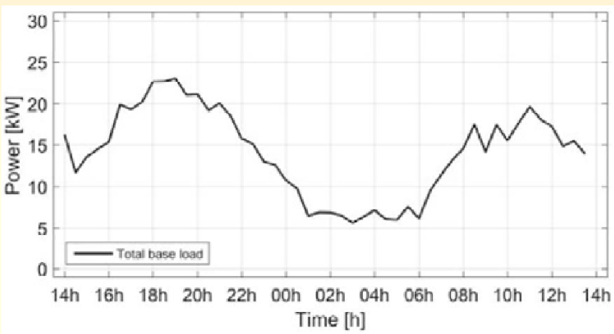


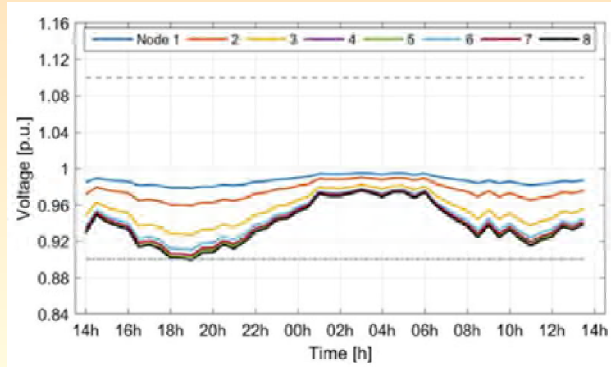
Fig. 4. Load profile

As the present study is applied to a residential LV distribution grid, the voltage at the transformer node is fixed at 230V. The limit to the charging/discharging rates of the EV chargers has been selected as 3kW with nominal battery capacity of 20kWh for each EV. To avoid negative impact on the battery lifespans, 16kWh of capacity is available for optimal energy management which is around 80% of the nominal battery capacity. The initial state of charge for the connected plug-in EVs are assumed as 40%, 20% and 50% of available capacity, respectively. The line parameters selected for demonstration of the present study are described in table IV.

TABLE IV. LINE PARAMETERS

Line Nodes		Parameters	
Source Node	Desitnation Node	Length, L (m)	Resistance, R (Ω)
0	1	64	0.05
1	2	64	0.05
2	3	128.2	0.10
3	4	192.3	0.15
4	5	192.3	0.15
5	6	128.2	0.10
6	7	64	0.05
7	8	128.2	0.10

A LV cable line with 25mm2 cross-sectional area and resistance per unit length of 0.78 ©/km. The voltage profiles for the nodes of the LV distribution grid case is shown in fig. This is the benchmark case for the grid without plug-in EVs connected to the nodes. As can be seen, that for each node the voltage profile is within the limits of 0.9 p.u. to 1.0 p.u. and the loads on the test grid are not causing any voltage limit violations (fig. 5).



Now, when plug-in EVs are connected to the loads, then without the use of the developed optimal energy management strategy the batteries of the EVs shall be charged at their maximum charging rate to enable fast charging. As soon as the SoC of the battery reaches its maximum limit, the EV stops to charge and hence, there is no further energy consumption from the grid. The energy consumed to charge the EVs along with the time of charging is shown in table V.

The voltage profiles of all the nodes with PEVs connected to the LV distribution grid is shown in fig. 6. It can be clearly seen that the voltages at nodes 3 to 8 drop down to 0.85 – 0.86 p.u. (in comparison to thst shown in fig. 5) This happens during 18:00 hrs to 21:30 hrs which coincides with the peak demand hours for any residential sector. If a single tariff of ¹ 6/kWh is taken (arbitarily), then he total charging cost of all the three PEVs is around ¹ 184 for one day of charging.

Voltage profiles and SoC for the batteries of EVs connected to the test grid, after applying the developed optimal energy management strategy is shown in fig. It can be observed that with the application of the developed optimal energy management strategy, the power consumed by the plug-in EVs has been redistributed along the 24h simulation period. Also, it can be noticed that the peak charging period does NOT coincide with the peak demand hours and moreover, the peak charging occurs

TABLE V. POWER AND ENERGY STATUS OF EVs

EV	Node	Power (kW)	Time taken (h)	Energy Consumed (kWh)	Price p.u. kWh (₹)	Charging cost (₹)
EV_1	2	3	3.2	9.6	6	58.8
EV_2	3	3	4.27	12.81	6	76.86
EV_3	8	3	2.67	8.01	6	48.06

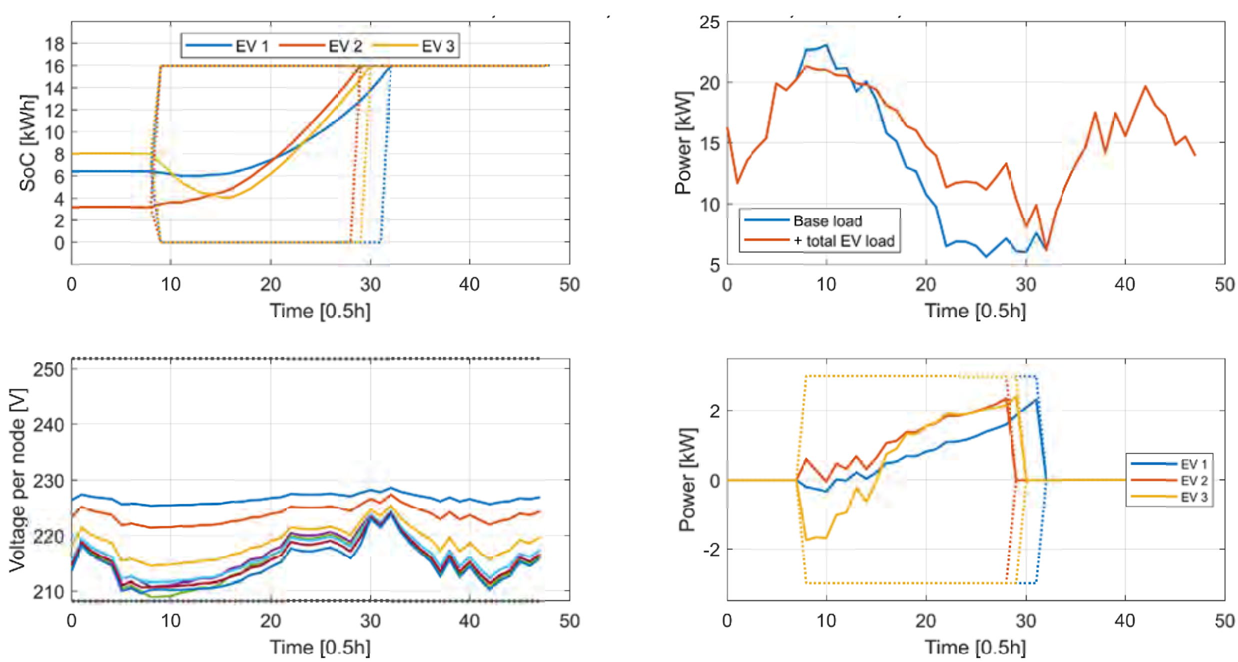


Fig .6. Simulation results with optimal energy management for PEVs connected to the LV residential distributed test grid

at low demand periods of the day which supports the valley filling structure of the load profile thereby facilitating matching of the demand-supply gap. This means, the with the help of a charged EV plugged-in to the grid, sufficient amount of energy is injected into the grid which compensates with the power consumption of the charging EVs and thereby, maintains the voltage profiles of all the nodes within the limits of nominal operation. However, even under this case the total amount of energy consumed for a 24h simulation period remains the same and the cost of energy also remains unchanged.

VI CONCLUSION

In the present study, a linear-based centralized approach has been developed to calculate the voltage profiles for a 8-node low voltage residential desitribution test grid. The load profiles developed are as per the house instantaneous load and the instantaneous consumption/injection of PEVs. A linear optimization problem is formulated to control the charging schedule and charging/discharging rate of three PEVs connected to the LV test grid under certain assumptions. Simulation results for the nodal voltages are shown under the situations of "without PEVs" and "with PEVs".

The voltage profiles of the test grid without PEVs suffer with voltage limit violatoions for load disturbances occurring in the test grid. Whereas, the voltage values remain within limits when PEVs are connected to the test grid with the developed optimal energy management strategy with controlled charging and discharging. Adequte power is injected into the grid by the charged EV at the times of peak demand periods and maximum charging occurs during the low demand periods.

The developed strategy acts only as a benchmark for the further study of peer to peer energy trading among EVs in a amsrt parking facility. Also, a single factitive charging price in ₹ 6/kWh has been considered. A two part or three-part dynamic tariff can be considered and the developed strategy can be applied for the 24h simulation period.

REFERENCES

1. S.P. Boyd and L. Vandenberghe. Convex Optimization. Cambridge University Press, 2004

2. Cazzola, P., Gorner, M., Schuitmaker, R., & Maroney, E. (2018). Global EV outlook 2018. International Energy Agency, France.

3. Yinliang Xu and Zhicheng Li. “Distributed Optimal Resource Management Based on the Consensus Algorithm in a Microgrid”. In: IEEE Trans. Ind. Electron. 62.4 (Apr. 2015), pp. 2584–2592

4. S. Sarabi, A. Davigny, V. Courtecuisse, Y. Riffonneau, and B. Robyns. “Potential of vehicle-to-grid ancillary services considering the uncertainties in plug-in electric vehicle availability and service/localization limitations in distribution grids”. In: Applied Energy 171 (2016), pp. 523–540.

5. A. Ovalle, S. Bacha, A. Hably, G. Ramos, and J. M. Hossain. “Escort Evolutionary Game Dynamics Approach to Integral Load Management of Electric Vehicle Fleets”. xIn: IEEE Transactions on Industrial Electronics 64.2 (Feb. 2017), pp. 1358–1369

6. A. Ovalle, J. Fernandez, A. Hably, and S. Bacha. “An Electric Vehicle Load Management Application of the Mixed Strategist Dynamics and the Maximum Entropy Principle”. In: IEEE Trans. Ind. Electron. 63.5 (May 2016), pp. 3060–3071.

7. Chenrui Jin, Jian Tang, and P. Ghosh. “Optimizing Electric Vehicle Charging: A Customer’s Perspective”. In: IEEE Trans. Veh. Technol. 62.7 (Sept. 2013), pp. 2919–2927.

CONFERENCE

ON

TECHNOSPHERE OF EVs

CHARGING INFRASTRUCTURE,
POWER DEMAND ESTIMATION & PRICING ISSUES

Presentations

Presentation by Shri Vikram Gulati, Country Head & Vice President, Toyota Kirloskar Motor

Profile

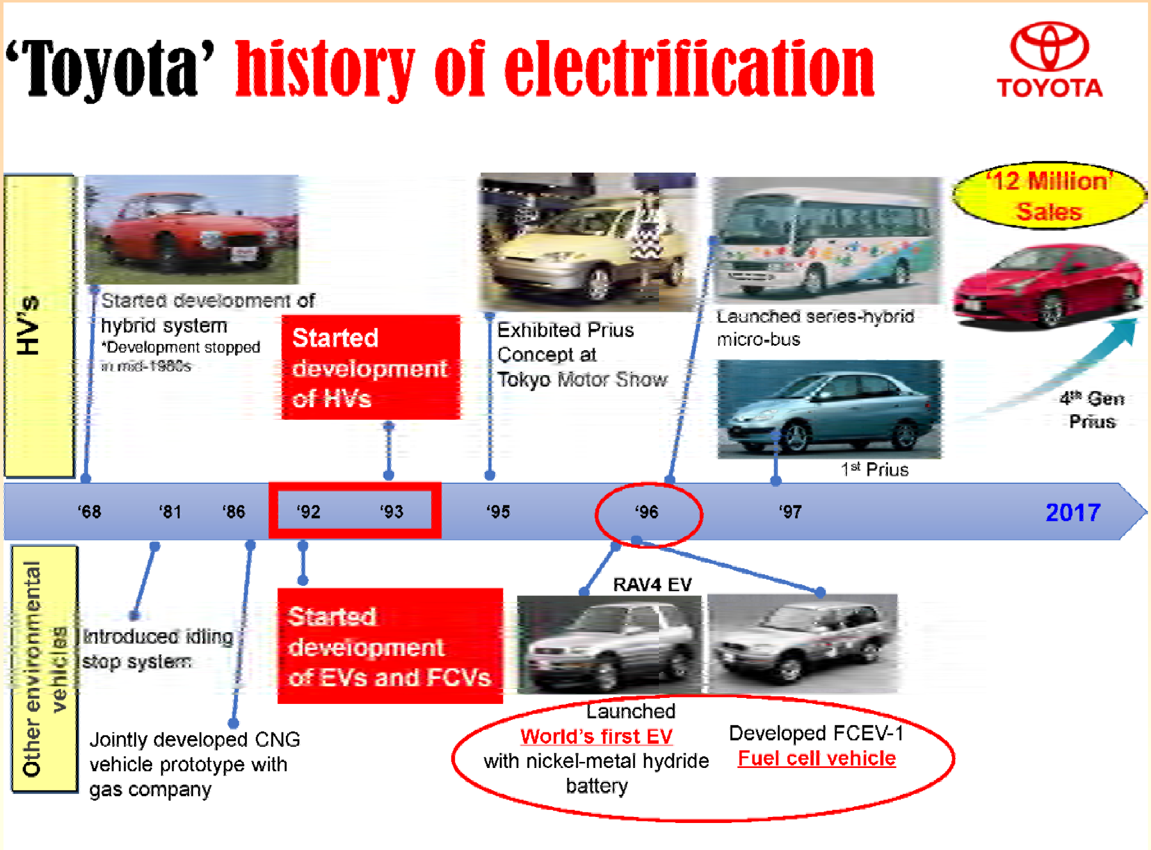
Vikram Gulati, Country Head & Vice President, Toyota Kirloskar Motor, Currently working as Country Head & Vice President (External Affairs Division) at Toyota Kirloskar Motor Pvt. Limited (TKM). He is a post graduate in Chemistry from St Stephen's College, Delhi University and holds a management degree from Management Development Institute, Gurgaon, Haryana, India. Earlier while serving as a Civil Servant (1992 batch), he has a rich and varied experience of over 22 years of working in the Government in various capacities. This includes working in Ministry of Railways and Department of Heavy Industry (DHI). While with DHI, he served as the Government Director on the board of a number of public sector companies and also handled the automotive sector. During this time he was also involved actively in shaping the electric mobility initiative and framing of the National Electric Mobility Mission Plan 2020.

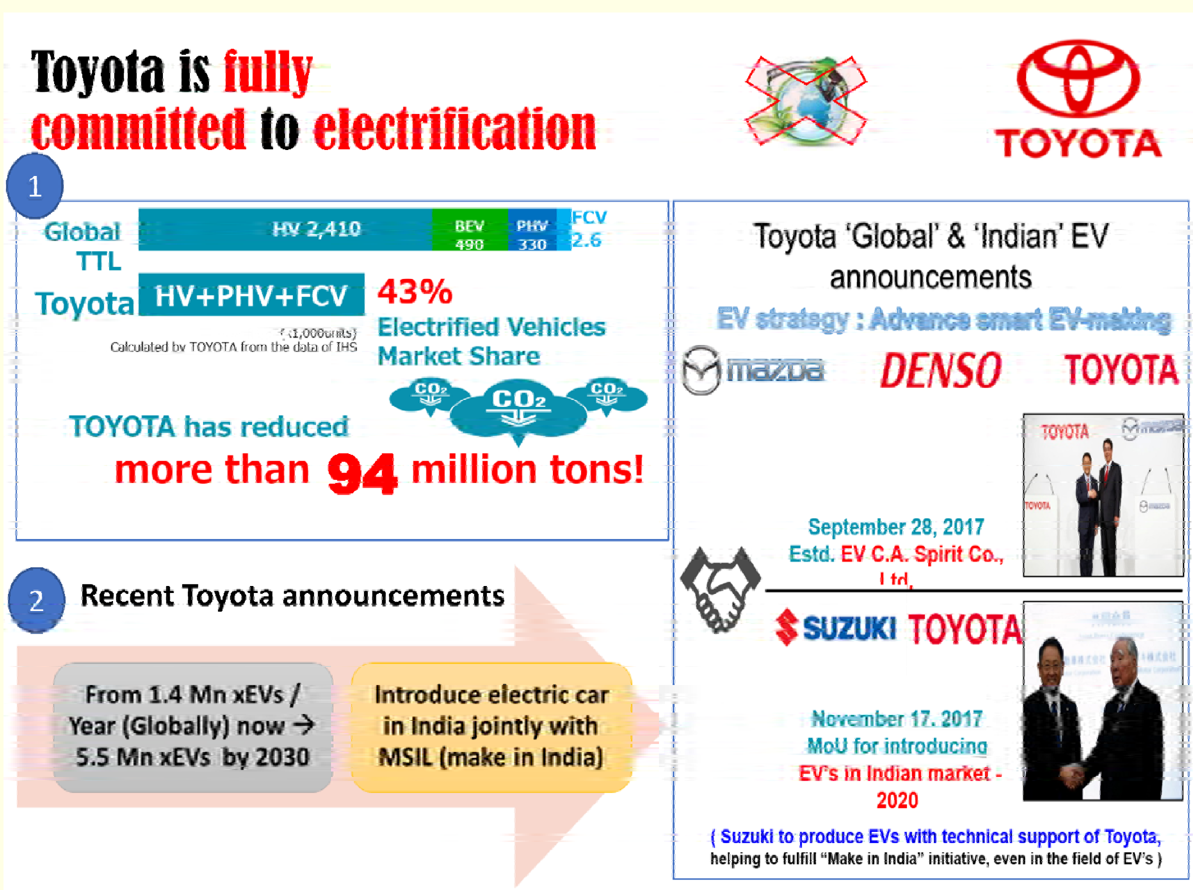
TOYOTA

'Electrification' – the imperatives for for India

4th Feb, 2019

By:
Vikram Gulati,
Country Head & Vice President,
Toyota Kirloskar Motor


'Toyota' history of electrification
TOYOTA
HV's
Started development of hybrid system
*Development stopped in mid-1980s
Started development of HVs
Exhibited Prius Concept at Tokyo Motor Show
Launched series-hybrid micro-bus
'12 Million' Sales
4th Gen Prius
1st Prius
'68
'81
'86
'92
'93
'95
'96
'97
2017
Other environmental vehicles
Introduced idling stop system
Jointly developed CNG vehicle prototype with gas company
Started development of EVs and FCVs
RAV4 EV
Launched World's first EV with nickel-metal hydride battery
Developed FCEV-1 Fuel cell vehicle


Toyota is fully committed to electrification
TOYOTA
1
Global TTL
HV 2,410
BEV 490
PHV 330
FCV 2.6
Toyota
HV+PHV+FCV
43%
Electrified Vehicles Market Share
(1,000units)
Calculated by TOYOTA from the data of IHS
TOYOTA has reduced more than 94 million tons!
Toyota 'Global' & 'Indian' EV announcements
EV strategy : Advance smart EV-making
mazda
DENSO
TOYOTA
September 28, 2017
Estd. EV C.A. Spirit Co., Ltd.
SUZUKI TOYOTA
November 17, 2017
MoU for introducing EV's in Indian market - 2020
(Suzuki to produce EVs with technical support of Toyota, helping to fulfill "Make in India" initiative, even in the field of EV's)
2
Recent Toyota announcements
From 1.4 Mn xEVs / Year (Globally) now → 5.5 Mn xEVs by 2030
Introduce electric car in India jointly with MSIL (make in India)

The key national objectives for shift to electric mobility

Energy security

- Reduction in fossil fuel use & imports along with its impact on the economy

Oil Imports > 80%

Crude Oil import bill = USD 87.7 Bn Trade Deficit = USD 87.2 Bn (2X of PY) (2017-18),

Manufacturing leadership

- Retain auto sector competitiveness, investment & jobs

Auto sector contributes 49% to manufacturing GDP, key outcome has to be to retain & increase local value addition.

COP 21

- Reduction in carbon intensity

India committed to reducing carbon intensity of economy by 30-35% by 2030 (base 2005).

Environment

- Reduction in emissions, especially city pollution

As per IIT K 2016 study for NCR vehicles contribute 20% to PM 2.5 emissions – trucks 9% & 2W 6.6%.

A. Key national objective – Reduction in fossil fuel consumption → (a) Trade Deficit (b) Geo Political strategy.

Reduction of fossil fuel imports → its impact on the economy (trade deficit, CAD etc)

1 Reduction of Fossil fuel consumption.

FACT 1: Diesel – CV amongst highest
Petrol – 2W highest (61.4%) Cars (34%)
MoPNG study 2014

FACT 2: BEV – 100% displacement
PHEVs – potentially 100%
HEVs - 35-50%

FACT 3: Fossil fuel savings will be maximum with tech agnostic approach.
BCG report

2 Impact of LiB, motors & electronic imports

FACT 1: EV parts Import - BEV>>PHEV>>>HEV
FACT 2: Import dependence on Raw materials

Fact 3: LiB demand:
1 million 2W (1-2.7 KWh/veh) – 1 – 2 GWhr)
1 million 4 W (20 KWh/vehicle) – 20 GWhr

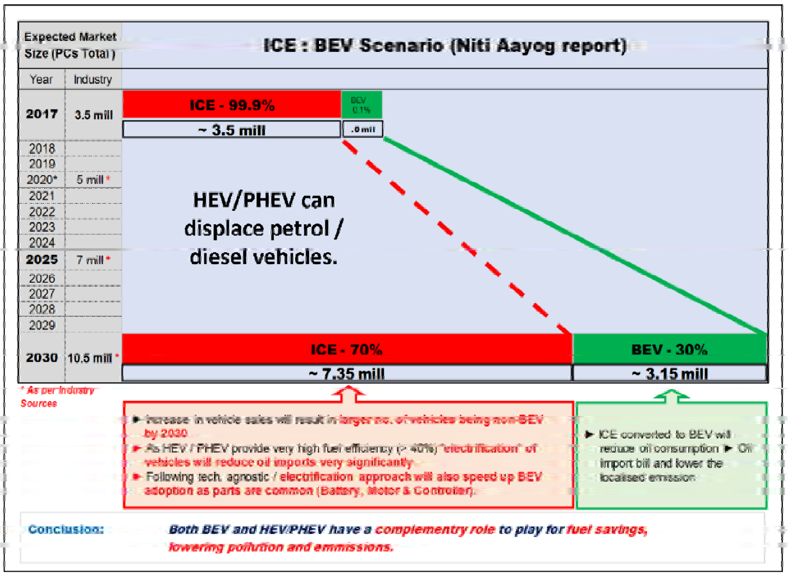
Fact 4: In 2017 – 18 – 2nd highest import in India was electronics – USD 55 billion

3 Export of auto components

With too sharp a focus on BEV only – new tech / investments for ICE will not come to India → impacting export competitiveness

Even with 30% BEV penetration – what about the other 7.35 million ICE 4W in 2030 (2X of 2018)?

- Using Niti Aayog Forecast of 30% 4W BEV by 2030; the new 4W petrol / diesel sales in 2030 will be twice the number today!!
- Note: Bloomberg @2018 - by 2030 BEV penetration – 7%



All xEVs – PHEV / HEV / BEV / FCV contribute to Fuel Efficiency Electrification of balance 70% 4W will result in much high fuel savings

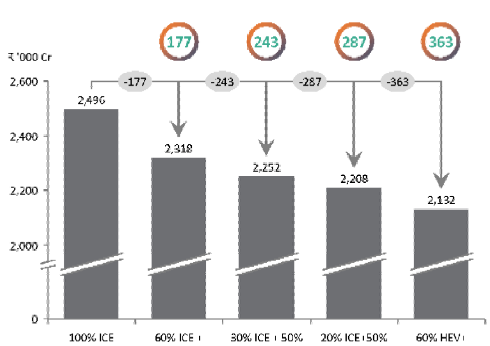
For instance the Toyota Camry hybrid :

- 48% fuel efficiency improvement over conventional gasoline variant
- Based on 3,530 Camry hybrid, sold far :
  - Estimated cumulative fuel savings of 1.05 million liters
  - Reduction of 2.49 million kg of carbon dioxide per year (HEV is 30% lower carbon intensity)

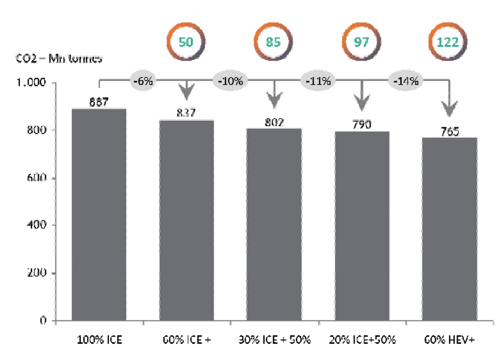
(Assumption : Average mileage of 1000 km / month / Camry Hybrid Vehicle)

Broad 4W xEV adoption (HEVs & BEVs) can create significant Fuel Savings and CO2 emission reduction.

Fuel Savings: xEV adoption has potential to bring saving of up to ~ ₹ 360,000 Cr cumulatively by 2030



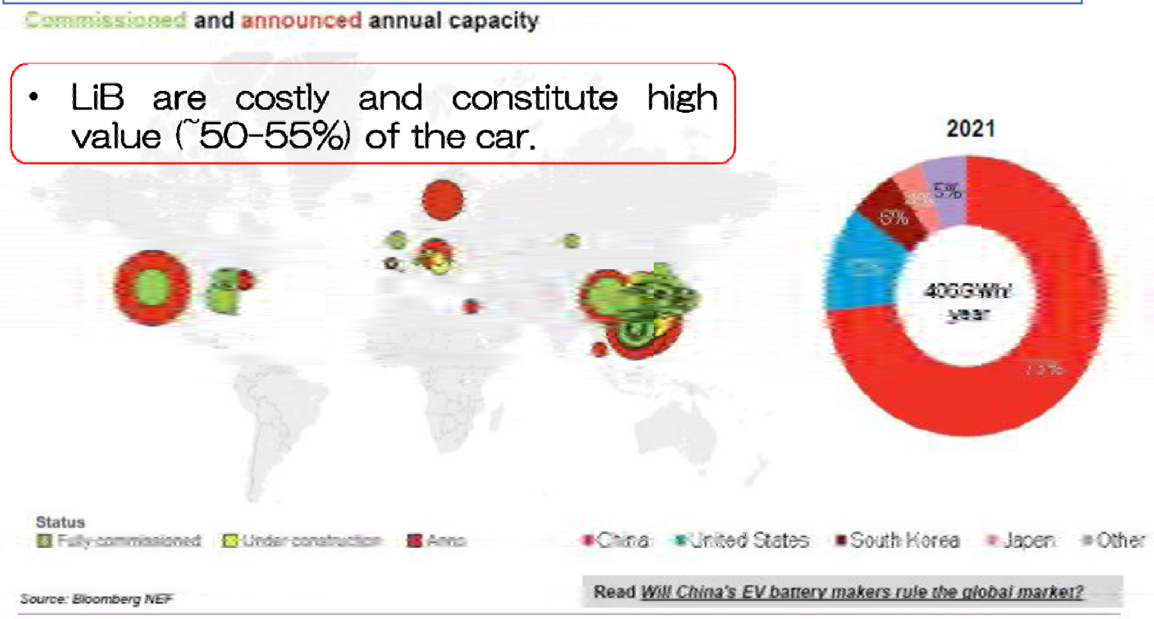
CO2 emission: xEV penetration can deliver cumulative CO2 reduction of ~120 Mn tonnes by 2030



Going from BEV only approach (40% BEV & 60% ICE) to a tech agnostic approach (40% BEV & 60% HEV) fuel and carbon savings increases from Rs 177,000 Cr → Rs 363,000 Cr & 50,000 → 122000 Million tons respectively.

Import & Geo Political implications: China's dominance in LiB manufacturing will increase

- LiB are costly and constitute high value (~50-55%) of the car.



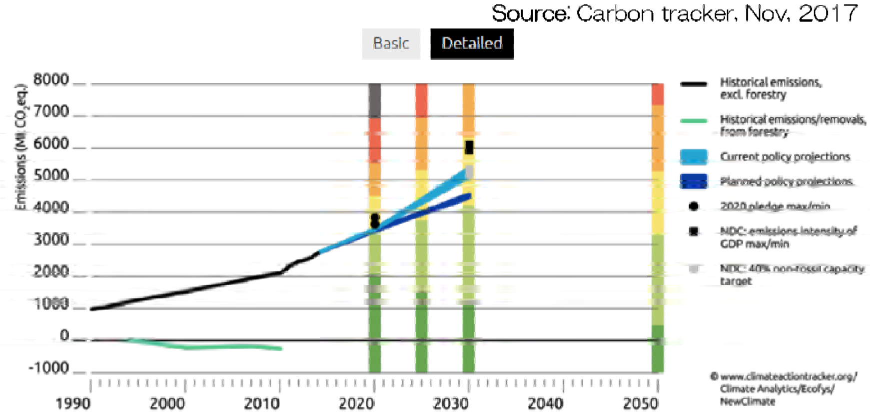
- China Global market share of LiB Manufacturing from 2018 → 2021 will increase from 59% → 73%

B. Key national objectives – carbon intensity.

India will easily achieve its carbon commitments even with current policy projections.

Source: Carbon tracker, Nov, 2017

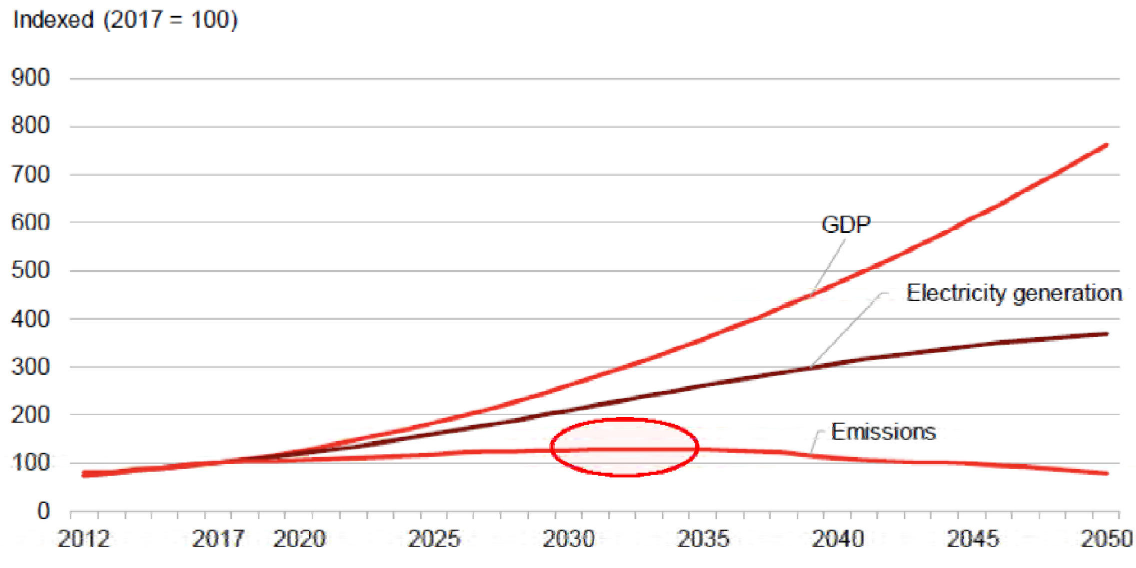
India committed to reducing carbon intensity of economy by 30-35% by 2030 (base 2005).



- On a well to wheel basis BEV in Indian conditions emits more carbon than HEVs.
- With Indian power sector carbon to peak by 2030 ` 2033 (BNEF, 2018 projections) this is not likely to change till than.

Electricity generation & emission Projections for India

For India the emissions from electricity generation will peak around 2033



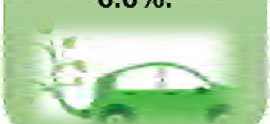
Source: Bloomberg NEF, The World Bank

41 July, 2018

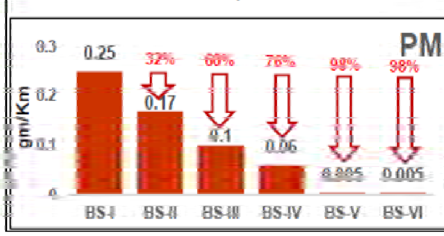
Bloomberg New Energy Finance

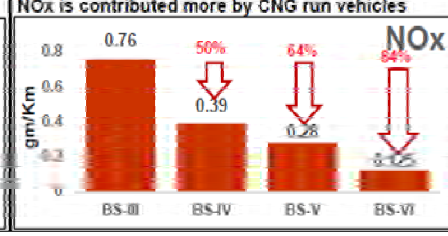
C. Key national objective for shift to electric mobility – emissions.

As per IIT K 2016 study for NCR vehicles contribute 20% to PM 2.5 emissions – trucks 9% & 2W 6.6%.



PM	NOx
- 2600 % (26 times) improvement in emissions from the veh. operating under Pre-BS & under BS-IV norms currently. - **BS-IV vehicles** w.e.f 2010 **pollute '7' times lesser.**	- 52 % of NOx : due to industrial stakes - NOx due to vehicles : 36 % 4Ws contribute : 17 % CNG contribute : 7.6 % (Gasoline - 5.3%, Diesel - 4.1%) **NOx is contributed more by CNG run vehicles**





Some facts:

- As per TERI report (2018), in NCT BS IV Cars contribute – 1.35% of PM 2.5,
- Greater problem in vehicular pollution is (a) commercial vehicles (9%), 2W (6%) and (b) old ill maintained vehicles (11.05% - pre 2010)
- 92% reduction expected by BS VI (over BS III)
- HEV emission is 1/10th of BS VI targets using BS IV fuel
- BEV – marginal cost of emission reduction is too high.

D. Key national objectives - manufacturing

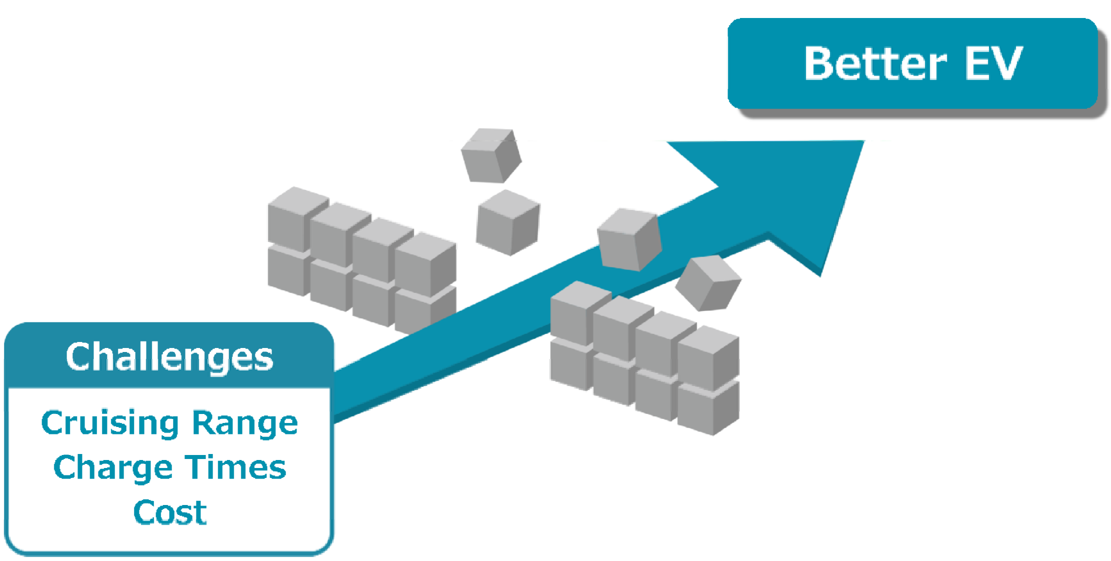
Auto sector contributes 49% to manufacturing GDP, key outcome has to be to retain & increase local value addition.

Snapshot of Indian Auto sector

7.2% To GDP	USD 100 Bn Turnover*	19 million Jobs created	8% - R&D Expenditure
4.3% Exports	USD 20 Bn Exports*	49% Manufacturing GDP	13% Excise

- Globally, OEM's strategy for electrification depend on
  - Vehicle segment,
  - customer acceptance, affordability,
  - scale and ease of localization,
  - Competencies, access to technology, R&D capacity and overall business needs.
- So while some OEM may desire to deploy one or more of the range of xEV technologies (PHEV and SHEV) in the path of EV, some may deploy EVs only.

Challenges of EV



Challenges of EV are

Challenges

- Cruising Range
- Charge Times
- Cost

Different for different countries

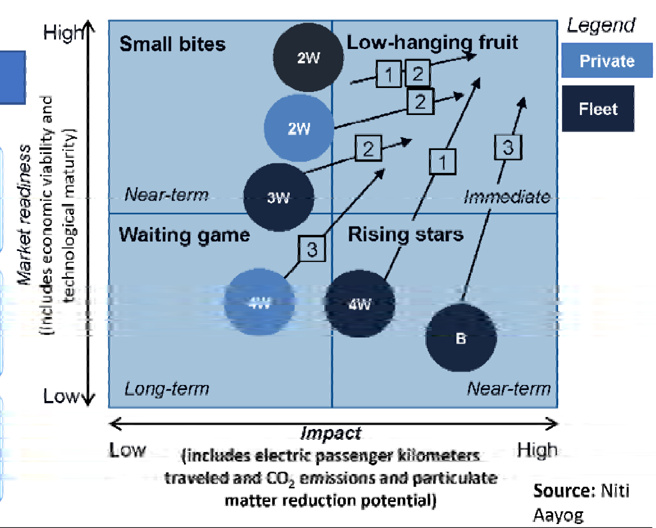
- Purchasing power
- Unique conditions
- Infrastructure
- Manufacturing Ecosystem

Different for different segments

Unique context of electrification in India and resources required

Indian 4W market is very challenging for BEV but this is not so for other segments

- Low vehicle (4W) penetration & low per capita income
- India is predominantly low cost car market with high 'value for money'
- Challenging climatic conditions, Low mileage & low maintenance costs



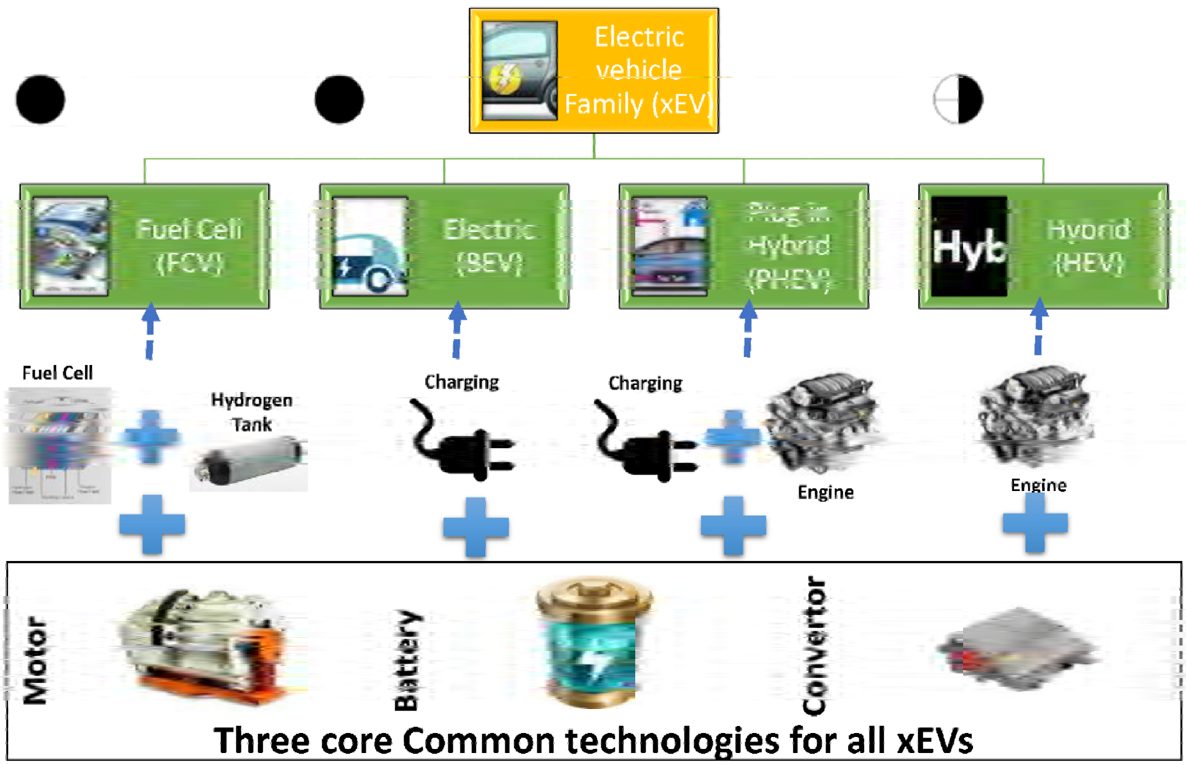
Source: Niti Aayog

Shift to electric mobility requires a vibrant BEV eco-system. The creation of local BEV eco-system (infra + local Supply Chain) will take time.

It is logical to (a) follow segmented approach and target BEV for easier segments – 2W / 3W etc (b) support all xEVs for 4W → faster displacement of ICE by xEVs for creation of local manufacturing eco-system.

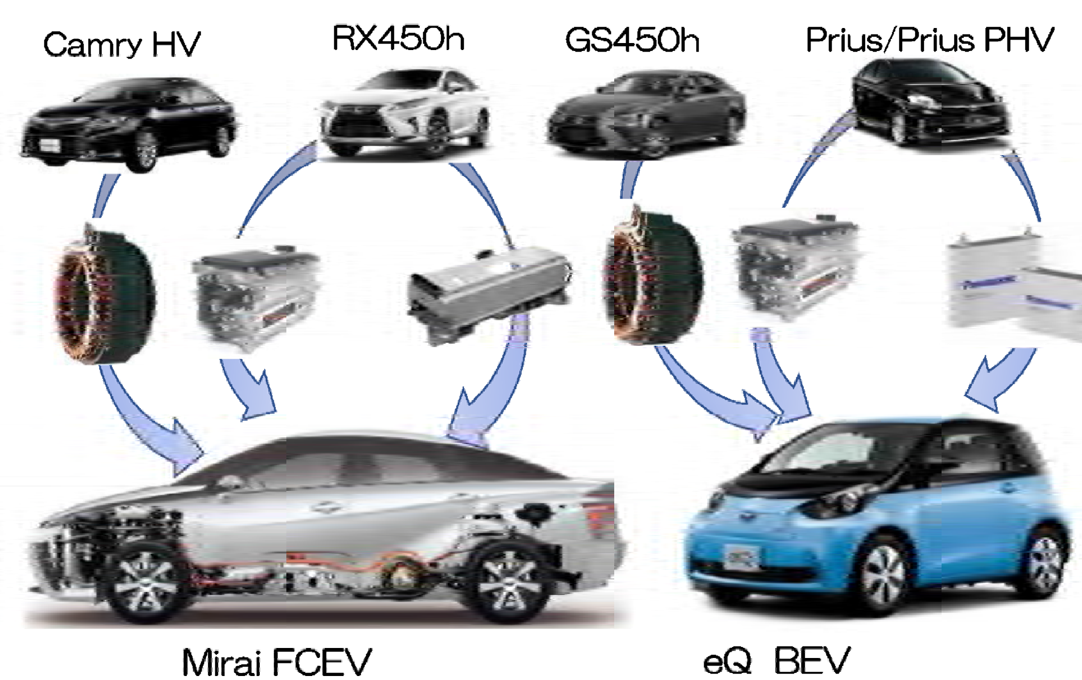
Local manufacturing of EV parts:-

All xEVs - have three common core technologies.

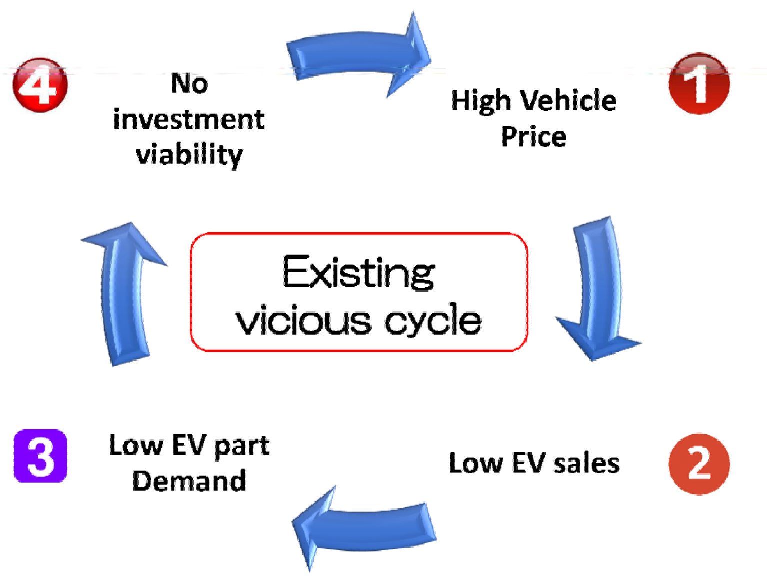


TOYOTA BEV and FCV's 3 Core parts are Same as existing Strong HEV/PHEV

Strong HEV/PHEV parts CAN be APPLICABLE for FUTURE EV.

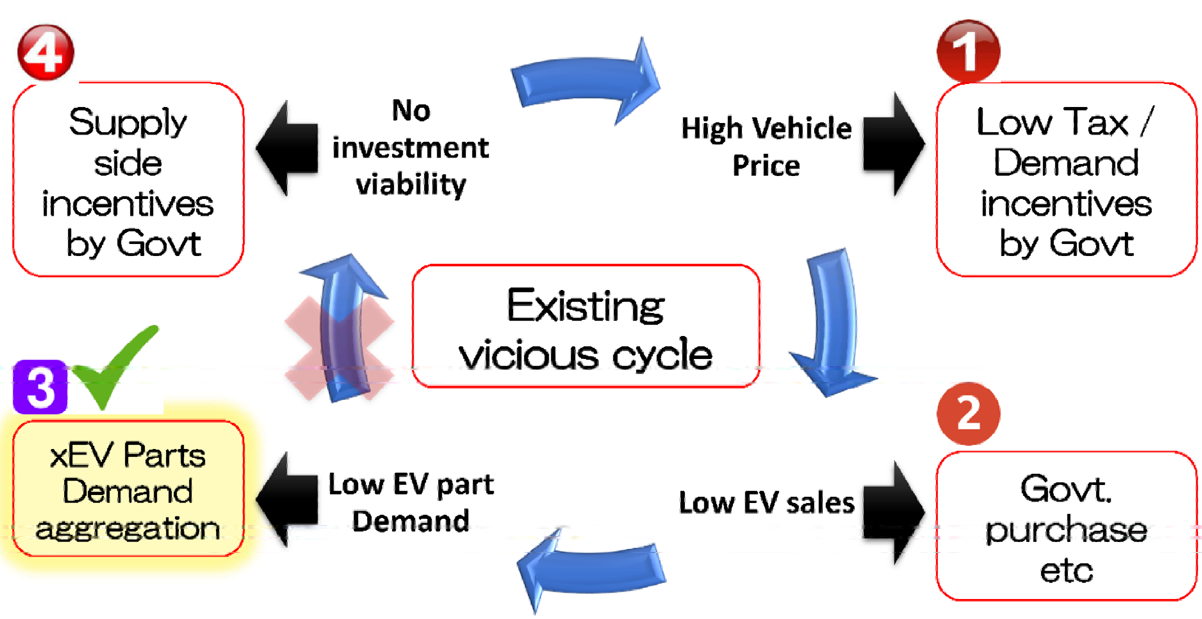


Levers to encourage local manufacturing - I



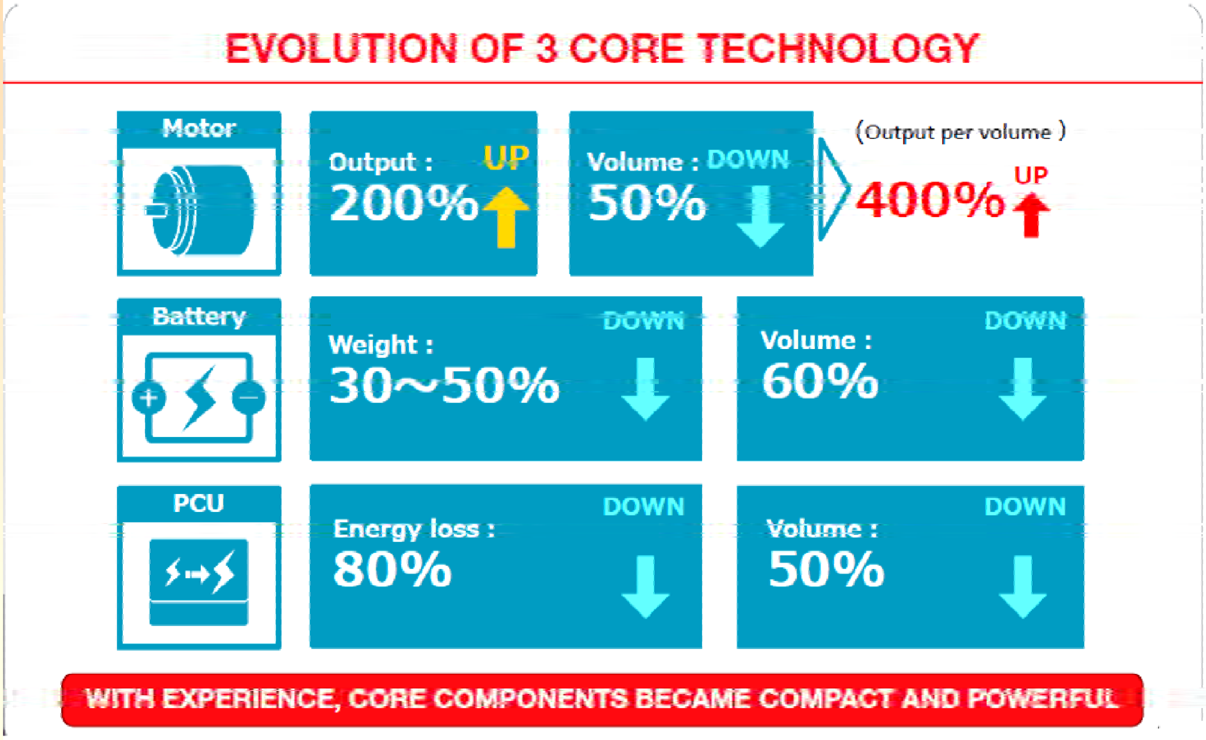
1. **Existing vicious cycle has to be broken .....**
2. **High EV parts demand is must for Investment viability**

Levers to encourage local manufacturing - II



As core technologies of all xEVs are common demand aggregation of parts by policy support for SHEV, PHEV and BEV is the most optimum approach for creating investment viability for local EV part manufacturing.

Tech. agnostic approach will also benefit faster BEVs technology evolution.



Conclusion:

1. Reduction of oil import bill is must but not by increased import bill of EV parts,
2. Tech agnostic approach → max oil savings
3. While shifting to Electrification – dominance by China will be an issue,
4. Well to Wheel carbon emissions BEV > HEV.
5. Transport pollution – old veh > CV > 2W.
6. In case of 4W BEVs; customer acceptance remains a big challenge.
3. High vehicle cost along with range anxiety and charging time need to be overcome.
4. Local manufacturing is critical for the economy and for faster adoption of EVs
5. EV Core parts being common across all xEVs, therefore Govt support to all xEVs is essential to create local manufacturing eco-system.

Presentation by Shri Aditya Ramji, Economist, Managing Director's Office, Mahindra and Mahindra Ltd.

Profile

Aditya Ramji is an Economist with the Mahindra Group, focusing on transportation, electric mobility and its interplay with energy. He has a specialisation in Energy and Development economics. His key areas of research have been energy policy, energy access and development policy, transport and renewable energy, programme implementation and impact evaluation. Prior to joining Mahindra and Mahindra, he has worked with two leading think tanks in India - the Council on Energy, Environment and Water (CEEW), and The Energy and Resources Institute (TERI). He has represented the Government of India at various forums related to climate change negotiations and has served on government committees related to renewable energy, railways, energy access, and public health. His work has involved policy analysis with a focus on quantitative modeling of energy-economy-environment linkages. He has extensive field experience across India. He has also published in leading academic journals including the Journal of Energy and Energy Policy (Elsevier Publications).

Abstract

Electric Vehicles not only signify a move towards Urban Mobility that is Clean, Connected and Convenient but is also undoubtedly, the Future of Mobility. A paradigm shift towards this requires a synergy between Regulatory, Policy, Engineering and Technological developments, among others. China and Europe today dominate this market with a share of more than 75% of global EV sales. In the transition to EVs, the early adopters have been personal mobility segments, whereas in the Indian context, we believe that the first adopters will be the shared mobility segment. With current cell costs around USD 150/kWh, commercial mobility players will be early adopters as they have higher capacity for asset utilization and minimal risk from low public charging infrastructure availability. As battery costs come below USD 100/kWh, the personal mobility segment is likely to pick up. Technology in the EV space has been rapidly evolving, with focus largely on battery chemistries and powertrains, which are the two biggest costs in an electric vehicle. Today, battery costs account for almost 40% of the EV cost. If we look at the Total Cost of Ownership (TCO) comparison of EVs and ICE vehicles, an important factor is electricity costs. Electricity is an important input for an EV in its life cycle, thus, the tariffs for EV charging will play a critical role. Going forward, auto OEMs will be new long-term partners of Electricity Regulators. One of the key concerns has been how EV charging will impact electricity demand as well as the grid infrastructure. Estimates indicate that an ambitious growth trajectory of electrified transport will impact peak electricity demand for India, by only 6% in 2040.

The government has also been promoting EV adoption with the FAME scheme at the central level. More than 10 Indian states also have notified/draft EV policies with states like Uttar Pradesh, Maharashtra and Karnataka leading the way.

The shift to EVs is also coming with other new technology shifts such as second life batteries, energy storage, renewables integration, among others. Thus, the road to this new mobility paradigm would eventually present opportunities for strategic partnerships, but will also require industry and regulators to work together to ensure seamless ecosystems in a dynamically evolving environment.

Mahindra Rise.

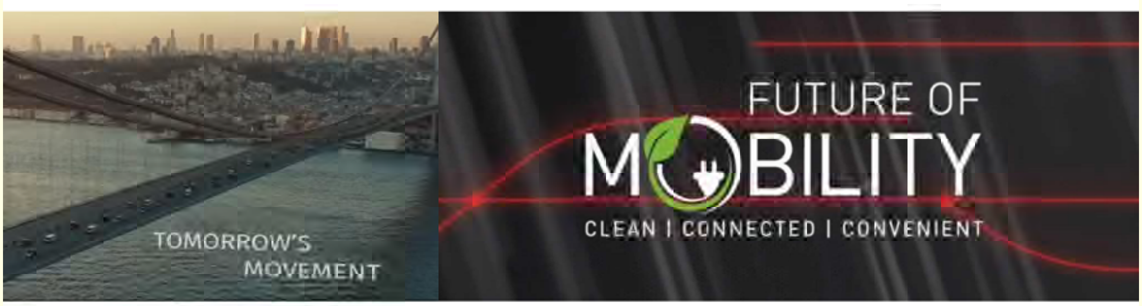
EVs in India: Technology and Business Models

Aditya Ramji
Managing Director's Office
Mahindra and Mahindra Ltd.

ramji.aditya@mahindra.com

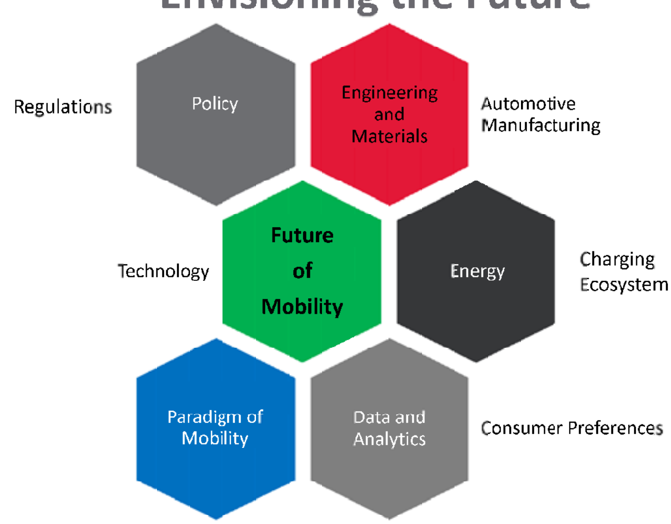
4 February 2019

Our Vision: Tomorrow's Movement, Today



Clean | Connected | Convenient

Envisioning the Future



Global Status of Electric Mobility

>1.2 million xEVs
sold in 2017

165 models

~4 million EV
car parc in 2018

>90,000
charging stations

66.4%
share of BEVs

>75%
market share in China and Europe

Global EV Market Outlook 2018, F&S

Paradigm Shift in Electric-based Mobility

Global Lessons

Personal Mobility → **Shared Mobility**

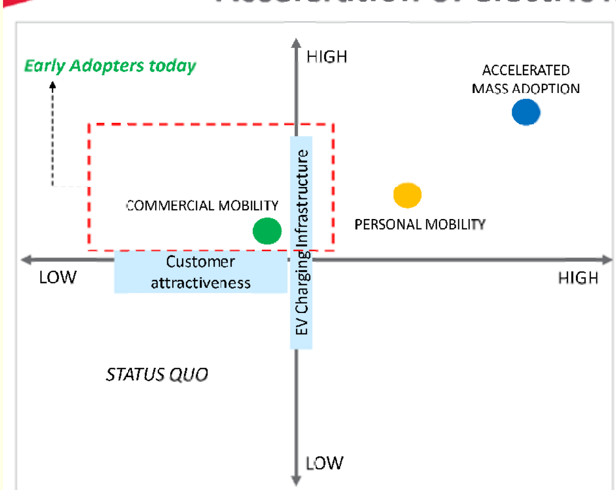
- Significant government support in the early years
- Tax incentives, investments in charging infra

India: Going Forward

Shared Mobility → **Personal Mobility**

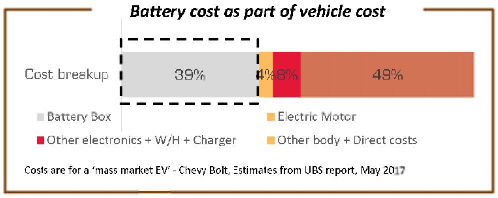
Fiscal Incentives	Non-Fiscal Incentives
• Continued support under FAME Scheme (2.0) • Road Tax and Registration tax waiver for EVs • Incentives for EV charging infrastructure such as land and electricity costs • State GST reimbursement, toll tax waiver for EVs	• Green Number Plate • Ease of permits • Green lanes on select routes • Integrate Climate Change in Transport Policy

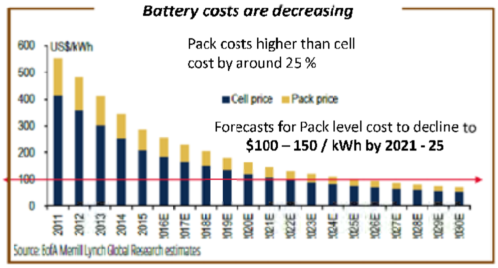
Acceleration of electric mobility in India

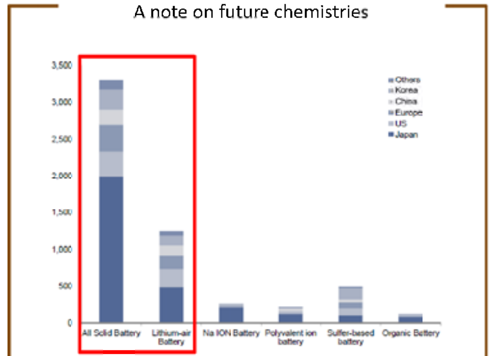


- With current cell costs around USD 150/kWh, commercial mobility players will be early adopters
- Commercial operators have higher capacity for asset utilization, and minimal risk from low public charging infrastructure availability
- As battery costs come below USD 100/kWh, personal mobility segment will pick up

Technology Drivers

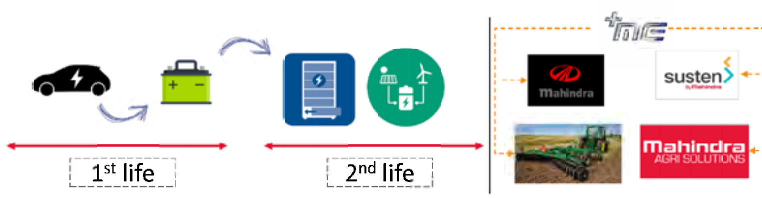




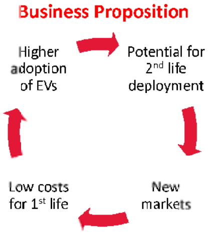


- Key research happening in Solid state and Lithium Air battery chemistry
- Benefits of Solid state :
  - High level of safety
  - Greater energy density
  - Higher conductivity → Leading to Faster charging times

2nd Life Batteries: Creating Shared Value



Business Proposition



Customer Value Proposition

- Low cost Li-Ion batteries for Non – Automotive applications
- Lower acquisition cost for EV's

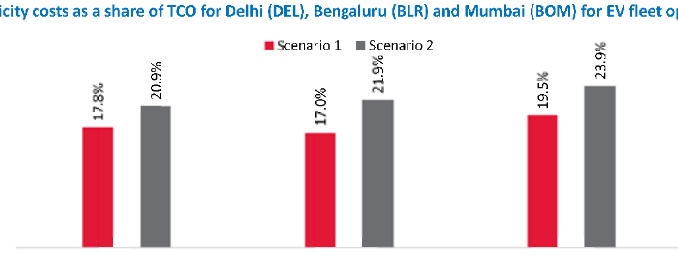
Social Value Proposition

- Improved system efficiencies by extending the recycling period of Li-Ion batteries
- Lower negative externalities to the environment

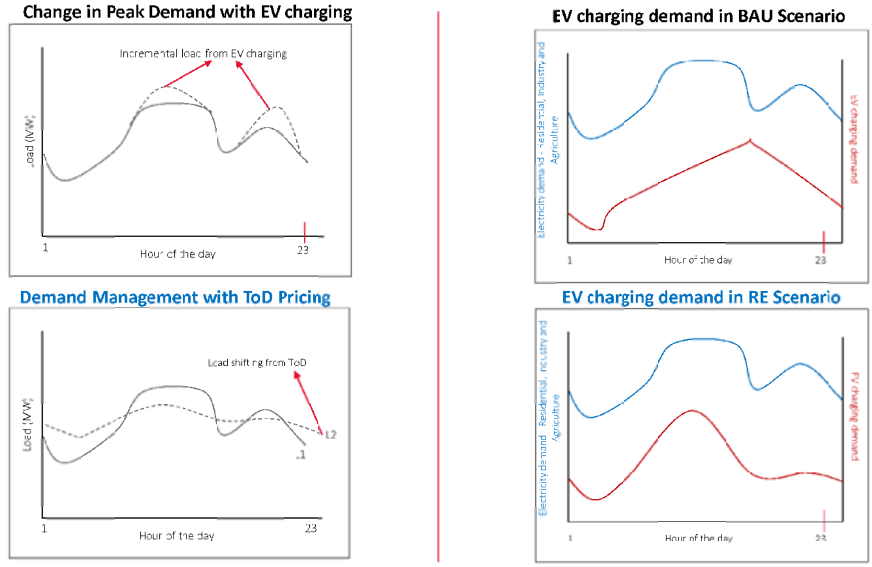
EVs and Electricity Demand

- Even with an ambitious target of only BEV sales from 2030 onwards, **the current trajectory indicates that electrified transport will impact peak demand by only about 6% in 2040** *(NREL, NITI Aayog)*
- This is primarily driven by two factors:
  - Total electricity demand will be significantly higher with increased consumption across the residential sector
  - Higher penetration of two/three wheelers which consume lesser for charging
- Electricity tariffs play a crucial role in the adoption of EVs – cost of charging defines the operations cost

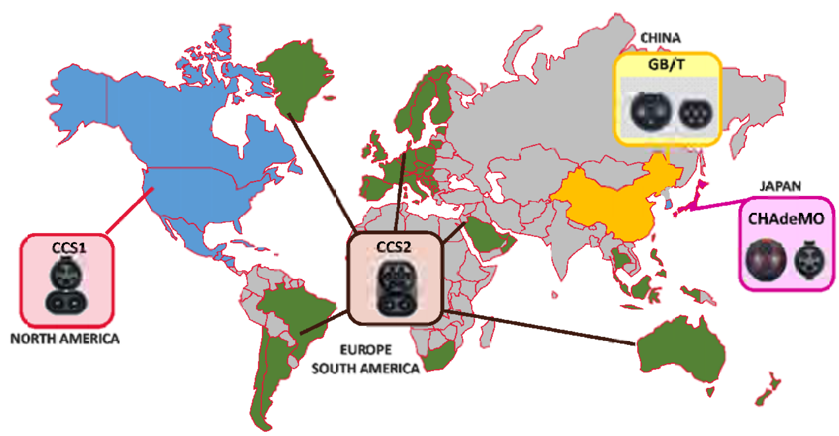
Electricity costs as a share of TCO for Delhi (DEL), Bengaluru (BLR) and Mumbai (BOM) for EV fleet operators



Demand Management for EV charging



Different Regions Have Adopted Different Charging Standards



DC Charging Systems Comparison

Charging System	Connectors & Protocol	Charging Capacity	Min FC charging time for 15 kWh battery	Advantages	Disadvantages
European	CCS based on PLC	350 kW	50min	✓ Combined connector for both AC & DC ✓ Less number of pins	× High System cost × Non-Proven Reliability for Indian Conditions × PLC × Transformer required
Chinese	GB/T based on CAN	250 kW	50min	✓ CAN based ✓ System Cost ✓ Proven in largest charging Infrastructure	× Not experimented outside Chinese set up. × Transformer required
Japanese	CHADeMo based on CAN	100 kW	50min	✓ CAN based	× Lower Power × Non-Proven Reliability in Indian Conditions × Transformer required
Bharat Charging Protocol	**BCP based on CAN**	**15kW**	**50min**	**✓ CAN based ✓ Experimented Intensively in Indian Conditions ✓ Ultra low cost.**	**X Not Experimented for HV**

Scenario 1 : Same battery capacities charged with different capacity chargers

Bharat Stage protocol – 15 kW

INR 2 lacs

Charging time:

0-80% - **50 min**

15 kWh Battery pack- 140 km range

~ INR 10.5 lacs

CCS protocol- 100 kW

INR 40 lacs

Dedicated Transformer required

Charging time:

0-80% - **50 min**

16 kWh Battery pack- 140 km range

~ INR 15-20 lacs

Range per charge time remains same BUT higher capital cost

Scenario 2 : Different battery capacities charged with different capacity chargers

Bharat Stage protocol – 15 kW

INR 2 lacs

Charging time:

0-80% - **50 min**

15 kWh Battery pack- 140 km range

~ INR 10.5 lacs

CCS protocol- 100 kW

INR 40 lacs

Dedicated Transformer required

Charging time:

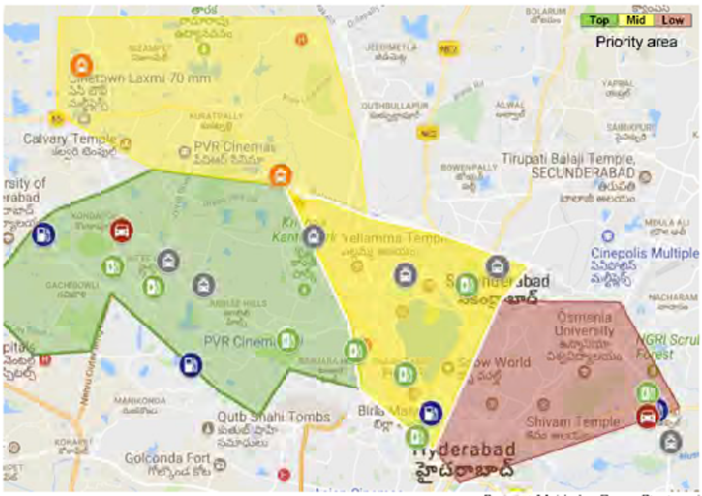
0-80% - **50 min**

60 kWh Battery pack- 350 km range

At Least INR 25-30 lacs

Range per charge time increases BUT significantly higher capital cost

Partnerships for City-wide Charging Infrastructure



Source: Mahindra Group Strategy | Representation

Role of the Electricity Regulator

Electricity is the most important input for an EV in its life-cycle

- Auto OEMs are a new and long-term partner of Electricity Regulators

- What is Public charging infrastructure?
  – Offices, commercial complexes, parking lots, malls, etc.
  – Defining public infrastructure based on the context is important

- Billing and Metering Regulations
  – Digital meters, net metering possibility
  – Vehicle to Grid applications

- Tariff Regulations
  – Determining tariff for EV charging for different consumers
  – EV tariffs will have to be dynamic as it is a rapidly evolving space

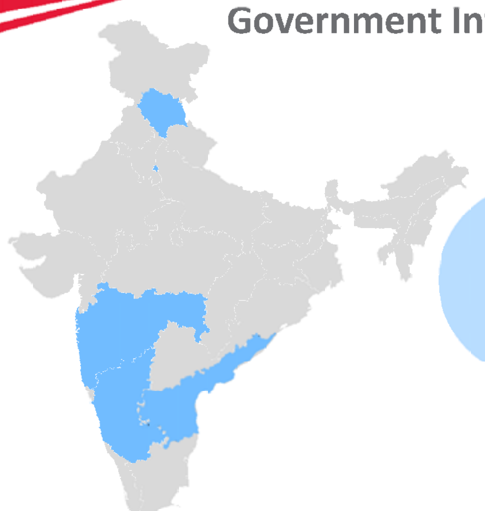
UPERC – Strategic Outlook Group

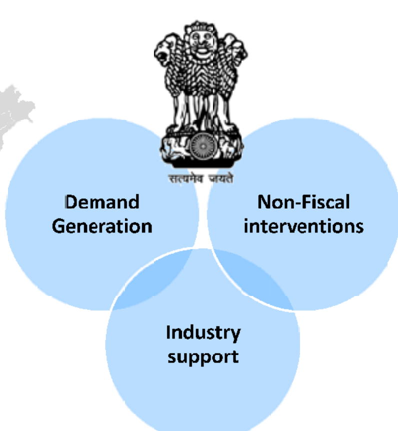
- UPERC may form a SOG to continuously review the developments in the EV space and the interplay with the electricity ecosystem

- SOG to help anticipate potential regulatory issues and be pro-active towards new technologies

- With a constantly evolving technology like EV:
  – Periodic reviews with DISCOMs and OEM partners to take stock on technology developments
  – Resolution of issues in operationalizing charging infrastructure
  – Creating a Dedicated EV Cell to assess requirements for grid infrastructure, costs, open access, renewables and energy storage

Government Interventions





National EV Policy

Launch of FAME 1 Scheme	India announces EV ambitions	FAME-I extended	FAME-2? Or State Policies?
2015	2017	2018	2019

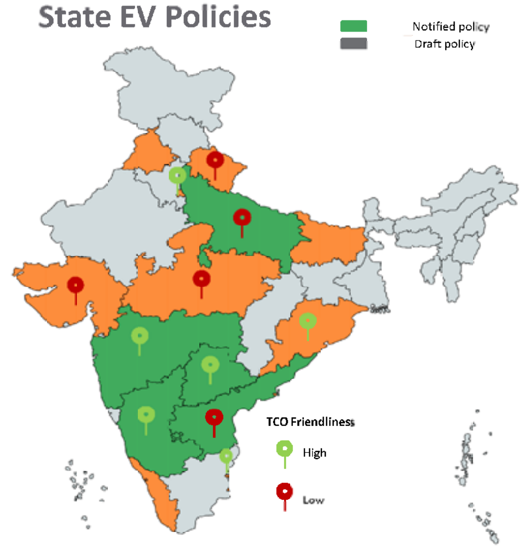
Segment	FAME 1
2W	29,000/-for motorcycle and 22,000/ for scooter
3W – High Speed	61,000
3W – Low Speed	45,000
4W Cars	1.2 – 1.4 lakhs
4W LCV	1,87,000
Buses	85 – 100 lakhs

- No incentives for hybrids
- Only for lithium-ion battery based EVs
- FAME 1 extended till March 2019

- **Policy Certainty:**
  - Government needs to provide clear direction for transport and mobility
  - Fuel preferences from an energy security perspective
  - Significant investments are required for the EV landscape
- **Policy Coordination and Implementation**
  - Multiple ministries involved
  - **Risks of policy uncertainty**
- **FAME-II ?**
  - Proposed with subsidy of INR 10,000/kWh with uniformity across segments
  - With limited resources, government needs to prioritize funds allocation

State EV Policies

- **Manufacturing Incentives**
  - Land, utilities
  - Tax rebates
- **Vehicle Incentives**
  - Capital subsidy in addition to FAME scheme
  - SGST reimbursement
  - Road tax/registration waiver
  - Green number plates
  - Toll waivers
- **Charging Infrastructure incentives**
  - Capital subsidy
  - Land at subsidized rates
  - Rationalized electricity tariffs



First Mover and Shaker

>100 Mn ekms
2010 – till date

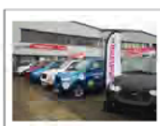
5000+
vehicles on road

70+
Patents applied

10+ years
of Li-ion in India

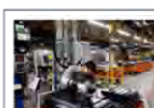
18+
cities across the country

Already invested 600 cr. in EV technology, product, capacity and supplier end investment



Market penetration
- Brand recognition, 51 experienced dealerships

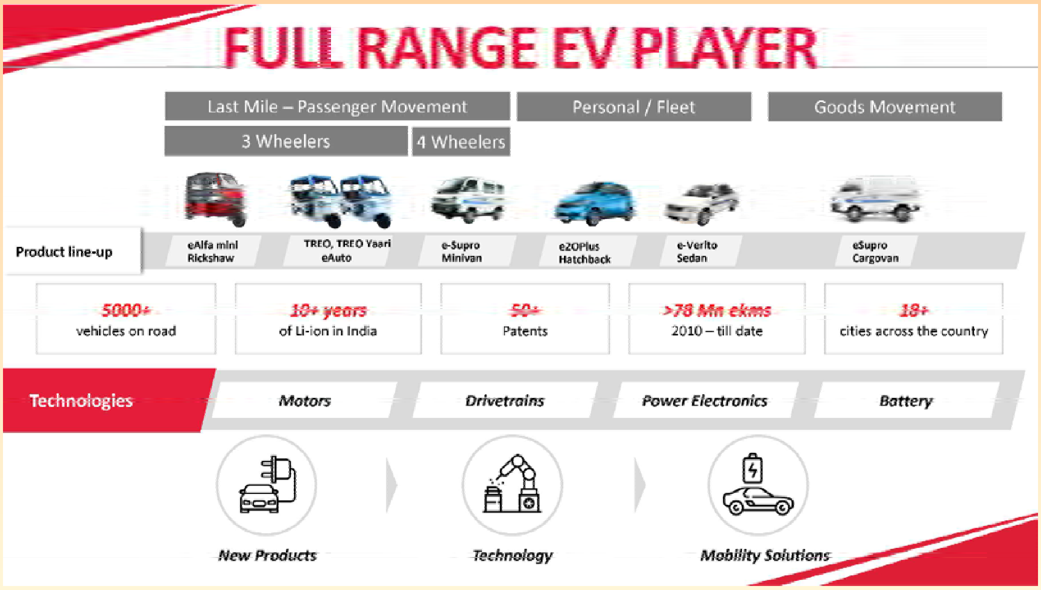
Electric powertrain (48V – 650V)
- Technology optimisation for Indian context



System manufacturing setup
- Low cost localised manufacturing experience, (India)

Strategic partnerships and pilots
- Global quality suppliers & strategic partners

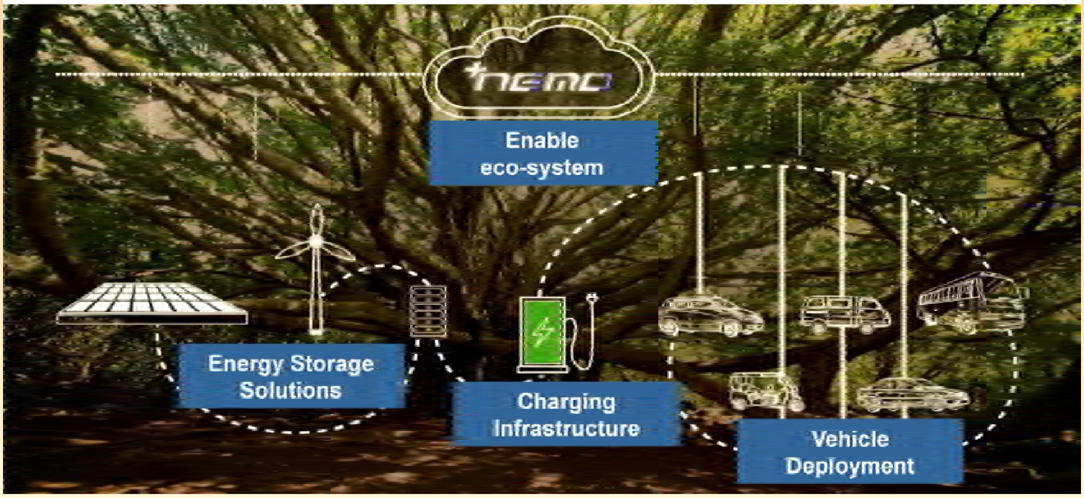
Faster time to market | High Quality | Cost competitive


FULL RANGE EV PLAYER
Last Mile – Passenger Movement
Personal / Fleet
Goods Movement
3 Wheelers
4 Wheelers
Product line-up
eAlfa mini Rickshaw
TREO, TREO Yaari eAuto
e-Supro Minivan
e2OPlus Hatchback
e-Verito Sedan
eSupro Cargovan
5000+ vehicles on road
10+ years of Li-ion in India
50+ Patents
>78 Mn ekms 2010 – till date
18+ cities across the country
Technologies
Motors
Drivetrains
Power Electronics
Battery
New Products
Technology
Mobility Solutions


Diverse mobility needs through EVs
OLA – Partnership for shared mobility in Nagpur
3.25mn KM; 162 tonnes CO_2; 16200 trees
Ride Sharing
Zoomcar Partnership
Self Drive Rental (300+ EVs)
Goods movement – pilots with e-commerce players
amazon
big basket
Last-Mile Freight
First and Last Mile
E-Alfa (3000 vehicles)
HRTC – Clean Public Transportation
Mass Mobility (50 e-Supros)
Lithium- Corporate Employee Commuting
Corporate Mobility (400+ EVs)

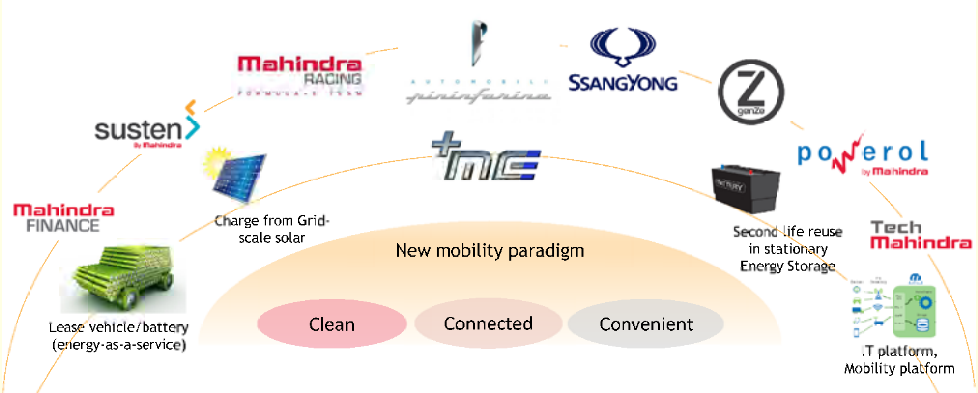

Developing India's first integrated sustainable mobility solution for a community at Auroville
nemo
Ride Sharing
Ride Hailing
Self Drive Rental
Last mile connectivity

NeMo to enable the entire EV ecosystem



Future of Mobility

The new mobility paradigm would present opportunities for exploring partnerships and building ecosystems – with synergies across the $20.7 Billion Mahindra group



Thank You.

Disclaimer

Mahindra & Mahindra herein referred to as M&M, and its subsidiary companies provide a wide array of presentations and reports, with the contributions of various professionals. These presentations and reports are for informational purposes and private circulation only and do not constitute an offer to buy or sell any securities mentioned therein. They do not purport to be a complete description of the markets conditions or developments referred to in the material. While utmost care has been taken in preparing the above, we claim no responsibility for their accuracy. We shall not be liable for any direct or indirect losses arising from the use thereof and the viewers are requested to use the information contained herein at their own risk. These presentations and reports should not be reproduced, re-circulated, published in any media, website or otherwise, in any form or manner, in part or as a whole, without the express consent in writing of M&M or its subsidiaries. Any unauthorized use, disclosure or public dissemination of information contained herein is prohibited. Unless specifically noted, M&M or any of its subsidiary companies is not responsible for the content of these presentations and/or the opinions of the presenters. Individual situations and local practices and standards may vary, so viewers and others utilizing information contained within a presentation are free to adopt differing standards and approaches as they see fit. You may not repackage or sell the presentation. Products and names mentioned in materials or presentations are the property of their respective owners and the mention of them does not constitute an endorsement by M&M or its subsidiary companies. Information contained in a presentation hosted or promoted by M&M is provided "as is" without warranty of any kind, either expressed or implied, including any warranty of merchantability or fitness for a particular purpose. M&M or its subsidiary companies assume no liability or responsibility for the contents of a presentation or the opinions expressed by the presenters. All expressions of opinion are subject to change without notice.

Presentation by Shri Yash Pal Sachar, General Manager, Honda Cars India Ltd.

Profile

Yash Pal Sachar is Working as General Manager – Corporate Affairs at Honda Cars India Limited. He is a Mechanical Engineer with MBA from Faculty of Management Studies, Delhi. He has over 30 years of work experience and has worked with Various Automobile and Consumer Electronics MNC's based all along at Uttar Pradesh. He has expertise in area of supply chain / Service Parts & Corporate Affairs. He is serving the SIAM, After Market Parts Group as Chairman since last 3 years. On personal front, play Badminton, Jogging, Yoga, Driving & reading.

Abstract

Honda will support Indian Govt. direction on Electric Mobility. Honda is committed to make two-thirds of its overall global sales from plug-in hybrid/hybrid vehicles and zero-emissions vehicles such as, FCVs and battery EVs by around 2030. Currently, Honda is adding worldwide 3.1 Crore customers annually. Honda Cars sincerely thank UPERC for organizing such a leading event and would like to mention three important points for Energy situation, Electric Vehicle direction and Mobility.

ENERGY SITUATION

Renewable Energy is necessary to reduce CO2 in future. This is to reduce India's dependence on Crude Oil.

ELECTRIC VEHICLE DIRECTION

BEV can be effective solution for short range driving without charging infrastructure. FCV can cover long range with Zero emission by renewable energy from "Well to Wheel" point of view.

HONDA ELECTRIC MOBILITY

Honda Globally has all the technologies which can be effectively used to cater to needs of Indian customer's.

Hybrids Vehicles" are intermediate to the journey of "Zero Emission Vehicle

Global Honda

Name	Honda Motor Co., Ltd.
Founded	September, 1948 by Mr. Soichiro Honda
Head office	Minami-Aoyama, Minato-ku, Tokyo, Japan
Capital	86* Billion Yen (Rs 5,576 Crore)
Number of Associates	215,638* (consolidated basis) 21,543* (non consolidated basis)

*As on 31st Mar. 2018

71% of the Sales is Automobile Business
88% of the Annual Sales is Overseas (12% Japan)
Honda earns a big part of the business outside Japan

Global Honda

- **Largest manufacturer** of internal combustion engines in the world.
- **20th** in 2017 World's Most Valuable Company.
- **74th** in **Global 2000 as per** 2017 Forbes Ranking.
- **7th biggest** Automobile company in the world.
- Sales Turnover of 15,361.1 Billion Yen* (**approx. Rs 10.43 Lac Crore**)

** As on 31st March 2018)*

Honda Worldwide Sales (2017-18)

- Production
- Sales
- Production & Sales
- Others
- Under construction
- Study Open Requested Proc.

Motorcycles - 19.49 Mn.

Automobiles - 5.29 Mn.

Power Products - 6.26 Mn.

Total – 31.04 Mn. (3.1 Crore customers added in 2017-18)

Honda in India

		Year of Establishment
HONDA Power Products	**Honda Siel Power Products Ltd** *Greater Noida (U.P.)*	1986
HONDA	**Honda Cars India Ltd** *Greater Noida (U.P.), Tapukara (Raj.)*	1995
HONDA HMSI	**Honda Motorcycle & Scooter India (P) Ltd** *Manesar (Har.), Tapukara (Raj.)* *Banglore (Ktk.), Vithlapur (Guj.)*	1999
	Honda R&D India Pvt. Ltd **Manesar (Har.)**	2003

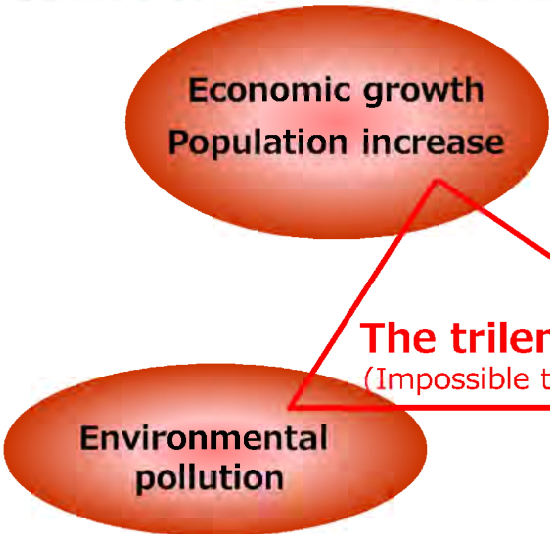

Honda Cars India Ltd. (HCIL)

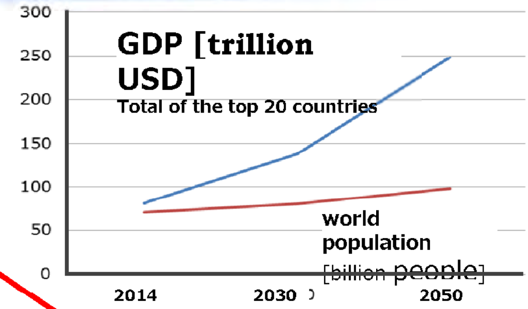
HONDA

President & CEO

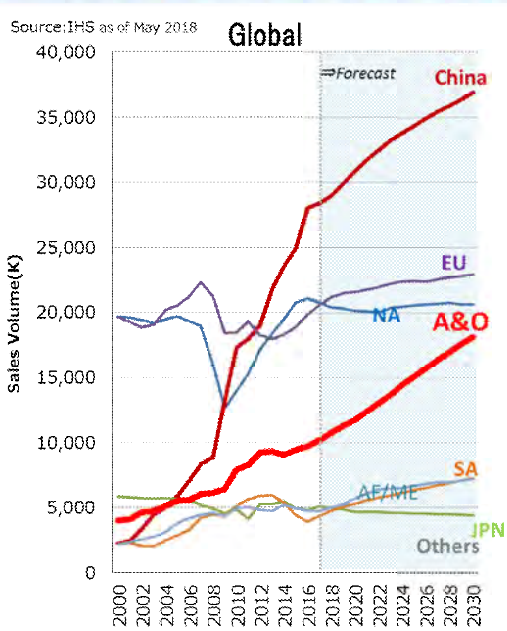
Established	1995
Honda's Equity	100%
Products	Automobiles
Capacity/ year (Nos.)	2,80,000
Employees (Nos.)	**8,660***

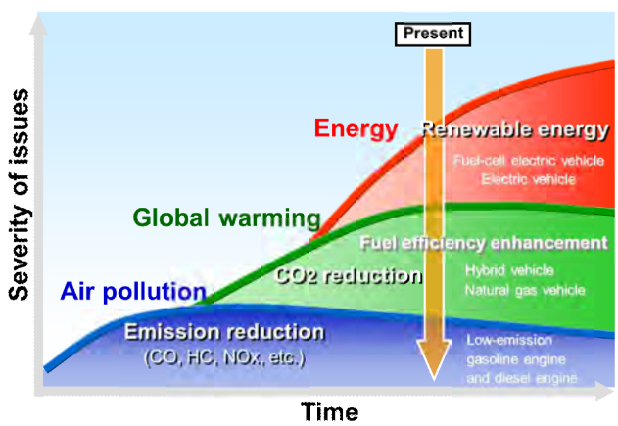
Current situation in the world





Environment and Energy Issues





<World Automobile Sales>

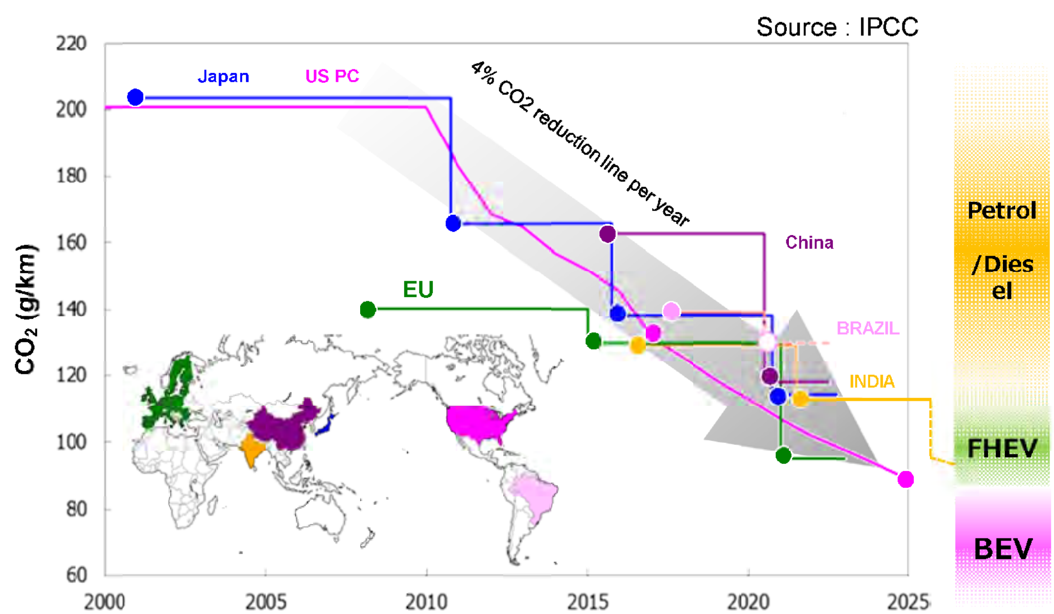
- **2000** (Actual) : **55 million** units
- 2017 (Actual) : 94 million units
- **2030** (Forecast) : **120 million** units

<Countermeasure>

Global warming : Fuel efficiency enhancement

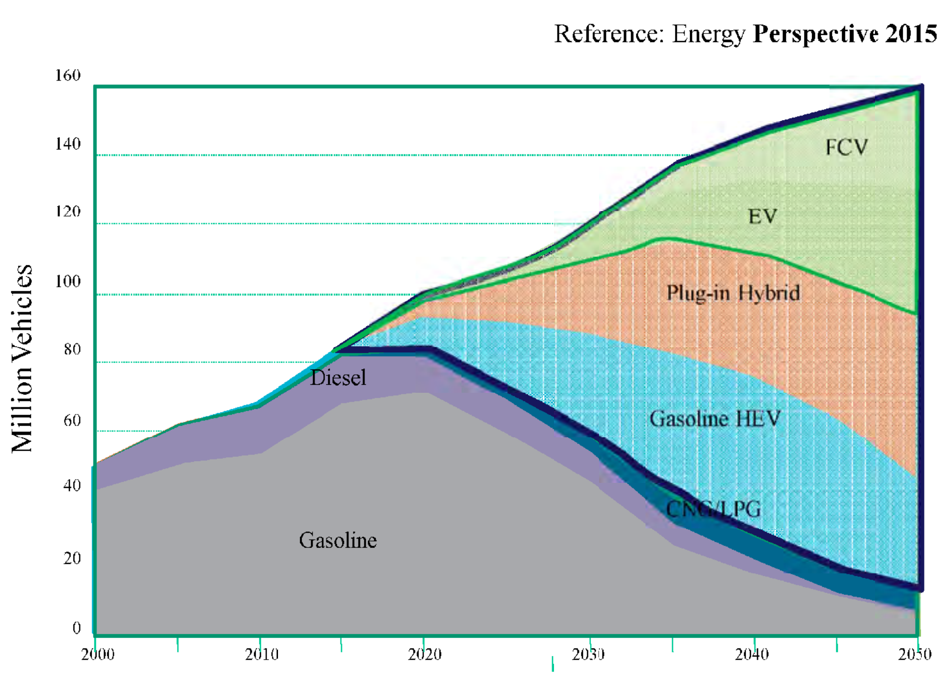
Energy : Renewable energy

Fuel consumption regulation trend of each country

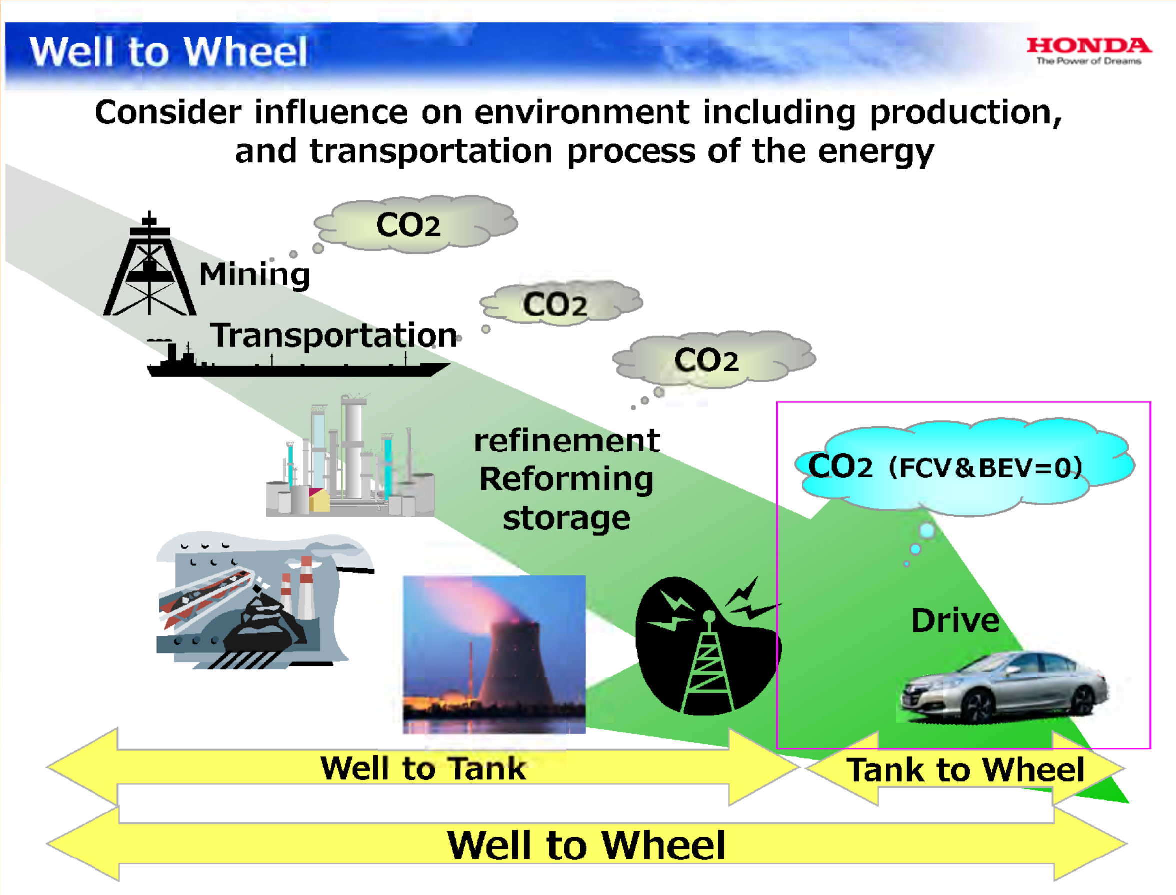


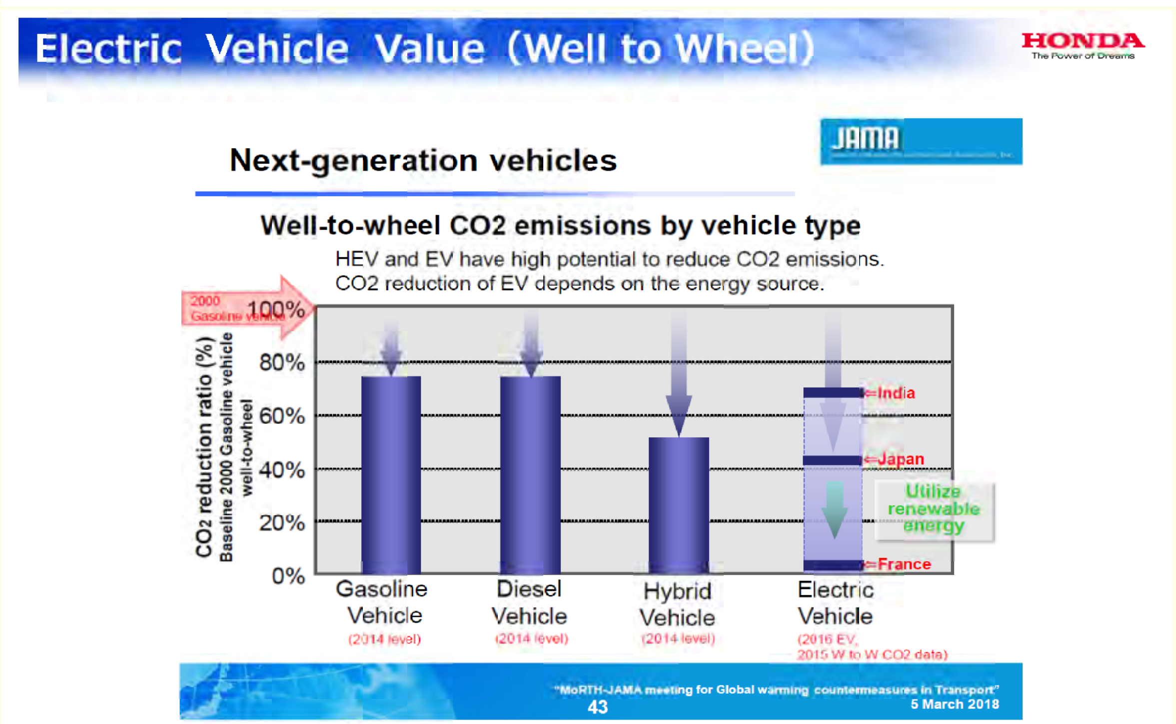
Each country's fuel economy regulation is strengthened year by year, reduction of CO_2 emissions is mandatory

Global portfolio of technologies



Electric drive vehicles are vital for the future.





Source : CO_2 Emissions Reduction in Japan's Road Transport Sector 2018

CO_2 of ICE & HEV are reduced by improving vehicle efficiency.
CO_2 reduction of EV`s depends on the power station CO_2.

Honda's Clean Fuel Technology Roadmap: Message from CEO

To become "a company society wants to exist"...

"To make two-thirds of our overall unit sales from plug-in hybrid/hybrid vehicles and zero-emissions vehicles such as, FCVs and battery EVs by around 2030"

Aim to become No. 1 in the areas of the environment and safety, Honda will become a company that leads the efforts to realize a carbon-free and collision-free society.

EV sales unit forecast on 2030

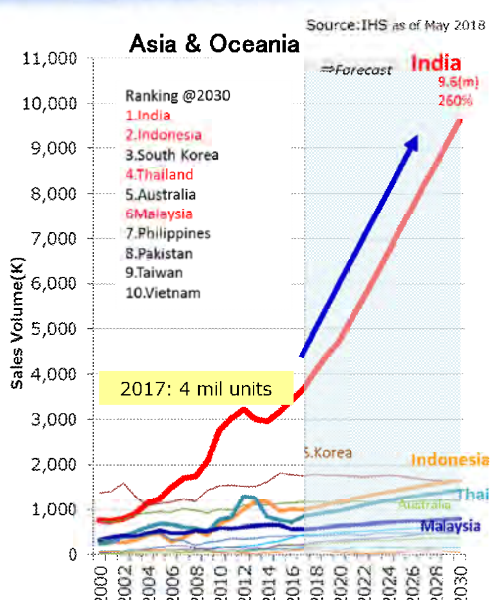
HONDA
The Power of Dreams

Government EV policy : EV 100% on 2030

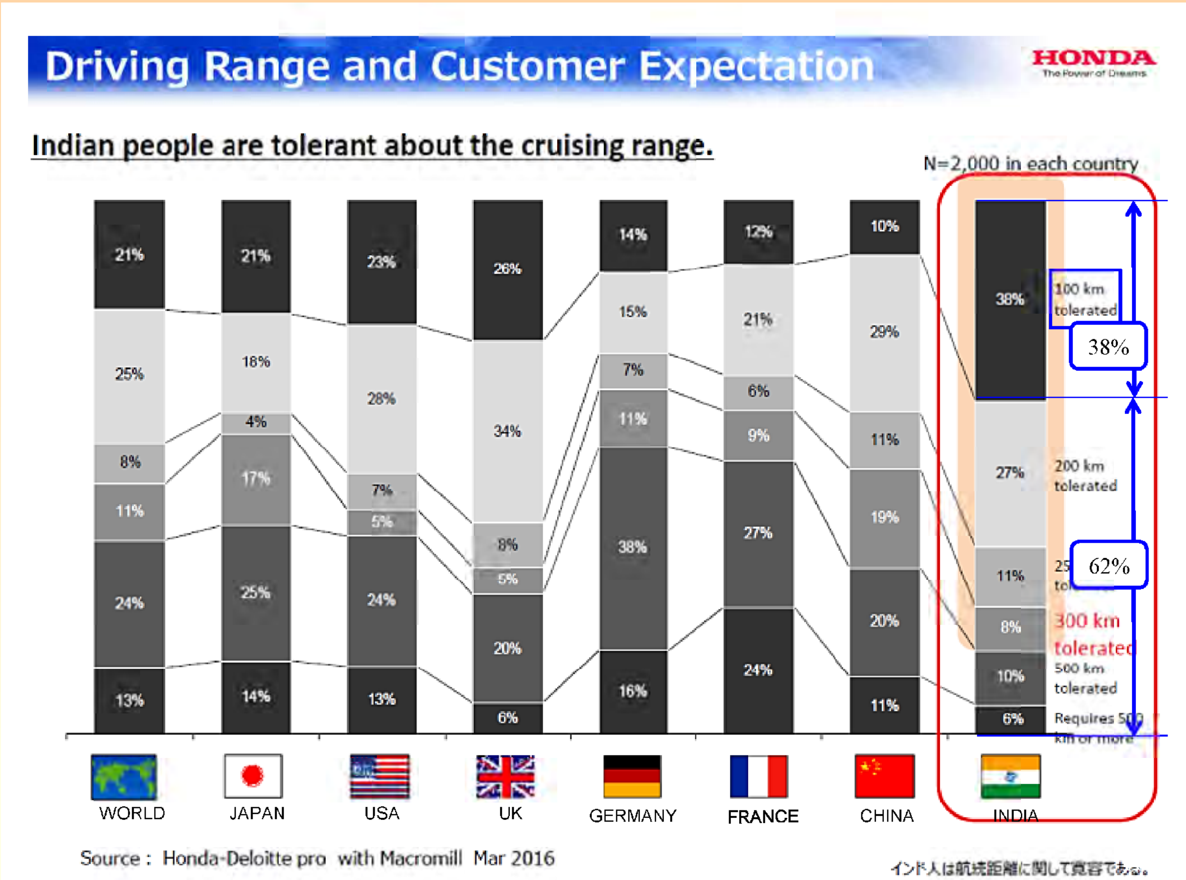
Government Policy (Feb 2018)

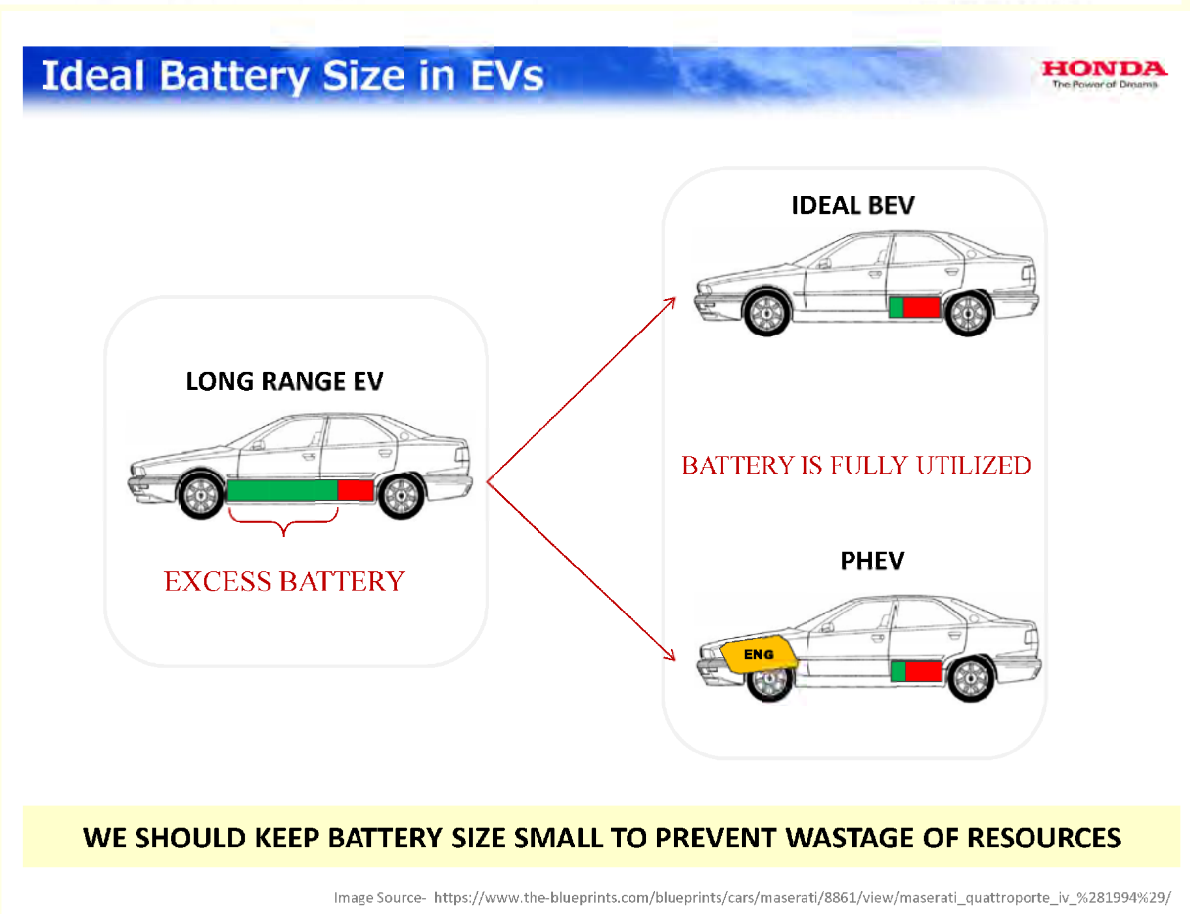
-Passenger car : EV 30% on 2030

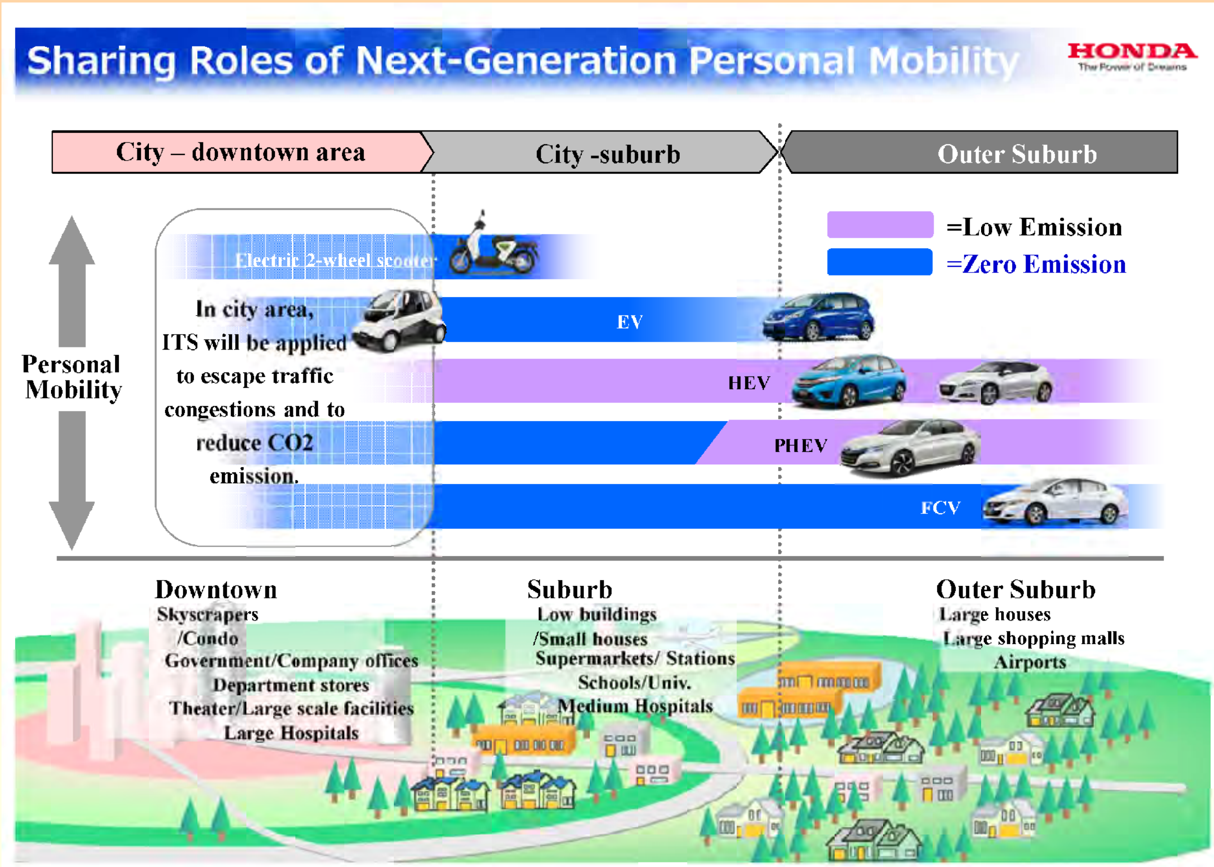
*Commercial car : EV 100% on 2030

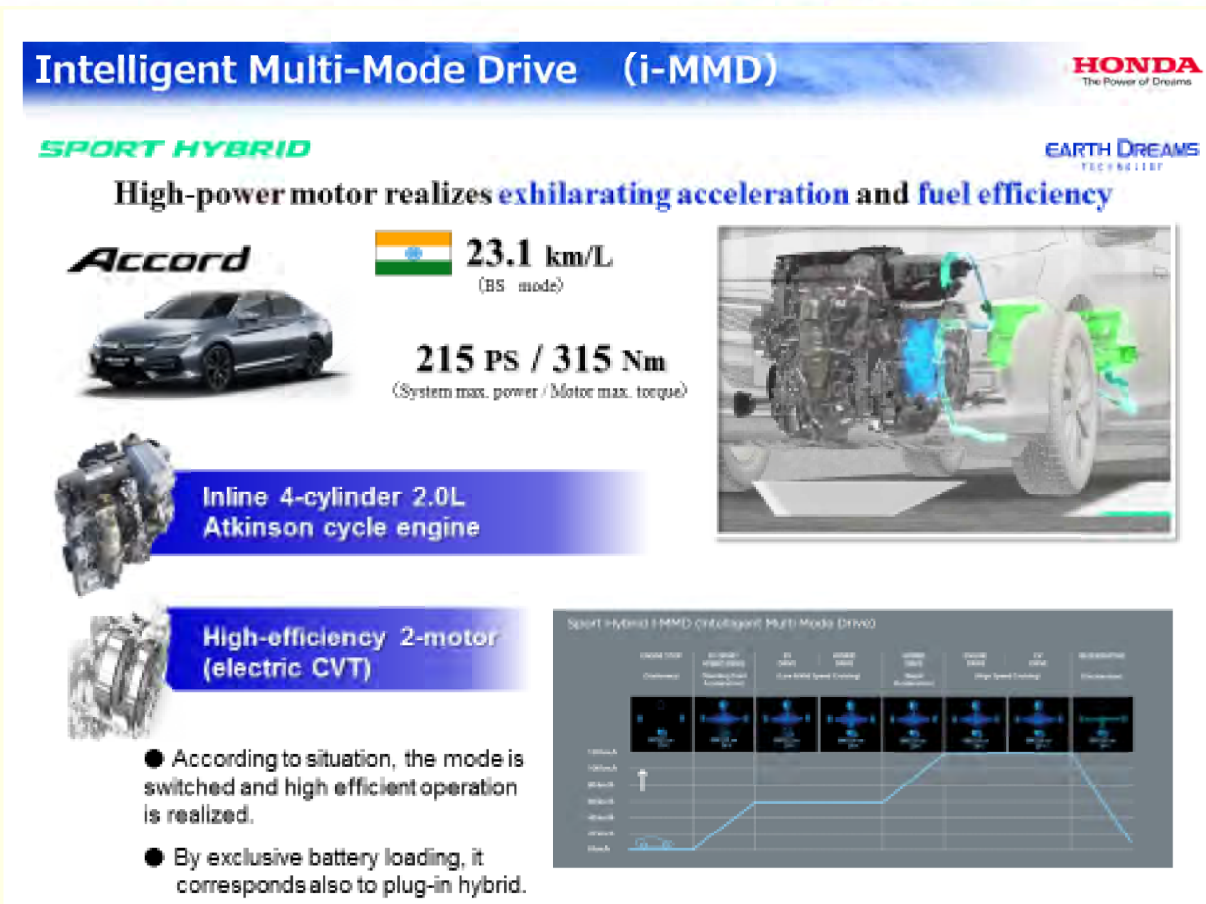


-2030 sales units in India : about 9.6 mil. units
-Assumption 30% EV on 2030 ➔ 2.9 mil. Units (near current annual sales)
➔ Concern : Charging infrastructure / Renewable energy supply
-Remaining 70%= 6.7 mil. Units (≒ 1.7 times of 2017 sales)
➔ If conventional PT F/E is no improved, Crude oil import is 1.7 times.


Driving Range and Customer Expectation
HONDA
The Power of Dreams
Indian people are tolerant about the cruising range.
N=2,000 in each country
WORLD 21% 25% 8% 11% 24% 13%
JAPAN 21% 18% 4% 17% 25% 14%
USA 23% 28% 7% 5% 24% 13%
UK 26% 34% 8% 5% 20% 6%
GERMANY 14% 15% 7% 11% 38% 16%
FRANCE 12% 21% 6% 9% 27% 24%
CHINA 10% 29% 11% 19% 20% 11%
INDIA 38% 27% 11% 8% 10% 6%
100 km tolerated
38%
200 km tolerated
62%
300 km tolerated
500 km tolerated
Requires 500 km or more
Source： Honda-Deloitte pro with Macromill Mar 2016
インド人は航続距離に関して寛容である。


Ideal Battery Size in EVs
HONDA
The Power of Dreams
LONG RANGE EV
EXCESS BATTERY
IDEAL BEV
BATTERY IS FULLY UTILIZED
PHEV
ENG
WE SHOULD KEEP BATTERY SIZE SMALL TO PREVENT WASTAGE OF RESOURCES
Image Source- https://www.the-blueprints.com/blueprints/cars/maserati/8861/view/maserati_quattroporte_iv_%281994%29/


Sharing Roles of Next-Generation Personal Mobility
HONDA
The Power of Dreams
City – downtown area
City -suburb
Outer Suburb
=Low Emission
=Zero Emission
Personal Mobility
Electric 2-wheel scooter
In city area, ITS will be applied to escape traffic congestions and to reduce CO2 emission.
EV
HEV
PHEV
FCV
Downtown
Skyscrapers
/Condo
Government/Company offices
Department stores
Theater/Large scale facilities
Large Hospitals
Suburb
Low buildings
/Small houses
Supermarkets/ Stations
Schools/Univ.
Medium Hospitals
Outer Suburb
Large houses
Large shopping malls
Airports


Intelligent Multi-Mode Drive (i-MMD)
HONDA
The Power of Dreams
SPORT HYBRID
EARTH DREAMS
High-power motor realizes exhilarating acceleration and fuel efficiency
Accord
23.1 km/L
(BS mode)
215 PS / 315 Nm
(System max. power / Motor max. torque)
Inline 4-cylinder 2.0L Atkinson cycle engine
High-efficiency 2-motor (electric CVT)
According to situation, the mode is switched and high efficient operation is realized.
By exclusive battery loading, it corresponds also to plug-in hybrid.

Summary

HONDA
The Power of Dreams

< ENERGY SITUATION >

- Renewable Energy is necessary to reduce CO2 in the future.

< ELECTRIC VEHICLE DIRECTION >

- BEV is effective for short range driving without charging infrastructure.
- FCV can cover for long range with Zero emission by renewable energy as WTW point of view.

< HONDA ELECTRIC MOBILITY >

- Honda Globally has all the technologies which can be effectively used to cater to needs of each country's requirement.
- Hybrids Vehicles" are intermediate to the journey of "Zero Emission Vehicle

Presentation by Shri Abhishek Ranjan/Chetan Pathak, AVP and Head Renewable/Manager - Renewable, BSES Rajdhani Power Ltd.

Profile

Chetan has 7+ years of experience in Renewable Energy Generation and Electricity Distribution. His present Focus areas are Integration of DER's (Distributed Energy Resources) to Distribution Infrastructure: a.) Solar PV Rooftop Net Metering, b.) Energy Storages (working on distributed energy storage & Community Energy Storage Solutions) c.) Concepts to Realization of Electric Vehicles (EV) charging infrastructure (Clean Energy Transportation) in DISCOMS area of operation. Before joining Electricity Distribution Company had worked for Billion Dollar Groups (Reliance, Azure Power, ACME) as Business Development Manager for Renewable Generation Companies and had been responsible for setting up of approx. 2 GW of Solar PV And Wind Power Projects in India.

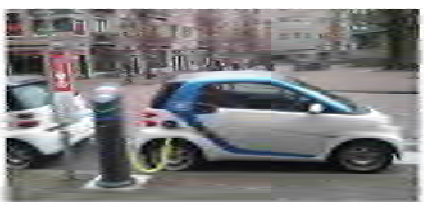
Abhishek Ranjan has about two decades of experience in Power and Information Technology sectors in India. He started his career with Infosys Technologies Limited, an IT company based in India, where he worked on development of enterprise applications for a major US utility and a technology MNC. He is currently leading a team in the areas of Energy Efficiency & Demand Side Management, Renewable Integration and Rooftop Solar, grid level Energy Storage solutions, EV charging infrastructure, Power scheduling & demand forecasting and Energy Analytics at BSES Rajdhani Power Limited (BRPL), New Delhi.

Abstract

EV in India - Sustainable Adoption of Technologies and likely Business Models

The proposed study aims at identification of key stakeholders in the E- Mobility landscape and the evaluation of various business models that can be envisaged in the near future, considering the policy framework, regulatory guidelines and standards notified for EV Charging Stations by Ministry of Power (MoP). The Discoms role is paramount in terms of both power supply as well as network availability for such EV charging infrastructure, Discoms readiness for anticipating capacity up-gradation, defining the grid connectivity process and administering a Universal Service of providing a Central Monitoring System / Interface for all its consumers shall be the key to successful rollout of technology and adoption of Business Models. The Paper concludes with the case-study on international adoption strategy, incentive schemes adopted for making the business models self sustainable and rapid adoption of the masses.

EV in India - Sustainable Adoption of Technologies and likely Business Models



By

Abhishek Ranjan
&
Chetan Pathak
BSES Rajdhani Power Ltd.

E-Vehicles Basic Principles

- Charging stations would be compliant with standards laid down by DHI, Niti Ayog, CEA & ARAI and would be **manufacturer agnostic** (even other vehicles can charge from the same infrastructure).
- Electricity supply to the Partner/ HOST of DISCOM shall be given at Single Point **after Techno-commercial Feasibility DISCOM.**
- Separate billing to be done as per tariff approved by SERC in the latest tariff order. This has been recently clarified by **MoP vide Notification dated 13th April 2018** that **EV Charging is a service** and **not violation with regard to sale of electricity without license provisions of Electricity Act '03.**
- Charging Service / Parking Service **to be priced and billed separately.**
- Discom to supplement the **"Managed Charging"** model to ensure that local distribution network doesn't get overloaded.

Regulatory Landscape (1/2)

MoP Standards & Guidelines Dated 14th Dec. 2018

- **Clause 2. Setting up of Public Charging Stations (PCS)**

  Clause 2.1 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.

- **Clause 3 Public Charging Infrastructure (PCI) Minimum Requirement**

  3.1 Every Public Charging Station (PCS) shall have the following minimum infrastructure:

  An exclusive transformer with all related substation equipment including safety appliance.

  33/11 kV line / cables with associated equipment including as needed for line termination / metering etc.

  3.1. ix. Share charging station data with appropriate DISCOMs and to maintain appropriate protocols as prescribed by such DISCOM for this purpose. CEA shall have access to this database. (This will help these charging stations to participate in DISCOM's Demand Response program, thereby help in optimal network planning and implementation.)

Regulatory Landscape (2/2)

- **3.2 Every Public Charging Station (PCS) shall be operational only after inspection and clearance** as communicated by suitable clearance certificate, by the electrical inspectors / technical personnel designated specifically by the respective DISCOM for this purpose. DISCOMs may also empanel one or more third party authorized technical agencies for this purpose.

- **Clause 6. Database of Public EV Charging Stations:**

  Central Electricity Authority (CEA) shall create and maintain a national online database of all the Public Charging stations through DISCOMs. Appropriate protocols shall be notified by DISCOMs for this purpose which shall be mandatorily complied by the PCS/ BCS. This database shall have restricted access as finalized between CEA and Ministry of Power.

- **Clause 8. Service Charges at PCS/BCS:**

  8.2 The **State Nodal Agency shall fix the ceiling of the Service Charges** to be charged by the Public Charging Stations.

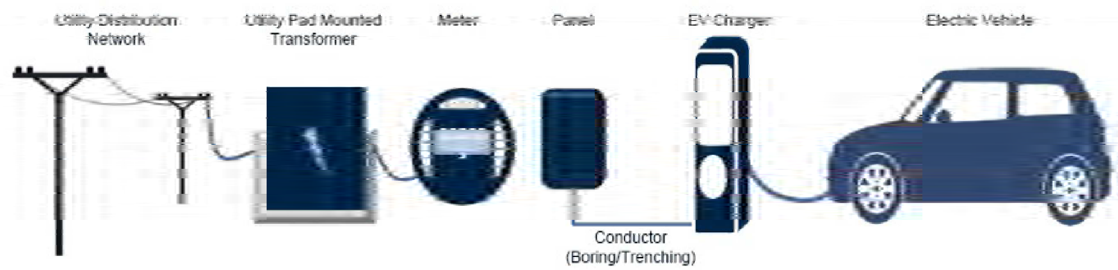
EV Charging Stakeholder's Requirement:

1. **Charging Stations/ Charging Point** hardware and chargers (AC/DC) from other OEMs operating on Charging Station network.

2. **Software as a Service (SaaS)** Network service plans sold on annual subscription basis. (White Labeled Solution Preferred).

3. **B2B Partnership** Station Data, Energy Management

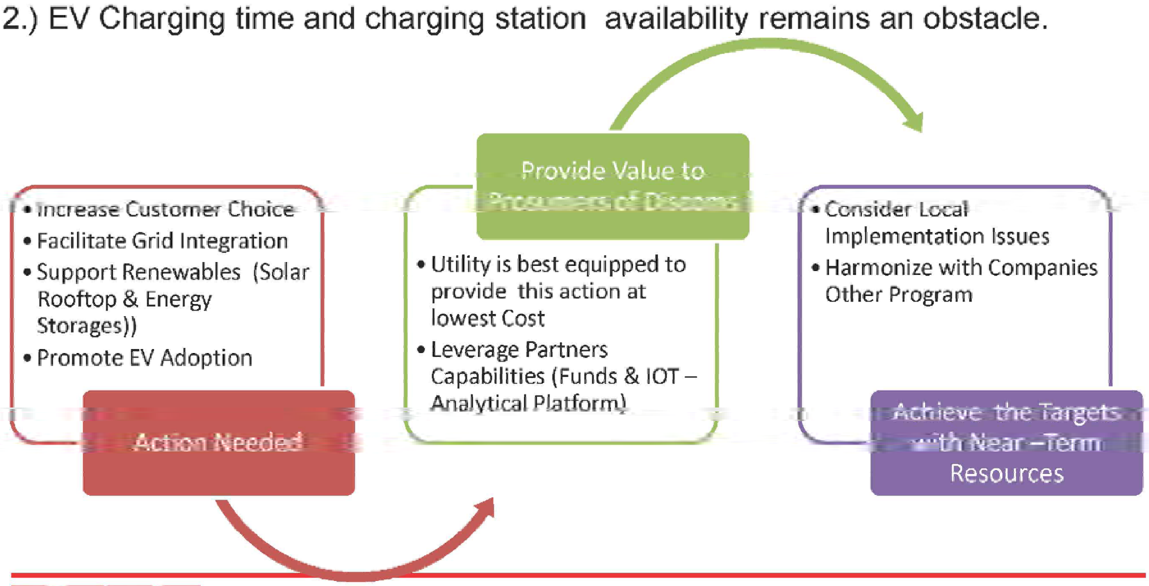
4. **Transaction-Based Services** BHIM App integration Credit cards & EV Charging cards



E-Mobility Mission of India

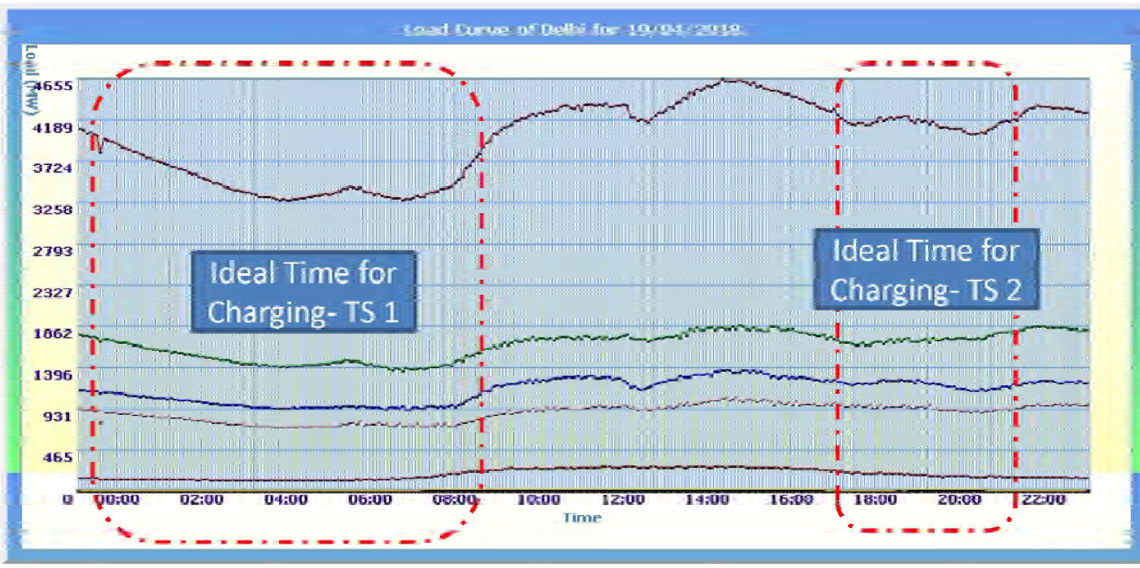
Hurdles in achieving this mission:

1.) EV Range , remains as a an obstacle for some drivers, especially on long distant travel.
2.) EV Charging time and charging station availability remains an obstacle.



BSES

Time of Day (ToD) to Time of Use (ToU) Based Charging



Entity	Peak Load	Peak Load Time	Min. Load	Min. Load Time	Avg. Load
Delhi	4677	15:49:14	3276	07:45:17	3992
BRPL	1951	16:06:48	1335	07:23:15	1663
NDPL	1393	16:00:57	909	07:21:46	1155
BYPL	1084	15:20:35	729	05:13:49	901
NDMC	302	14:31:33	134	05:52:02	208
MES	33	12:03:35	20	03:55:46	26

Benefits of dedicated connection of public EV charging points

- <u>As per Delhi Electricity Regulatory Commission (DERC) , Tariff Order for FY 17-18,Tariff Schedule , Clause 5.64 & Other Conditions Clause 13b:</u>

"CHARGING OF E-RICKSHAW/ E-VEHICLE:

The Commission has introduced a new Tariff Category for charging of batteries of E-Rickshaw / E-Vehicle at Charging Stations.

13	Charging Station for E-Rickshaw / E-Vehicle on Single Delivery Point	Rs. / kWh	NDLT Tariff range
13.1	Supply at LT	5.50	Rs 8.00/kWh
13.2	Supply at HT	5.00	

13. b. Tariff applicable for charging of batteries of E-Rickshaw / E-Vehicle at premises other than at Charging Stations meant for the purpose shall be the same as applicable for the relevant category of connection at such premises from which the E-Rickshaw / E-Vehicle is being charged."

There is a case for getting dedicated metered connection for public charging points / stations of EVs / E-rickshaws.

DERC Tariff for EV FY 18-19 & ToD Benefits

Time of Day (ToD) Tariff:

a.) ToD tariff shall be applicable on all consumers (other than domestic whose sanction load / Maximum Demand Indicator(MDI) (Whichever is higher) is 10 kW / 11 kVA and above.

b.) The Commission has decided to retain the Rebate during the Off Peal Hours and Peal Hours Surcharge at 20% .

c.) Further the commission has reviewed the latest available Demand & Supply of Delhi and has revised the time slots for Peak and Off-Peak hours as follows;

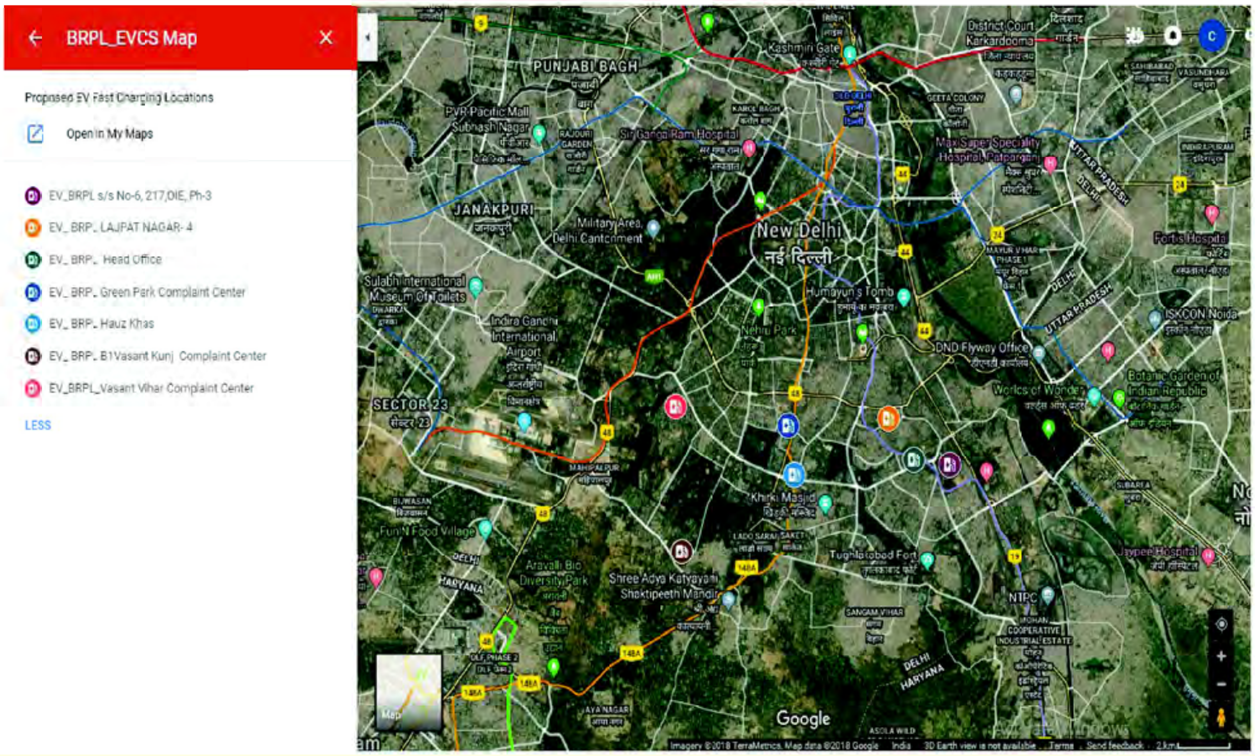
Months	Peak Hours	Surcharge on Energy Charges	Off-Peak Hours	Rebate on Energy Charges
May-Sept.	14:00 Hrs.-17:00 Hrs. & 22:00 Hrs. – 01:00 Hrs.	20%	04:00 Hrs.- 10:00 Hrs	20%

d.) EV Charging Station can wisely utilize this opportunity to charge during off-peak hours and avail an addition rebate of 20% on the tariff for Rs 4.40-4.00 / kWhr for LT-HT.

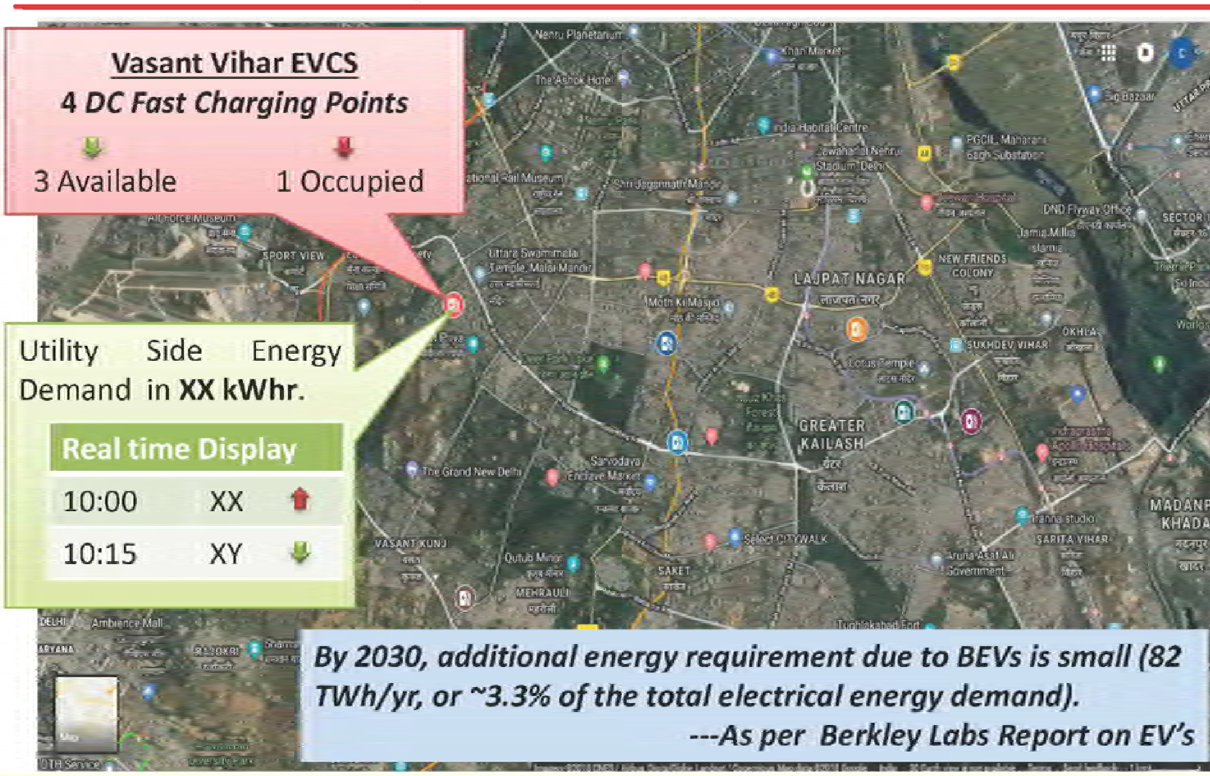
Process flow for Electric Vehicle Charging Station Connectivity Process:

SCOPE	APPLICANT	Application Form Submission	The request for setting up this charging station shall be submitted to DISCOM for Technical Feasibility and release of Permit. (Explicitly specifying load requirement for the EVCS & broadly identify preferable locations).
		EVSE Manufacturer's Information	The manufacturer's installation instructions and EV charger specifications shall be submitted with application form.
	DISCOM (BRPL)	Site Plan	Identify the complete layout of existing parking space(s) and proposed location of EVCS parking space(s) with respect to existing building and structures.
		Electrical Plan	Single line diagrams showing the system and point of connection to the power supply and the EVCS.
		Electrical Load Calculations	Electrical load calculation that estimates if an existing electrical service will handle the extra load from a EVCS and wiring methods based on the Central Electricity Authority (CEA) Regulations shall be strictly be followed. Power Quality aspects and other technical impact on network to be assessed as well.
		Procedure for grant of connectivity to EV Charging Station	Electrical Connectivity for EV chargers shall be awarded post completion of technical feasibility & validation of the above submission as per DERC Supply Code Regulation 2018 and an Electricity Connection in a stipulated time frame as per the said regulation shall be provided.

BRPL EV Charging Stations (EVCS)



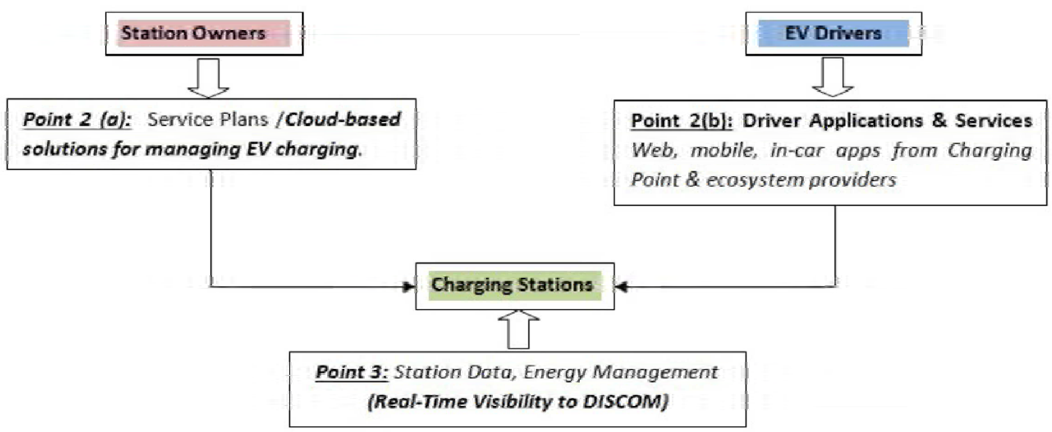
BRPL EVCS Analytical Platform



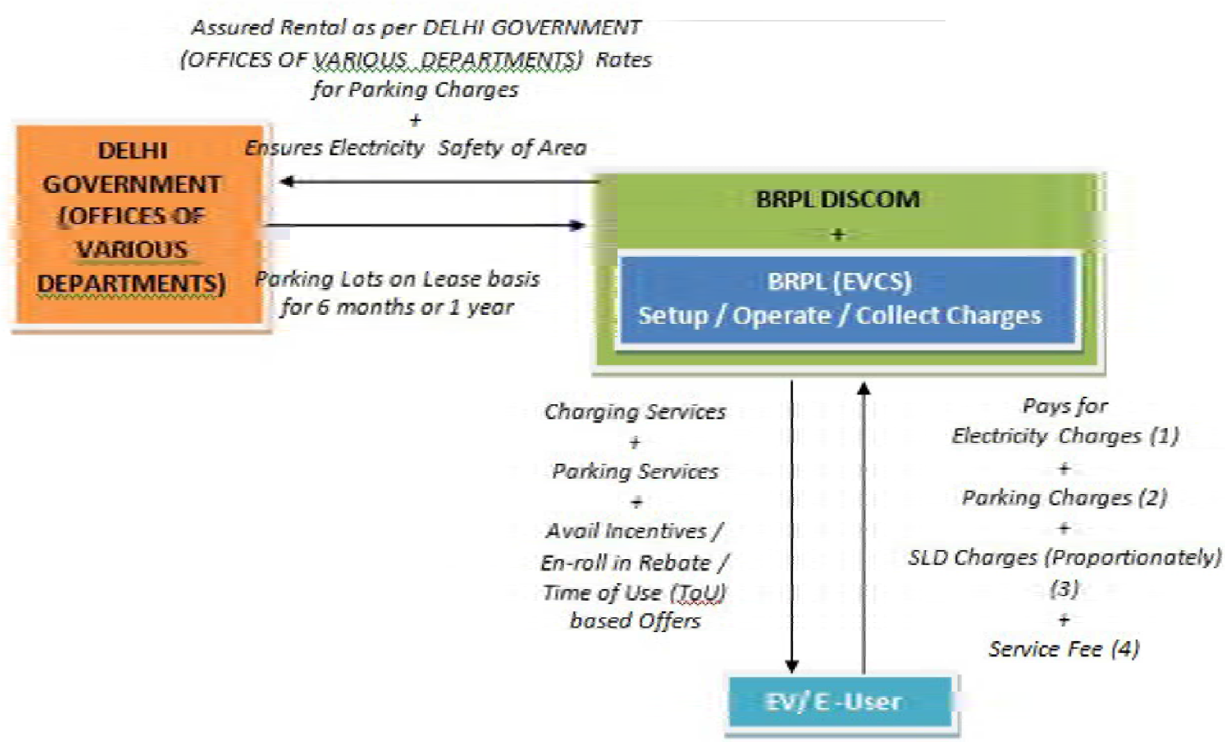
Key Stakeholder's

For setting up Electric Vehicle Charging Station (EVCS), registration with respective utility is required.

Stages shall be as follows; **Permit** (Compliance for Safety and Quality Requirement & Administer flow of any Govt. Subsidy applicable for such consumers) → **Installation** →**Inspection** →**Operation**.



Model 1:DISCOM's Driven EVCS (1/3)



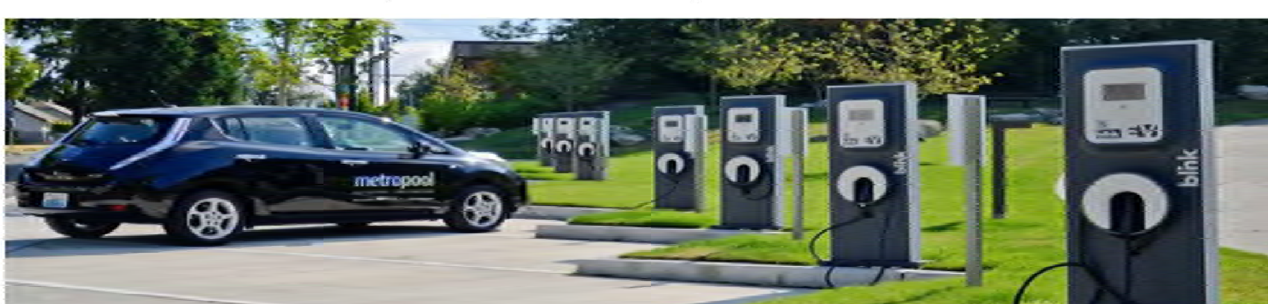
Model 1:DISCOM's Driven EVCS (2/3)

- **<u>Revenue Stream for various Stakeholders:</u>**

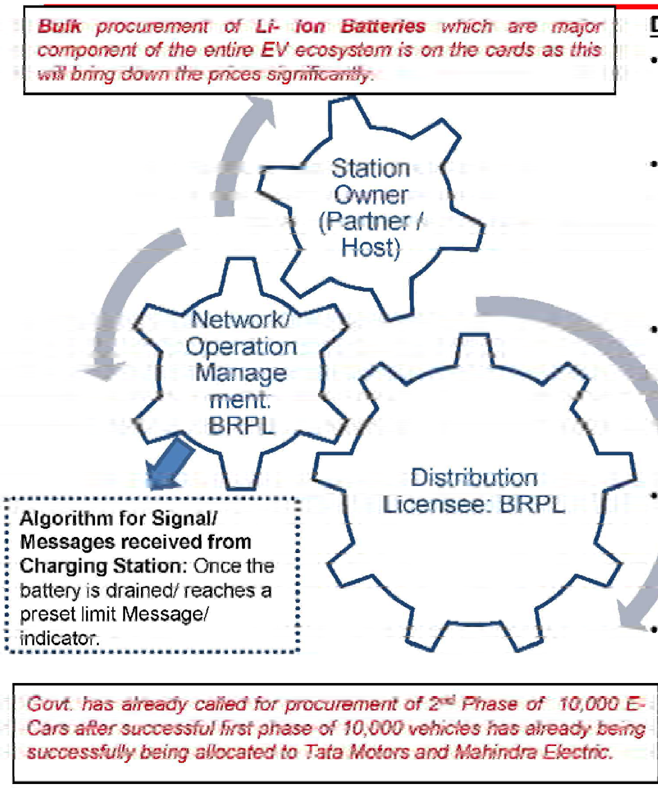
- **Electric Charges:** retained by BRPL (DISCOM)
- **Parking Charges:** BRPL passes on to DELHI GOVERNMENT (OFFICES OF VARIOUS DEPARTMENTS)
- **Service Line Development (SLD) Charges:** Undertaking Network Upgrades.
- **Service Fees:** Retained by BRPL towards Non Tariff Income (NTI) as an Implementation Agency for EVCS
  - Recovery of Cost Component by OEM
  - Depreciation of Charging Assets
  - Operation and Maintenance
  - Annual Subscription for Analytical Platform for App (Consumer & Discom Interface)
  - Security and Safe-up Keep
  - ***Pre-determined Profit Margin*** over and above this Cost.

Model 1:DISCOM's Driven EVCS

- Empanelment of OEM's
- Network Management (upgrades)
- Enhancing Capabilities for Real Time Monitoring (Algorithm for Signal/ Messages received from Charging Station)
- Inventory Management in case of Battery Swapping Station
- Next Level Planning: Based on evolving Vehicle to Grid Concept (V2G)



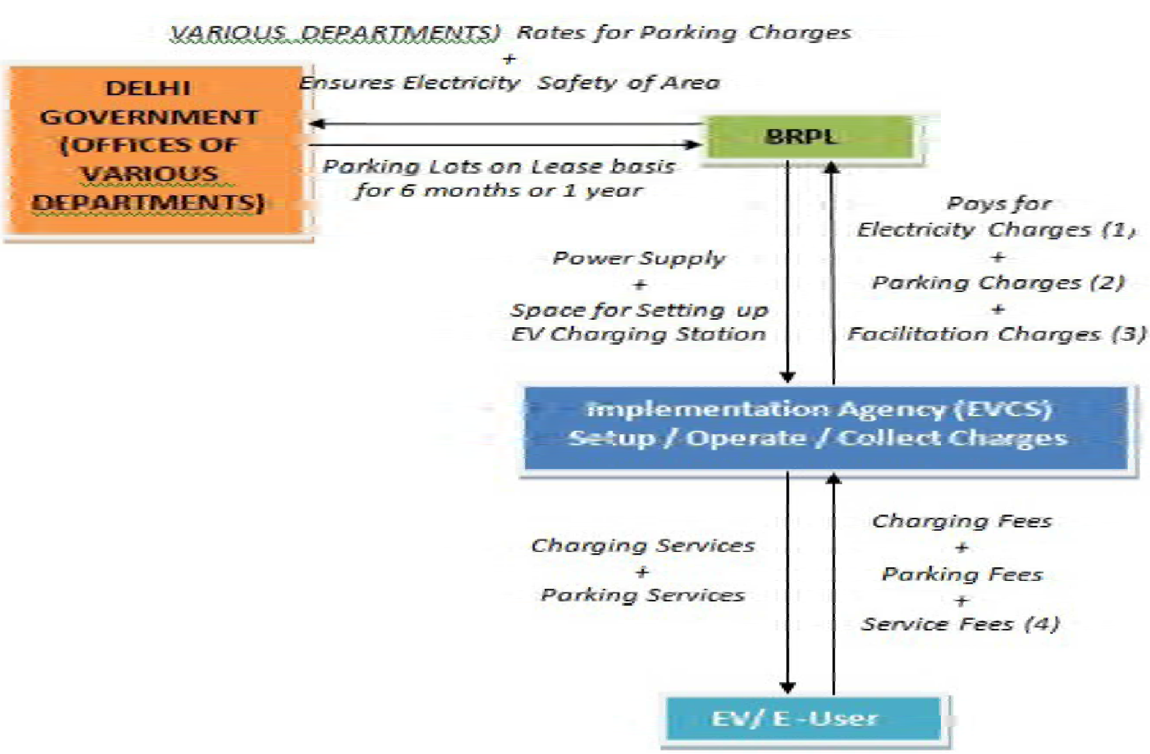
Model 1: Involvement of DISCOMS in EV Charging Station (Details)



Distribution Licensee:

- **Empanelment of OEM's** for setting up of EV charging / Battery Swapping Stations. EPC of the project.
- For Providing **Electricity Connection** & ensuring that consumers pays for DERC determined Tariff billed separately by Operator. (LT Side @ Rs. 5.50 / kWh & HT Side @ Rs. 5.00 / kWh)
- **Network Management** diversion of the e-Vehicles to the nearest battery swapping station & maintaining optimum health of the grid by addressing load balancing issue. Based on telematics.
- **Inventory Management:** Stocking of Battery Bank (with a proportionate capacity available as spare at all time as requisite to Grid Requirement.)
- **Based on evolving Vehicle to Grid Concept (V2G):** Engineering of Total Battery Capacity, Minimum Stock (in case of Battery swapping model) & Fixation of State of Charge (SoC) in discussion with Nodal Agency for Policy.

Model 2: Third Party Driven EVCS Model



Model 2: Third Party Driven EVCS Model

- **<u>Revenue Stream for various Stakeholders:</u>**

- **Electric Charges:** retained by BRPL (DISCOM)
- **Parking Charges:** BRPL passes on to DELHI GOVERNMENT (OFFICES OF VARIOUS DEPARTMENTS)
- **Facilitation Charges:** retained by BRPL to be paid by IA for Single Window for providing space, Undertaking Network Upgrades.
- **Service Fees:** Retained by Implementation Agency for EVCS
  - Recovery of Cost Component by OEM
  - Depreciation of Charging Assets
  - Operation and Maintenance
  - Annual Subscription for Analytical Platform for App (Consumer & Discom Interface)
  - Security and Safe-up Keep
  - ***Pre-determined Profit Margin*** over and above this Cost.

Model 3: Leasing of EV Charging Station Spaces/ Private EV Franchisee Business Model:

- No upfront cost to Existing Consumer of DISCOM willing to enroll in this program.

- Fixed payments aligned to usage.

- Includes installation, service, and warranty.

- Preferential interest rate for qualified customers willing to invest in Charging Stations

- Purchase at HT Level qualifies for rebates in charging station (i.e. 10 Charging Station per Location)

- End of lease no-cost buyout

DISCOM will facilitate : Station Owners

(From applying to DISCOM for Leasing Asset to Implementation of installation of Charging Station and Hosting of SAAS platform and DISCOM Energy Data Management)

- Site Survey, Purchase, Ship
- Installation
- Activation of Charging Points at the Charging Station (Generation of Franchisee No.)
- Configure access control, pricing, visibility, etc.
- Drivers begin to charge at station
- Manage Return on Investment (ROI) — collect money (Cashless / Online)

DISCOM will facilitate EV Drivers

- Create Online Account (for availing EV Facility)
- Find Charging Stations on mobile , Dashboard or Web
- Authenticate with DISCOM'S Card, BHIM App, Credit card and start session.
- Continue normal activity while car is charging.
- Station sends session update to driver on completion of EV Charging.
- Drive away with car topped off with instant deduction from DISCOM'S Card.

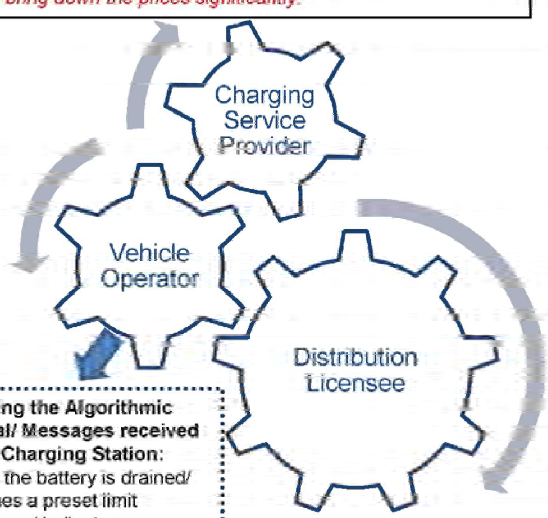
Charging Station Models (On –ground Implementation)

Model	Land /Space Provided by	Setting up of Battery Charging / Swapping Station	O&M of Charging Infrastructure	Supply of Electricity	Inventory Management / Grid Operation Reliability
Charging & Parking Scheme	Respective Agency (Public / Private) (DISCOM's Consumer / DDA / SDMC/ NBCC/ DUSIB)	Empanelled OEM's	OEM's / Vendor's by BRPL	Discom (BRPL)	Discom (BRPL)
Battery Swapping Station (Li-Ion Base)					

- Discom will provide single point meter to PARTNER / HOST for each charging station at different location. (& Sign Connectivity Agreement for Proper Transparent Energy Accounting).
- Tariff for EV Charging will be as determined by DERC from Time to Time.
- GoNCTD may incentivize charging through Direct Benefits Transfer through Smart Card.
- Charging stations will act as load centres for BRPL, vital for grid planning and management.

Business Architecture for Battery Charging / Swapping Station (1/2)

*Govt. / PSU's may initiate bulk procurement of **Li- Ion Batteries** which are major component of the entire system and this bring down the prices significantly.*



Abiding the Algorithmic Signal/ Messages received from Charging Station:
Once the battery is drained/ reaches a preset limit Message/ indicator.

Govt. is working on redefining the specs with battery swapping. These new ones will have Li Ion batteries. They will work with swapping model rather than charging.

Charging Service Provider:

- **Fleet Management** of the e-Vehicles.
- **Quality & Standard maintenance** for Vehicle Charging Infrastructure.
- **Inventory Management:** Stocking of Battery Bank (with a proportionate capacity available as spare at all time.

Distribution Licensee:

- DISCOM's will be Instrumental in Providing **Electricity Connection** & ensuring that consumers pays for DERC determined Tariff billed separately by Operator. (LT Side @ Rs. 5.50 / kWh & HT Side @ Rs. 5.00 / kWh)
- **Empanelment of OEM's** for operation of Battery charging / Swapping Stations.
- **Based on evolving Vehicle to Grid Concept (V2G):** Engineering of Total Battery Capacity#, Minimum Stock & Fixation of State of Charge (SoC) in discussion with Nodal Agency for Policy formulation & DERC.

BSES

*# **Engineering of Total Battery Capacity at Charging Station:** Charged Battery available for E Vehicles, Grid Support, Partial Charge (dependent on SoC), Discharged battery under charging.*

Business Architecture for Battery Charging / Swapping Station (2/2)

•Li-Ion Battery Based Charging / Swapping station offers many advantages and can drastically change the dynamics of e-vehicles efficiency, reliability & operability in the region.

•Key features of the solutions are 4 times the battery life, electronics based battery management system, double the mileage and increase the speed of the vehicle to 40-50 km/ hr.

•The Cost Benefit Analysis in comparison to the added initial cost are much higher and will lead to recovery & increase the net income of these vehicle operator's drastically.

•Adding to this a shift of only day time operation and night time charging concept to 24*7 operable model could be achieved due to zero down time achieved with battery swapping infrastructure in place in comparison to present battery charging model.



Prayers for OEM's

- **(No Discrimination of EV charging networks from individual charging stations.)**

- <u>EVCS OEM shall mandatorily to abide by Open *Charge Point Protocol (OCPP)*</u> for establishing EVCS network, an international standard for enabling communication and networking of charging station infrastructure.

- <u>Station Owner to ensure OEM's to abidance of *Service Level Agreement*</u> that can be signed back to back with utilities by any Station Owner (i.e. third party/ Consumer/ Private EV Franchisee) who wishes to establish EV charging network to ensure abiding by T&C's of the agreement.

CASE–STUDY

on

California Public Utility Commission (CPUC) Zero Emission Vehicle's (ZEV) Electricity Tariff / Rebates / Infrastructure Pilot Program

for

Southern California Edison (SCE), San Diego Gas & Electric (SDDG&E) & Pacific Gas & Energy (PG&E)

California Public Utility Commission (CPUC) Zero Emission Vehicle's (ZEV) Strategy

- CPUC in **2011** decided to not allow utility –owned charging stations.
- However in **2013**,CPUc proceeding's again brought up the issue of;

  Utility-Owned Charging Station V/s Large Private EVSE Operator's

  Companies argued that Utility –owned infrastructure is not the approach for maximizing innovation, cost reduction, customer choice and customer ownership of EVSE.

- In **2014**, reversing its prior position , CPUC allowed Utility driven model on case to case basis and started evaluating proposals and granting approvals. For the proposals that where approved, Utilities needed to show their would be net benefit to all consumers.

- Very recently in **Jan 2018**, have imbibed rate limiter's and expansion of EV Network to disadvantaged communities, which was called for due to creation of **artificial scarcity by Private EVSE provider's , who limit their expansion to advantageous locations only.**

California Public Utility Commission (CPUC) Zero Emission Vehicle's (ZEV) Electricity Tariff / Rebates / Infrastructure Pilot Program

- **Electric Tariff :** PG&E, SCE , SDG&E and Liberty Each offer electric vehicle " Time of Use " Energy rates for consumers and encourage customers to charge during Off-Peak Hours . This helps minimize the impact of the energy demand from electric vehicles on the electric grid.

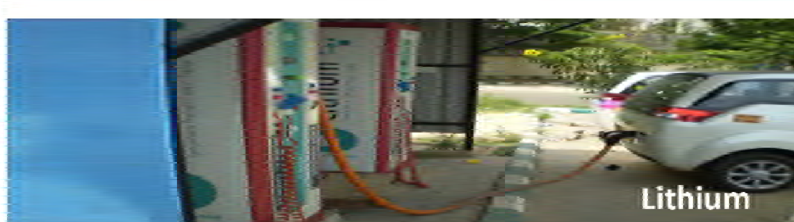
- **Rebates:** Electric Utilities provide rebates/ Loyalty point to their customers that drive Plug-in Electric Vehicles and charge them at DCFC's.

- **Infrastructure Pilot Program:** PG&E, SCE , SDG&E are currently implementing pilot programs to install infrastructure to support electric vehicle charging at multi- unit dwellings, workplaces , and public interest destinations.

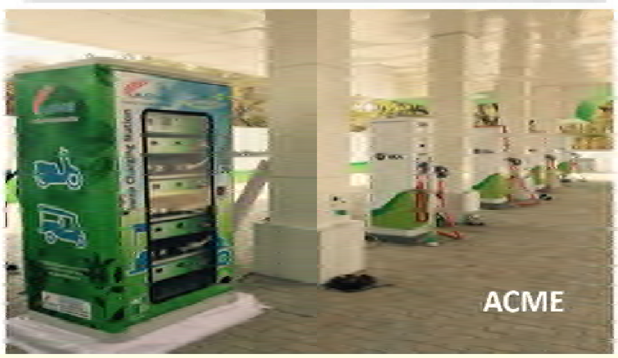
- **Demand Response Pilot with V2G enablement:** Pilot Program that allowed it's electric vehicle to send power back to grid , wherein the vehicle battery acts as storage , they charge when power is cheapest and discharge when there are supply constraints in the grid.

Vendors EV Charging Station -Portfolio

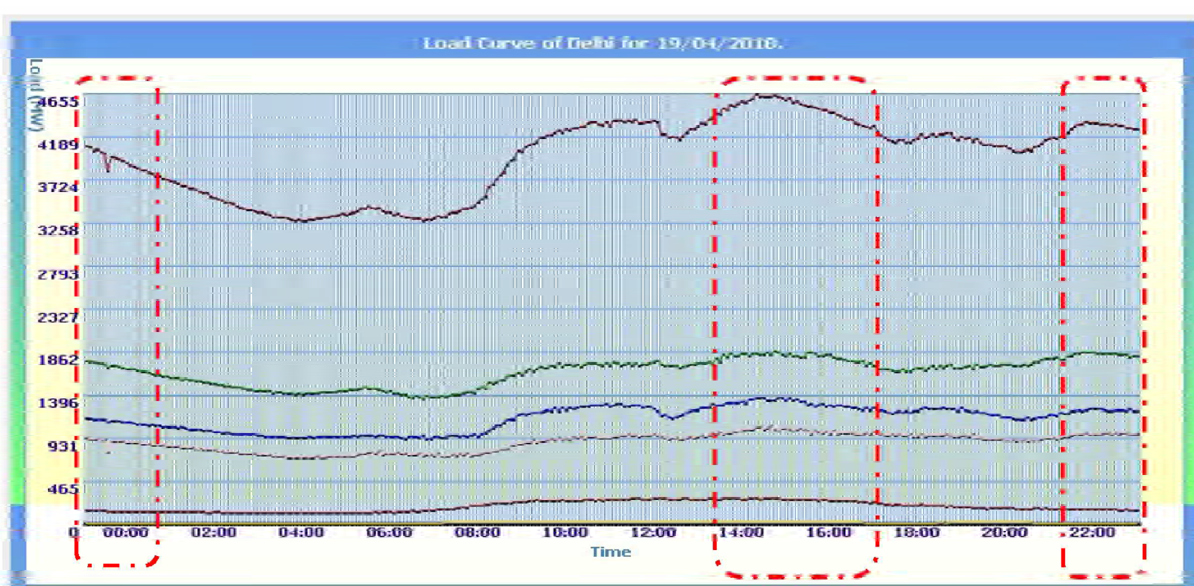
ABB's Terra 53 DC fast charging station interface, featuring the credit card payment terminal option.



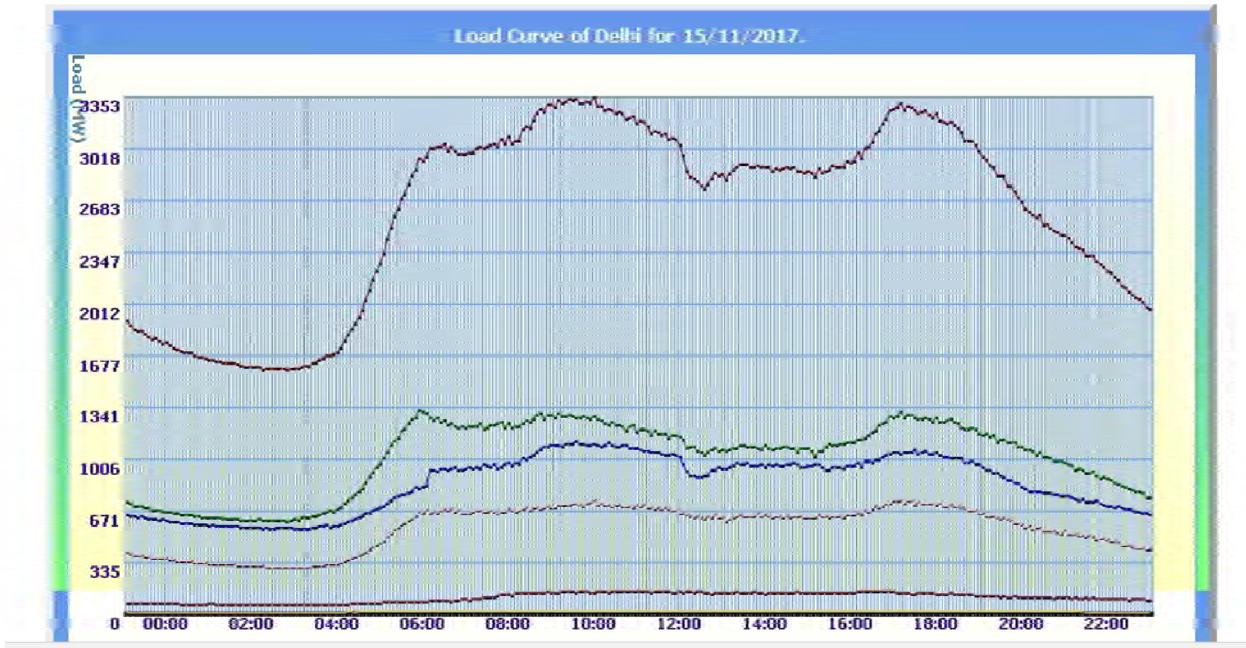
Vendor Battery Swapping Stations



Summer



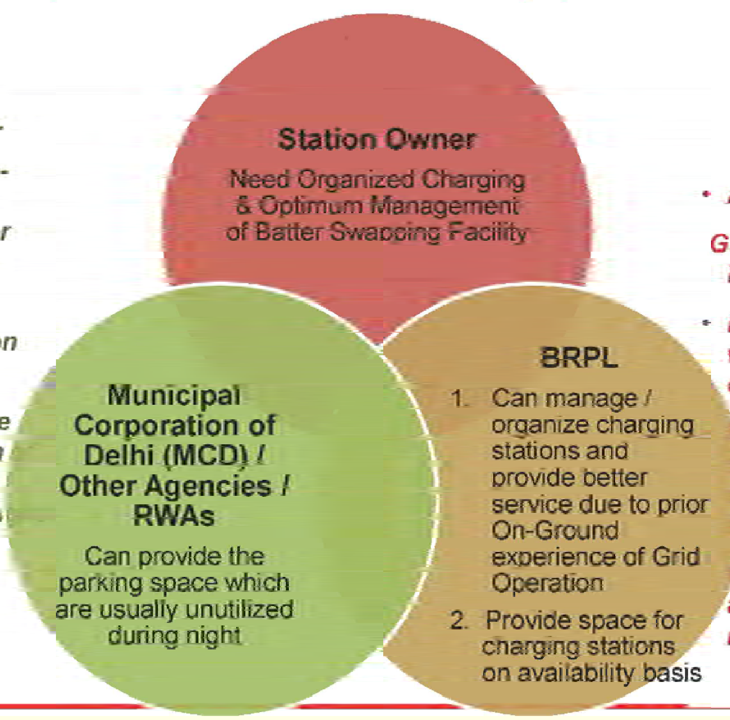
Winter



Stakeholder's & Their Concerns

Facilitation of Eco-friendly public transport, good for the city, Returns on Capex incurred during Engineering Procurement & Construction of Charging Station , Positive Media

- *Employment & Ancillary services.*
- *Facilitation of Eco-friendly public transport, good for the city, positive media*
- *Additional E Tax on electricity*
- *Additional revenue through utilization parking space specially during ni*



- *Assured Charging:*

  Guaranteed Kilometers Per Battery Swapping.
- *Proper Chargers which will in-turn enhance battery life .*

'roper electrification , ıch that even bulk ıarging will not fect Voltage quality.

.oad Curve Balancing after midnight when requirement is low.

Indian E- Mobility Finance (IEMF) Initiative

Profile

Vinod is an entrepreneur and one of the early movers in the area of sustainability. In 1999, he founded Emergent Ventures India Pvt Ltd (EVI), focused it on Climate Change in 2004, and thereafter helped launch a number of pioneering ventures in the area of Renewable Energy, Sustainability and Climate Change. EVI has become one of the leading service providers in these areas, with delivery across 25 countries and more than 500 engagements. EVI's clients include Governments, Public Sector units, Multi National Corporations, Development Finance Institutions, Banks, Investors, Utilities and so on.

Recently Vinod, with the support partners and well known foundations, has launched India E Mobility Finance (IEMF), a not for profit Initiative to **help cities , public sector entities and innovative entrepreneurs prepare 'viable' projects, supported with 'market-based business models', and 'catalyze' flow of investments' into E Mobility.**

Vinod specialization is Finance and Incubation of Technology businesses. He is a Mechanical Engineer with PGDM from IIM Ahmedabad.

Abstract

Indian Market for EVs, is set to take off across variety of applications such as Public Transport (Buses, Last mile 3 Wh/2wh, Taxies), Personal Use (4/2 wheelers), Urban Freight etc. EVs are viable in most applications at today's costs. Once the market is kick-started, subsidies can be withdrawn. In 2-3 years time, EVs will start to give 20%-40% cost advantage on INR/KM basis, thus reducing overall costs in India. A bouque of policy support can be constructed to kick-start EVs in Cities. Cities will drive adoption of EVs. Financing will play an important role. A number of business models around leasing, performance linked leasing, battery leasing, battery swaps etc evolving and getting implemented.

Indian E Mobility Finance - IEMF

'India E Mobility Finance (IEMF) prepares 'viable' projects, supported with 'market-based business models', and 'catalyzes' flow of investments from public and private sources into the Electric Mobility space'

SYSTEM BENEFITS OF EVS

EV's Expected to Deliver Significant Benefits to Indian Economy

1. **Reduce Fuel Import Bills**
   - $14 bn by 2030 and $100 bn/a by 2045-50
   - Energy Security Goals
2. **Reduce GHG Emissions, Local Air Pollution (PM2.5, Sox, Nox), Noise Pollution**
   - Critical for Indian Cities which are facing great stress due to air and noise pollution
3. **Easier and Less Costly Integration of 350-500 GW of Renewable Capacity in the Grid by 2030**
   - Smart Management of EV Loads and Grid Services (V2G)
   - EV's will add 3-4% average load on the grid with 6-8% addition to Peak.
4. **Reduced Cost of Transportation**
   - India transportation and logistics costs contribute 14% of GDP. This needs to be brought down to 8-9% in line with OECD Norms.
   - EVs can lead to 30-40% reduction in transportation costs
   - EVs will effectively use digital technology, improving asset utilization, reducing inventories and costs.
   - Less driver fatigue, safer driving.

COMPETITIVENESS OF EVS

Large Market for EVs, *readying* to take off in India

Lower TCO → Deflationary → Easy to Drive → Low Noise → Easy to Maintain → Lower Pollution → Allows RE Integration

1

10-18 T

- Intra City Travel (150-200 Km/day)
- Inter City Travel(250-500 KM/day)

2

0.5-1.0 T

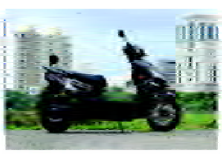
- Urban Freight ~100-150 Km/day
- Last Mile Connectivity (100-150 KM/day)

5

3-30 T

- Short Haul 100-200 Km/day
  - Home deliveries
  - Milk
  - Garbage
  - Others
- Long Haul (Inter-city)500-1000 Km/day

4



0.1-0.2 T

- Urban Freight (80-100 Km/day)
- Taxis (80-100 Km/day)
- Private Use (18-20 KM/day)

3

0.8-1.5 T

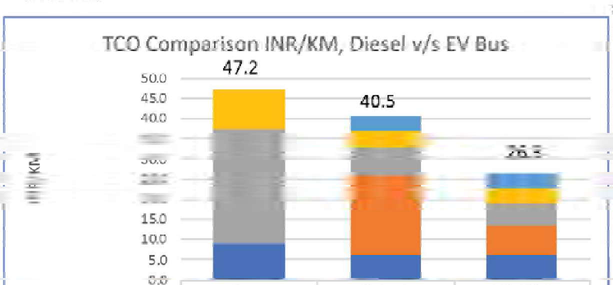
- Taxis – Intra City (200-250 KM/day)
- Corporate Travel (100-150 Km/day)
- Taxis- Inter-city (250–500 Km/day)
- Private Use (40-60 Km/day)

Starting to Grow | Likely to take off in 2 years (2021) | Will grow in > 3-5 years

Buses- very attractive first market for EVs

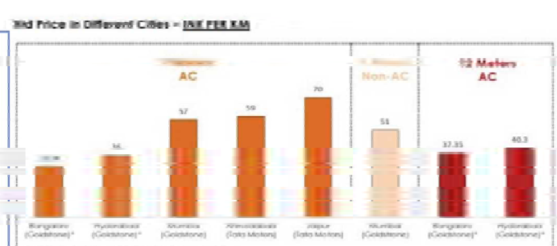
- Driven by FAME Subsidy (60%, INR 85 lacs-1 Cr), flurry of buying by STUs
- Costs have fallen from 1.5-2.0 Cr/bus to, INR 0.7-0.9 Cr/bus in 2 years (9-12 M AC)
- GCC Model makes it easy to buy (no capex), and transfers the Technology/ Performance Risk to Bus Suppliers
- Bangalore bid INR 29.28/km, (with electricity cost to STC) is in line with 2018 estimated TOC.
- As the KM/day increases EVs become more attractive

9M AC



	Diesel	EV's Today	EV's 2021
Charger Cost INR/KM	0.0	3.6	3.6
O&M Cost INR/KM	10.0	4.0	4.0
Fuel Cost INR/KM	28.0	7.2	5.4
Battery Cost INR/KM	0.0	19.6	7.3
Bus Cost INR/KM	9.2	6.1	6.1

EV estimates based on bottom up costing

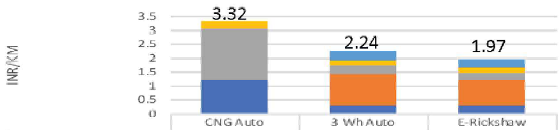


- Any New Bus Should be EV
- Replacement of Old Bus stock with EV is viable today.
- Subsidy not essential anymore to accelerate the market

3 Wheeler- Accelerating use

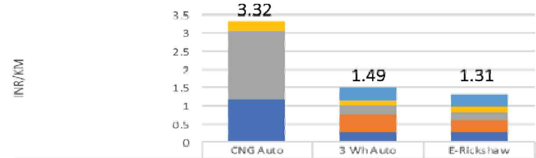
- E Rickshaws – already successful in Delhi and many other Urban markets as last mile solution. Urban freight likely to move to EVs, driven by lower cost and benefits of low pollution.
- Lead Acid battery based rickshaws cost INR 70-80 K; Li-Ion Battery E-Rickshaws ~ INR 1.3-1.4 lacs
- TOC for EVs much lower than CNG rickshaws. Life (excluding batteries) expected to be better for EVs.
- Mahindra TREO (Auto) and Yaatri (E-Rickshaw) in the market Other OEMS also launching their products

TCO, INR/KM for 3 wh, 2018



	CNG Auto	3 Wh Auto	E-Rickshaw
Charger Costs		0.32	0.32
O&M Cost	0.25	0.15	0.15
Fuel Cost	1.89	0.32	0.29
Cost of LV Battery	0.00	1.15	0.90
Cost of Vehicle without Battery	1.18	0.30	0.30

TCO INR/KM, 3 Wh, 2021



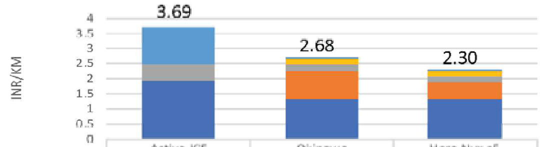
	CNG Auto	3 Wh Auto	E-Rickshaw
Charger Costs		0.32	0.32
O&M Cost	0.25	0.15	0.15
Fuel Cost	1.89	0.25	0.21
Cost of EV Battery	0.00	0.47	0.32
Cost of Vehicle without Battery	1.18	0.30	0.30

- New 3-Wh EV's more competitive than CNG. This is the reason for their significant popularity. 3-Wh autos will grow driven by higher power and ability to go up the gradients in cities.
- Replacement of OLD stock by EVs, viable today.
- Financing of batteries and swap facilities will make the market take off rapidly. Swap time is less than CNG filling time. This allows more productive use of Autos

2 Wheeler- Worldwide trends of fast transition to EVs may be seen

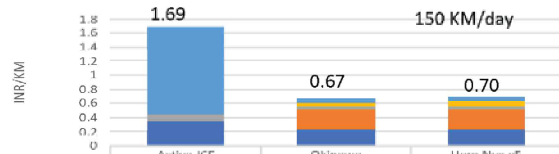
- Many models (Hero Photon, Nyx E5, Ather 350/450, Okinawa Praise, Flow (Twenty Two motors) are now in the market.
- As batteries become cheaper, higher performance likely to be built in.
  - 2 Wh EVs cheaper than ICEs in capital costs globally
- TCO for EV's is lower than ICE 2 wheelers.
- Easier to drive and control
- Strong interest for delivery vehicles (e.g. Zomato, Swiggy, Amazon, Flipkart etc.) to shift to EVs.

INR/Km cost, 2Wh, Personal Use 18KM/day



	Activa ICE	Okinawa	Hero Nyx e5
Fuel Cost	1.25	0.06	0.07
Charger Cost	0.00	0.16	0.16
O&M	0.51	0.20	0.20
Battery Cost	0.00	0.92	0.55
Scooter Cost	1.94	1.34	1.32

INR/KM, 2 Wh , Local Delivery Use (Urban Freight) 150 KM/day

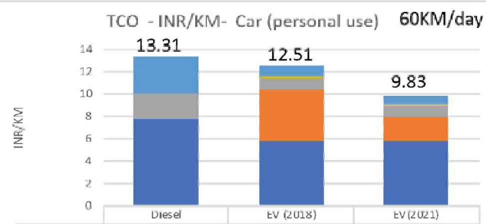


	Activa ICE	Okinawa	Hero Nyx e5
Fuel Cost	1.25	0.06	0.07
Charger Cost	0.00	0.05	0.08
O&M	0.09	0.04	0.04
Battery Cost	0.00	0.28	0.27
Scooter Cost	0.35	0.24	0.24

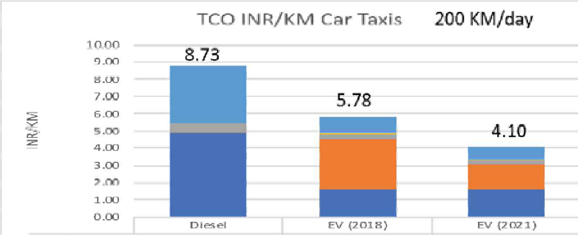
- Both for Personal and Local Delivery use, EVs TCOs are significantly lower compared to ICEs. The % cost difference is higher for Local delivery (because KMs/day are higher)
- Replacement of OLD stock by EVs is viable today, for *Local Deliveries*
- Cheap Financing and support for Home and Office Charging (slow chargers) will drive the market

Cars- Taxis ready to transition to EVs

- Most car manufacturers have announced plans to have all their car models to have EV variants (next 2-5 years)
- EESL has begun leasing of Cars. Leasing is an attractive model for cars
- Corporate Travel is shifting to EVs rapidly.
- Driven by lower TCO, the Shared Taxi market also may shift to EVs.
- High Performance products needed to accelerate



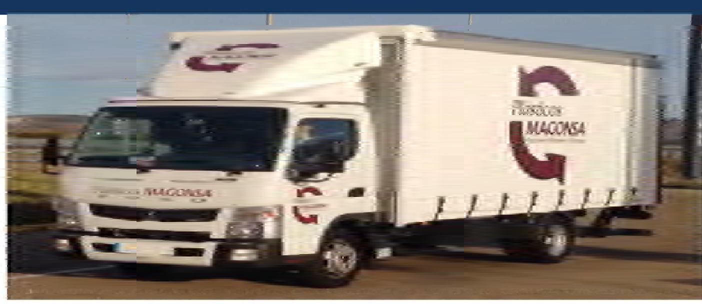
	Diesel	EV (2018)	EV (2021)
Fuel Cost	3.33	0.92	0.71
Charger Costs	0.00	0.18	0.18
O&M Costs	2.14	1.07	1.07
Battery Costs	0.00	4.56	2.09
Car Costs	7.83	5.78	5.78



	Diesel	EV (2018)	EV (2021)
Fuel Cost	3.33	0.92	0.7
Charger Costs	0.00	0.01	0.0
O&M Costs	0.52	0.26	0.3
Battery Costs	0.00	2.91	1.4
Car Costs	4.89	1.65	1.7

- E-cars are competitive compared to ICE cars, thought the cost difference is not significant for persona use. For Taxi's the cost differential is significant.
- Replacement of OLD car stock by EVs is viable in 2-3 years, for *taxi purposes*.
- Cheap Financing and support for Home and Office Charging (slow chargers) will drive the market

Freight – Urban Freight to shift much more quickly, compared to long haul trucking.



- Urban Freight (e.g for groceries, garbage, milk, fruits and vegetables---1.5-5 T vehicles) can shift faster, driven by availability of charging infrastructure and city preference for EVs
- Good products, locally available, are needed to accelerate the market
- Long Haul Trucking (10-35 T, 500 KM/day+) is not competitive for EVs:
  - Capital cost of EV: Diesel ~ 5-6 times.
  - Non availability of fast charging infrastructure (600 KW+)
  - Current EV costs (TCO, INR/KM) are likely to be 100% higher compared to diesel.
- Volvo, Nikola Motors, Tesla, Aeos, Mitsubishi, Peterbilt and many others are developing long haul trucking solutions (class 7/8).
- ***The biggest benefit of EVs, apart from lower TCO cost, would be reduced driver fatigue and therefore less accidents, better productivity etc.***
  - ***50% of drivers face health related issues***

Charging Stations

Speed	Slow	Medium	Fast	Rapid	Super Fast
Type	AC	AC	AC	DC	DC
KW	3.3	7.2	22	50-70	100--350-600
Cost/W	4-5	5-6	6-8	20-25	20-30
Speed of Charging	<C/3	C/2-1C	1C-2C	~2C	~10C
Charging time	3 Hr+	1-2 Hr	0.5-1 Hr	5-30 Min (50-70% of SOC)	
Battery	N	N	N	N- for normal larger batteries S- for fast charging smaller batteries	
Controls				Charge Cycle controls, temperature management	
Applications	Home	Home/ offices	Home/ Public	Public, Depots, Terminals etc	Highways, long distance vehicles

- Costs of charging stations are falling
  - Low capacity stations are selling at 1/5th of costs of 2 years back.
  - Costs will improve further.
- Globally, Fast chargers are being set up with ~70-80% of charge being given in 5-15 minutes.
  - Fast charging needs to have control over charge cycle and temperature. It can also age batteries faster.
- Swapping provides many benefits
  - Financing of batteries and charging
  - Improved life management
  - Little time needed for charging
- Inter-city transportation will be possible with EVs only when highways have fast chargers
  - MOP policy to set Fast chargers every 25 KM on major highways.
  - With such chargers Inter-City Bus and Long Haul Freight can move to EVs

Summing Up

EV:ICE Comparison	EV: ICE Costs			EV Ccompetitiveness		Product Avaiability
	Capital Costs 2018	TCO 2018	TCO 2021	New EVs	Replacement of Old Stock	
Buses	1.37	0.86	0.56			
3Wheeler						
Autos	1.11	0.67	0.45			
E-Rickshaws	0.70	0.59	0.394			
2 Wheelers						
Personal Use	1.16-2.0	0.62	0.4			
Local Delivery	1.16-2.0	0.40	0.25			
Cars						
Personal Use	1.33	0.94	0.74			
Taxis	1.33	0.66	0.46			
Freight						
Urban Freight	1.2-1.3	0.65-0.70	0..6			
Long Haul	5+	2.22	1.09			

- EVs require more upfront investment but their TCOs are superior
- Product performance and availability needs to improve across categories
- EVs are competitive with ICE, across segments except in Long Haul Freight
- Freight and Taxi applications are very attractive
- EV's can replace old stocks today or in 2-3 years across most segments

Business Models

Vehicle Leasing

- For cars, used by EESL
- Great potential for 2Wh, 3Wh leasing

Performance based leasing

- GCC model for Buses.
  - Payment based on INR/Km
  - Can similar models be used for Taxis
- Battery leasing
  - INR/KM leasing options

Battery Swap Models

- Per-charge, per kWh, models

Public Charging Infrastructure

- **Hybrid Model**
- Utility pays a minimal rental
- As demand picks up, reduce the rental paid.
- Locations as identified by Public EV Board and space provided by City/State
- Can be used for fast charging infrastructure
- Station can also benefit from commercial use of space

Utility Anchored EV Programs

- **Discoms offer their customers**
- EV leases; On Bill Financing
- Take back old vehicles
- Private/shared slow Charging stations at home/office part of the overall offer.
- Can be implemented at homes/commercial malls etc.

Public Aggregators

- **For Public Charging Infrastructure**
- Charging Stations managed and operated by private players.
- Public sector aggregator ensures quality, service and benefits of costs
- V2G Services (in time), to get paid for grid services
- Procures Low Cost Renewable Energy

Supportive Incentives

Financing Support

- Upfront subsidy payouts to finance companies
  - 2Wh, 3Wh
  - Individual drivers
- Interest Cost Subvention

Registration, Road Tax waivers

- Waiver on Licensing Fee for commercial EVs
- Road Tax, Parking Fee waivers.

Preferential Access

- Specially for city areas where congestion, pollution issues are high.
- Marked out Zones only for EVs

Capital Subsidies for EVs

- **FAME and State Level Subsidy Schemes**
- Capital subsidies are useful initially
  - To promote more efficient, high performance products
  - To support high Capex requirements.
  - Support charging infrastructure
- Can be removed with time (2-3 years as the demand takes off)

Taxation on ICEs

- **Tax collected can be used to support EVs**
  - Tax on Fuel (Diesel, Petrol)
  - Taxation on ICE Taxis
  - Higher parking tax on ICE vehicles
  - Congestion tax on ICE vehicles
  - Registration costs for ICE.

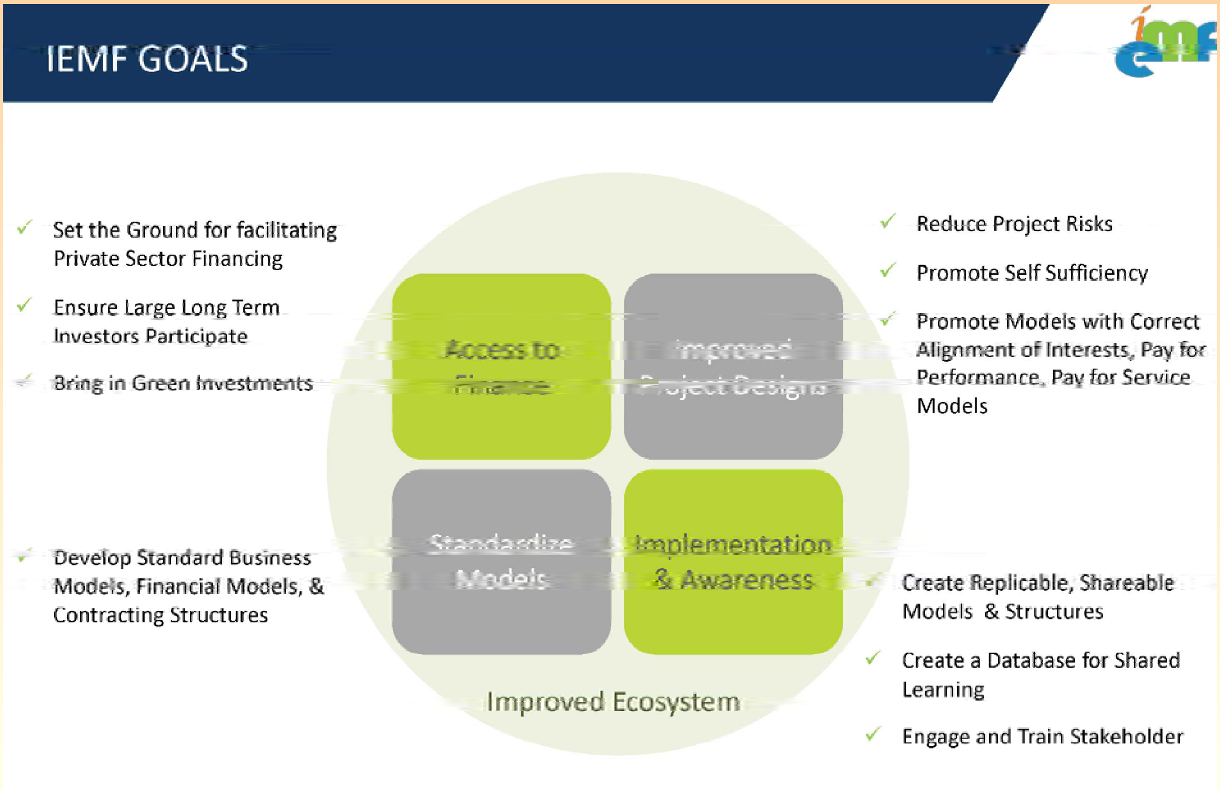
Lower Electricity Costs

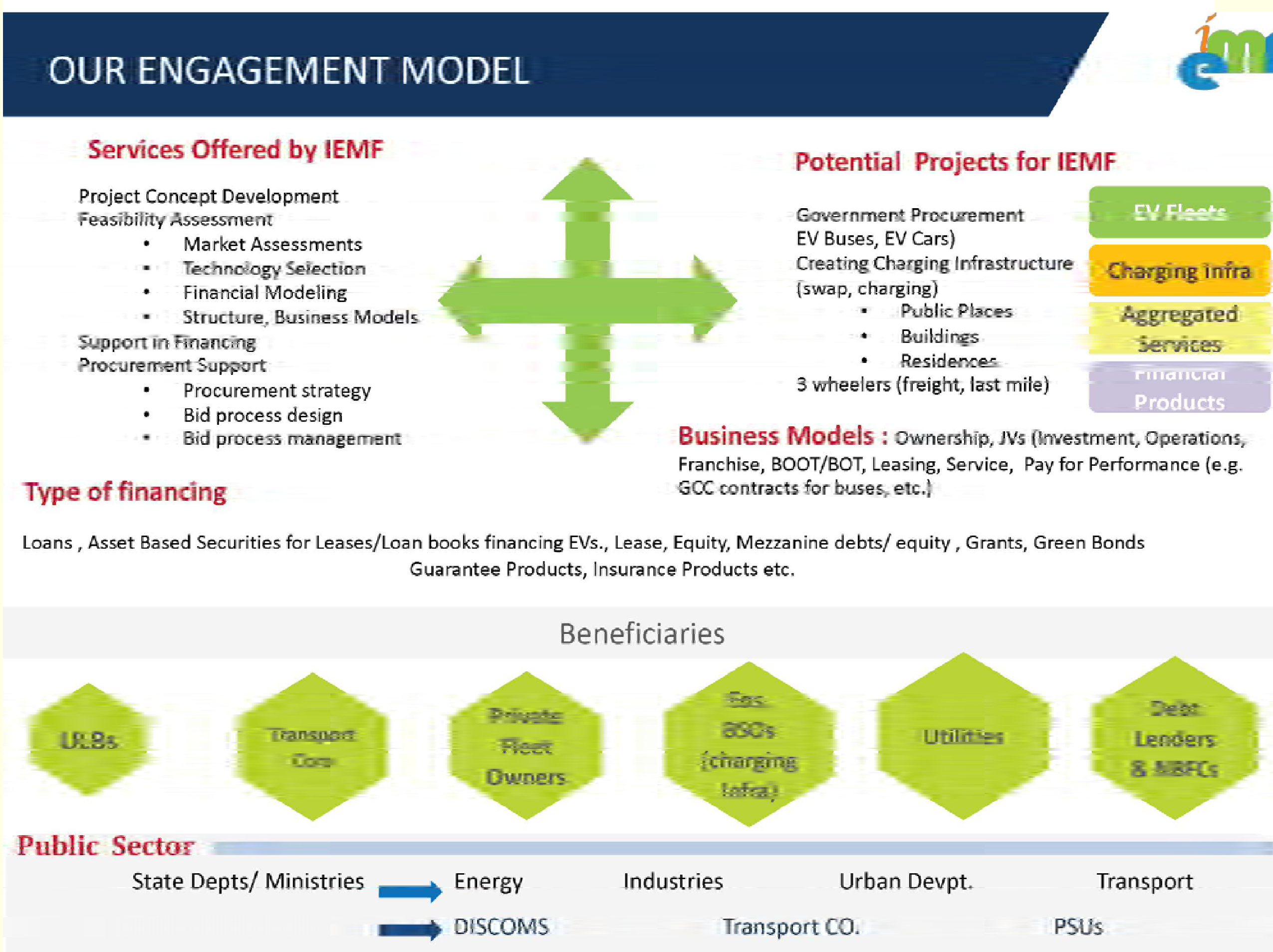
- Lower Grid Tariffs, Demand Charges
- Permitting use of Renewable Energy under Open Access.

Rebates to Customers

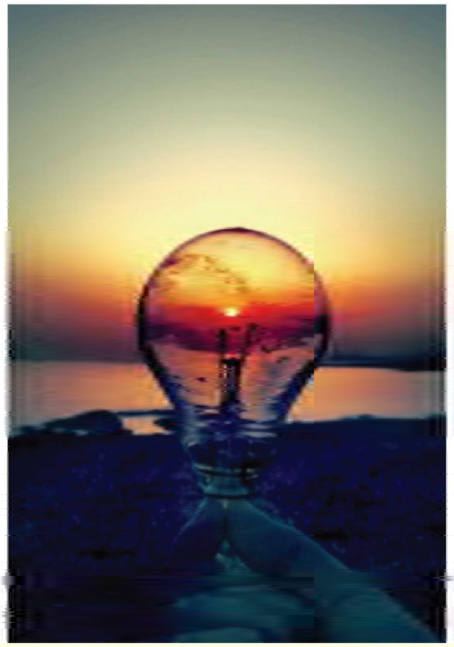
- Fare rebates to customers who use EVs

To support faster decision making and resolution of problems, Cities could set up a special body to promote EVs – Smart City Office, Municipal Corporation, Distribution Company, STC, Transport and Finance Departments.


IEMF GOALS
Set the Ground for facilitating Private Sector Financing
Ensure Large Long Term Investors Participate
Bring in Green Investments
Develop Standard Business Models, Financial Models, & Contracting Structures
Access to Finance
Improved Project Designs
Standardize Models
Implementation & Awareness
Improved Ecosystem
Reduce Project Risks
Promote Self Sufficiency
Promote Models with Correct Alignment of Interests, Pay for Performance, Pay for Service Models
Create Replicable, Shareable Models & Structures
Create a Database for Shared Learning
Engage and Train Stakeholder

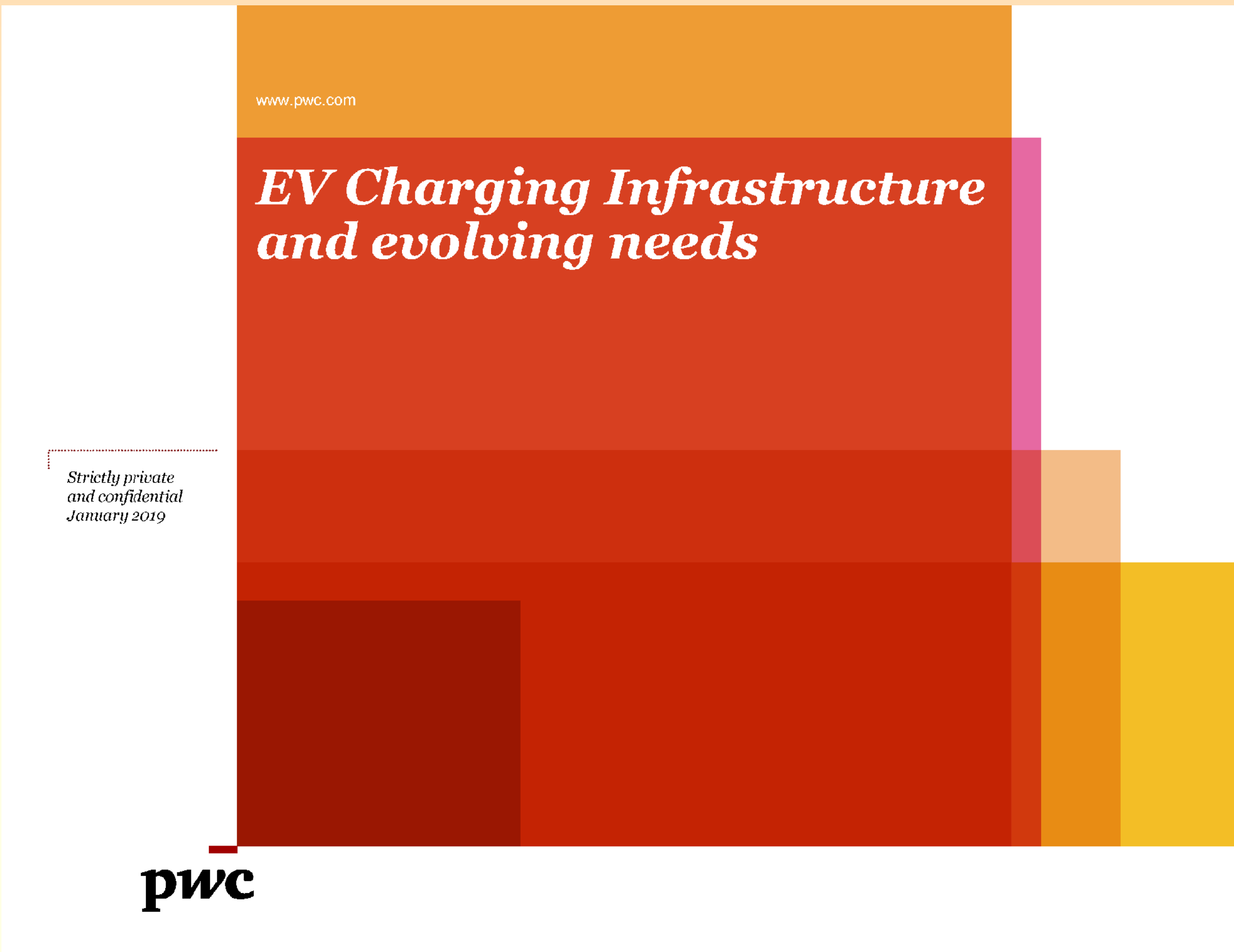

OUR ENGAGEMENT MODEL
Services Offered by IEMF
Project Concept Development
Feasibility Assessment
• Market Assessments
• Technology Selection
• Financial Modeling
• Structure, Business Models
Support in Financing
Procurement Support
• Procurement strategy
• Bid process design
• Bid process management
Potential Projects for IEMF
Government Procurement
EV Buses, EV Cars)
Creating Charging Infrastructure (swap, charging)
• Public Places
• Buildings
• Residences
3 wheelers (freight, last mile)
EV Fleets
Charging Infra
Aggregated Services
Financial Products
Business Models : Ownership, JVs (Investment, Operations, Franchise, BOOT/BOT, Leasing, Service, Pay for Performance (e.g. GCC contracts for buses, etc.)
Type of financing
Loans , Asset Based Securities for Leases/Loan books financing EVs., Lease, Equity, Mezzanine debts/ equity , Grants, Green Bonds Guarantee Products, Insurance Products etc.
Beneficiaries
ULBs
Transport Cos
Private Fleet Owners
(charging infra)
Utilities
Debt Lenders & NBFCs
Public Sector
State Depts/ Ministries
Energy
Industries
Urban Devpt.
Transport
DISCOMS
Transport CO.
PSUs

REACH US AT



Vinod Kala
vinod.kala@iemf.in
+91-9810122509

Presentation by Shri Akash Gupta, Consultant, PWC



Contents

Snapshot of Central-level EV Policy initiatives

2010

MNRE initiative to promote EVs
Ministry of New and Renewable Energy proposed 20% capital subsidy for EVs that resulted in a big uptake of e-bikes

2011

National Mission of Electric Mobility (NMEM) by the Govt. of India
To promote electric mobility through development and adoption of EVs

2013

National Electric Mobility Mission Plan 2020 (NEMMP 2020) by the Ministry of Heavy Industry
Target of 7 million EV sales

2015

Faster Adoption & Manufacturing of (Hybrid &) Electric Vehicles (FAME) by the Ministry of Heavy Industry
- Eligible vehicle categories - 2W, 3W, 4W, LCV, HCV and Retrofit
- Restricted to major metros, capitals, Smart Cities, cities in North-eastern states

- **As FAME 1 incentives didn't have the anticipated impact on EV penetration, Government has identified demand aggregation as one of the EV adoption strategies and is carrying out bulk procurement through EESL.**
- **FAME I has been extended till March 2019 or the notification of FAME II whichever is earlier along with a discontinuation of incentives to vehicles which do not require registration and conventional battery operated vehicles.**

Institutional Framework

Niti Aayog has been mandated as the nodal agency for EV initiatives in India

NITI Aayog (National Institution for Transforming India) Government of India

Coordination of the e-Vehicle initiative among various government departments

Ministry of Power
- To address the Policy/Regulatory and Planning aspects related to charging infra
- CEA: To address the technical aspects related to charging infrastructure and EVs

The role of departments and organizations under MoP is as follows:

- EESL: Responsible for large scale procurement of e-Vehicles and establishing business models around it
- NTPC / Power Grid Corporation of India: Responsible for establishing charging infrastructure in the country. Limited actions taken till date
- Working towards setting standards for charging infrastructure, EVs and batteries

Department of Heavy Industry
Ministry of Heavy Industries & Public Enterprises, Government of India

- Responsible for Bharat Charging Standards AC-001 and DC-001
- Managed FAME before it was transferred to NIT Aayog
- Released NEMMP 2020

NATRiP Driving India Into the Future

NATRIP labs including ARAI would be responsible for testing of e-cars and charger

MORTH Government of India
- Administration of the Motor Vehicles Act, 1988
- Taxation & compulsory insurance of Motor Vehicles
- Vehicle registration

Ministry of Housing and Urban Affairs Government of India
- Development of urban transport, infrastructure and reforms
- Policy related to separate stands for electric vehicles in case of shared mobility
- Declaration of low emission zones and streets

State Government
- Each state in India can define rules regarding registration and road taxes
- Policy regarding city planning would also be state specific

EV Charging Infrastructure Standards

➢ *Global standards*

Country/Region	Standards
US	CCS (Combined charging system), CHAdeMO
Europe	CCS (Combined charging system), CHAdeMO
Japan	CHAdeMO
China	GB/T

➢ *Indian standards*

Bharat Charging Standard has been developed and finalized in India by a Committee on Standardization of Protocol for Electric Vehicles Charging Infrastructure. The Charger itself is **based on AIS** (Automotive Industry Standards) and the **communication protocol is based on GB/T** with added features.

Charger type	Standard	Power Output	Safety Requirements
Slow charger	Bharat AC 001	3.3 kWh	Based on AIS 138 Part 1
Fast charger	Bharat DC 001	15 kWh	Based on AIS 138 Part 2

Government is working on the FAST Bharat 002 type chargers.

EV Charging Infrastructure Guidelines – Dec 14, 2018 – Ministry of Power

Public Charging Infrastructure Minimum Requirements

Charger Type	Charger Connectors	No of Chargers	No of charging guns
Fast	CCS (min 50 kW)	1	1
	CHAdeMO (min 50 kW)	1	1
	Type-2 AC (min 22 kW)	1	1
Slow/Moderate	Bharat DC-001 (15 kW)	1	1
	Bharat AC-001 (10 kW)	1	3 (3.3 kW each)

- Exclusive transformer
- 33/11 KV cables with associated equipment
- Appropriate civil works

Priority for roll-out of EV Public Charging Infrastructure

PHASE I (1-3 years)

- All Mega cities with population of 4 million plus as per census 2011
- All existing expressways connected to these Mega cities and Important Highways connected with each of these Mega cities

PHASE II (3-5 years)

- Big cities like State Capitals, UT headquarters
- Highways connected with each of these Mega cities

Every State Government shall nominate a Nodal Agency for that State for setting up Charging Infrastructure.

Issues and Challenges in Charging Infrastructure

- **Regulatory Challenges**
  - Tariff issues
- **Economic Challenges**
  - Business Viability issues
- **Technical Challenges**
  - Charger Standards and Protocol issues
  - Grid stability issues

Battery swapping

Batteries can be swapped at a swapping station, replacing a discharged battery with a charged one.

Battery can be separated from the vehicle and will not be owned by the vehicle owner. Instead it will be owned by an **Energy Operator** (provider of charged battery as a service), who will **buy the batteries, charge them and lease it** to the vehicle owners at convenient **Charge-cum-Swap Centers**.

Swapping can be done in a few minutes.

As of now, Indian Government is skeptical about the existence of swapping centers but the opportunity may pop up in the future.

Swapping stations economics

Swapping model for 2-W, 3-W and buses

Merits

- Faster turnover of vehicles
- No requirement of land for charging multiple cars
- Less degradation of batteries over time as all batteries would be charged in optimum conditions

Demerits

- It involves swapping of batteries of a particular make/type. Battery being the USP of any automobile manufacturer, may not be standardized
- Hence primarily it is a proprietary business
- The batteries are heavy in case of buses and will have to employ robotic based battery swapping which is costly
- Security issues in leasing of battery to the EV owner
- Infrastructure is expensive

Auto Sub-sectors vs EV Sub-sectors

What's new?

Auto Sector Ecosystem

- Manufacturing
- Fuel Pumps
- Sales OEM
- Sales Vehicle Ownership
- Service OEM
- Service Vehicle
- R&D
- Driving

EV Sector Ecosystem

- Manufacturing
- Charging Swapping stations
- Telematics
- Sales OEM
- Sales Vehicle Ownership
- Service OEM
- Service Vehicle
- R&D
- Driving

Skill requirements in the EV sector

Some examples of transition in jobs

Key Skills

Entirely New Skills

- Battery pack assembly
- Manufacturing of charging infrastructure
- Servicing of batteries and motors (imported)

Re-skilling from Automotive Sector

- Testing and validation of EVs
- Charging Infrastructure Operations Management
- Mechanical structure assembly
- Thermal management: This would require cooling of static devices, power electronics etc.

New Skills from other sectors other than Auto

- High voltage handling : Expertise from **Safety**
- Developing Apps for GPS, billing etc., control, analytics, real time communication: Expertise from **IT/Software**
- Expertise from **Power Electronics**

Skills replaced/removed from Auto sector

- No requirement of emission expertise
- Reduction of skill requirement in ICE engines
- Petrol/gas station attendants to be replaced by charging/swapping station operators

Presentation by Shri Rahul Bagdia, Director, Co-Founder, Pmanifold Business Solutions

Profile

Rahul has 18+ years of Research and Consulting experience across industries and geography. He is Co-Founder of pManifold, a Strategic Energy & Utilities focused Research and Consulting company, helping industries and organisations innovate and transform their solutions, services and business models, for higher customer experience and market growth. He specialize in new energy technologies and market development, business transformation, PPP structuring, financial modelling, technology valuation, customer experience, econometrics, policy advocacy, and stakeholder engagement. His work spans power, electric vehicles, solar, Low Voltage DC (LVDC), smart, and enviro sectors. He is Secretary of India Utility Knowledge and Network (IUKAN) and Nagpur Smart City Council (NSCC).

Abstract

Ease of EV charging is an important element for driving adoption of EVs in any vehicle and usage segments. The battery design (size, chemistry etc.) and EV architecture (voltage, on-board charger rating etc.) shall be important determinants of type of charging required - slow AC or fast/ rapid DC. Hence different vehicle segments (2Ws, 3Ws, 4Ws, buses) will need different types of charging and associated infrastructure. The usage characteristics of different vehicle segments (personal vs. commercial use, kms/ day, etc.) will further drive the selection of location and time of day for charging. A 2W, which forms close to 80% mode share in India, would mostly use small battery, and may need say 2 times charging in a week, depending on its travel distance. With such characteristic, it may be convenient for the users to charge it overnight at home on simple 15A AC plug point. In contrast, a commercial 4W cab that runs some 200 kms a day may need 2 times charging in a day -one of which may be conveniently done at home through AC slow charging, and another during day time would benefit from fast charging.

Above diversity of EVs and use cases shall need different combination of private and public charging infrastructure. India's dominant mode share of 2Ws, comparative lower avg. travel distance and lower affordability will likely lead to higher percentage of home charging and increased adoption of battery swapping system. In one of our study for city of Pune, these aspects of EVs and charging choices selection was studied from end-user adoption, charging business economics and operating model and city planning and integration perspectives.

MANIFOLD
BUSINESS SOLUTIONS

INTRO

Electric Vehicle Services

Transforming Public and Private Services

Research	Consulting	Engagement	Technology

Power | Water | Waste | **EVs** | LVDC | Solar | Smart Cities | ...

'P' in our name stands for triple bottom line sustainability of people, profit and planet that we want to bring in all our internal functioning, projects we do, and industries we support. It also keeps us prompt, progressive and partnership valuing. **Manifold** represent abstraction of complex problem to smaller dimension, still preserving elements which matters and are available to influence/control and also measure the system dynamics. We are **'small data'** company and take pride in collecting and analysing most relevant data to help our clients with decisions and actions.

Who we are and what we do?

A **Strategic Research and Consulting** company helping **industries and organizations** innovate and transform their solutions, services and business models, for faster **reforms,** higher **customer experience** and profitable **market growth**

Research	Consulting	Engagement	Technology
Create and sell information products for global markets (in EVs and Utilities)	Service custom Management needs around customers and markets	Program Management services for Industry reform Events, plus organize self events & content (online and offline)	Build custom and for self Technology products

Our focus in Energy & Utilities

We cover various emerging Utilities, Infra, clean & smart Technologies all rolling around **Communities & Cities**

Power	Water	Waste
Solar, LVDC	**Cities**	Smart Infra
Technology	Citizen Services	**Electric Vehicles**

Select Clients

Spanning sectors, value chain, geography, size, countries

Utilities	TATA POWER-DDL, Essel Group, Smart Utilities, पावरग्रिड, CESC Limited, enzen, Bharat Petroleum, NPCL, GTL, OCW, NWS, Godawari Power & Ispat Limited, SPANCO, SMS, Shapoorji Pallonji Group
Institutions & Think Tanks	The World Bank, BEE, UNEP, ECO, APQI, IEEMA, ISGF, giz, NIUA, SHAKTI Sustainable Energy Foundation, IET, International Copper Association India, QCI, Nagpur First
Consultants	EY, IDRA, FEEDBACK INFRA, SAGACIOUS IP, Aagami, PRDC
Financial Institutions	General Atlantic, VESTERGAARD, Sangam Ventures
Service Providers	SAP, accenture, Raychem RPG (P) Ltd., FERRANTI, CYGNI, GRAMPOWER, ABB, Global Education, Raisoni Group, moserbaer Technologies, exceleron, Ceinsys, IEX

Executive Team

Globally connected, Locally immersed, functionally diverse, Knowledge driven ...

Rahul Bagdia
Co-founder and Director
BE VNIT, Dual MS UMich
15+ years of work experience

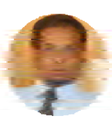
Faiz Wahid
Co-founder and Director
BE VNIT, MS BITS Pilani, MBA HEC Paris
15+ years of work experience

Sohel Khan
Director, Technology
16+ years of work experience

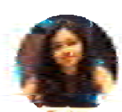
CA Uma Bagdia
Director, Finance & HR
12+ years of work experience

Ankit Agrawal
Principal Consultant, EVs
8+ years of work experience

Kunjan Bagdia
Principal Consultant, Energy & Utilities
10+ years of work experience



Godwyn Francis
Lead, KPO Business
14+ years of work experience



Snehal Gadre
Lead, New Opportunities
6+ years of work experience

Nilofer Memon
Lead, Digital
10+ years of work experience

Building EVs and City's interconnections Global Database

RESEARCH

Launching soon ...

EVIS©

Electric Vehicles and City Interaction & Aggregation **Global Digital Portal**

Coverage

- City EV attractiveness index
- Charger Deployment Tracker
- User reviews and perception
- OEM and Dealer reviews
- EV and Charger City level Forecast and impact
- EV related Projects Tracker
- EV Innovations & Org Tracker

Cities to cover

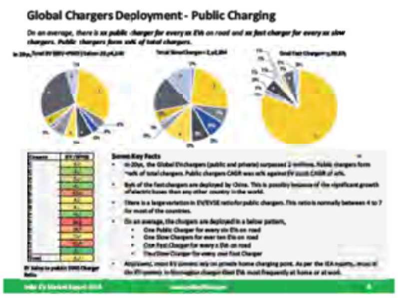
- 10 Indian cities
- Global EV Capital 20 cities
- 100 India smart cities
- Others...

Raising Global EV Content & Community

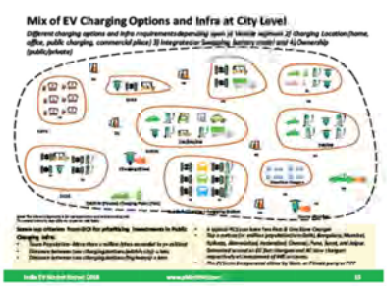
- Pointed EVs data, insights, and benchmarking
- Interactive Workshops, Webinars, Conferences
- Syndicated reports
- Others...

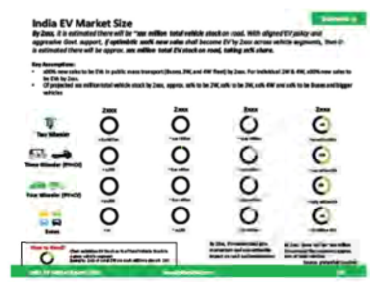
India Market Report on EVs and Charging

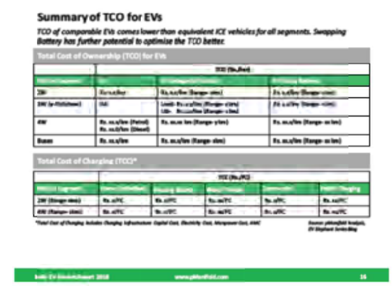
Published comprehensive Market report updated till **Dec, 2018**



Coverage:
- Global Overview
- India Scenario
- Related Tender Opportunities
- EV Charging Technology Overview
- Value Chain and Business Opportunities
- Techno Commercial Assessment of EV Charging Opportunities





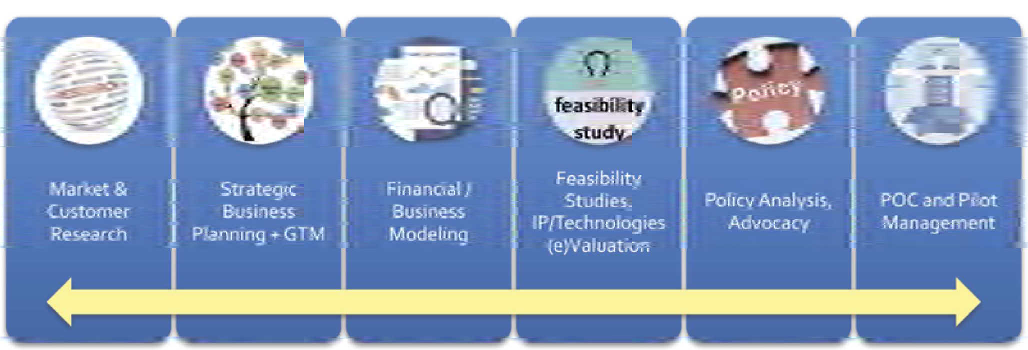


Completed multiple EVs & Charging road map studies – India (National/ Cities) and International

CONSULTING

Consulting Services

Spanning across EV value chain – **Electric Vehicles, Lithium Cell, Battery Pack, Charging, Components, IT, Fleet, Logistics, Network, Recycling**, others



- Demand & Supply Assessment
- Market study – Market size, share, segmentation
- Customer Experience Strategy

- Business Strategies – Entry, Go-to-Market, Growth, Operations, Marketing
- Corporate Planning

- Investment Feasibility
- Techno-Commercial Modeling
- Sensitivity Analysis

- Due Diligence
- Technology Evaluation
- IP Valuation

- Policy Assessment / Advocacy
- Stakeholders Mapping & Consultation

- Proof of Concept (PoC), Pilot Design & Management
- Monitoring (M&E), Benchmarking
- Impact Assessment
- Partnerships Development

1 Case Study: Technical Study of EV and Charging Infrastructure for Government of India

Market Study | **EV**

Client: A Govt. of India (GoI) enterprise under Ministry of Power

Client Objective

- The client wanted to understand EV landscape with key focus on EV Charging Infrastructure, its related business models, standards & regulations, best practices adopted, etc. for development of EV ecosystem in India.

Solution Approach

- Studied & Analyzed Global benchmarking of EV industry and Charging Infrastructure covering standards, testing protocols, charging and communication technologies (AC/DC), policies, regulations on tariff, etc. in four countries US, Finland, China and Japan to understand best practices being adopted by those countries.
- Developed city level EV adoption projections until 2030 for 3 cities (Delhi, Nagpur & Lucknow) including no. of EV projections, charging stations (public, private, fleet, battery swap), chargers, electricity requirement, impact on grid/network requirements, etc.
- 20+ diversified stakeholders were interviewed through different modes to get inputs on latest technologies in Charging Infrastructure. Also, their views on EVSE standards and testing protocols were collected and reported.
- 'As-Is' Supply Chain readiness of EV in India was studied and certain policy measures were suggested to help increase EV uptake.

Results

- The study guided the client with charging infrastructure related standards, business models, policies, tariff setting, and overall EV supply chain and ecosystem building up in India.

	Units	2,018	2,020	2,025	2,030	CAGR
City population	no.	27,50,000	29,45,869	34,98,768	41,55,439	3%
Total Vehicle stock on road*	no.	15,77,721	17,17,758	21,76,468	28,43,503	5%
2W	%	88.0%	88.1%	88.1%	87.8%	0%
3W - PV	%	1.4%	1.4%	1.4%	1.5%	0%
3W - CV	%	0.6%	0.6%	0.6%	0.5%	-1%
4W - PV	%	8.3%	8.3%	8.2%	8.2%	0%
4W - CV	%	1.5%	1.5%	1.6%	1.8%	2%
Bus	%	0.1%	0.1%	0.1%	0.1%	1%
Vehicle per unit 1000 Population	no.	574	583	622	684	2%
Total EVs stock on road	no.	650	61,367	3,93,004	11,16,965	34%
2W	no.	500	55,286	3,52,537	9,83,254	33%
3W - PV	no.	50	2,119	11,275	24,765	28%
3W - CV	no.	-	805	3,915	7,780	25%
4W - PV	no.	-	266	9,583	64,826	73%
4W - CV	no.	100	2,652	14,489	33,536	29%
Bus	no.	-	239	1,295	2,804	28%
EVs % mix of total vehicle stock on road in that year	%	0%	4%	18%	39%	27%
New EVs mix as % of total new vehicles added in that year	%	1%	39%	59%	100%	10%
Total EVs stock on road	no.	650	61,367	3,93,004	11,16,965	34%
With Integrated LIBs	%	85%	85%	75%	64%	3%
With Swapping LIBs	%	8%	6%	7%	8%	2%
With Range Extension LIBs	%	8%	9%	18%	28%	12%
Cumulative LIBs in system	MWh	2	168	1,178	3,968	37%
Integrated LIBs	%	89%	86%	78%	71%	-2%
Swapping + RE LIBs	%	11%	14%	22%	29%	7%
Total no. of LIB charges in a year	lakhs/year	2	103	635	1,725	33%
Home charging	%	65%	72%	68%	62%	-1%
Office/Private charging	%	9%	7%	6%	8%	1%
Public charging	%	11%	8%	8%	8%	1%
Swapping + RE	%	15%	14%	18%	21%	5%
Total Avg connected EV charging load to grid	MVA	2	125	687	1,811	31%

2 Case Study: Study to guide Electric Vehicle Charging Strategy for a Lighthouse city in India

Market Study | **EV**

Client: One of the leading international research & advisory institution on energy, climate and sustainable development

Client Objective

- The client wanted to make contextual assessment of barrier and possibilities of implementing EV charging infrastructure of 2W and 4W in one of the Lighthouse cities in India. Also, the study included capturing end-users preference for EV adoption.

Solution Approach

- Developed Business Models for electric vehicle charging of 2W and 4W at six different locations : Home, Common Building, Office, On-street, Public and Mall Charging for combination of slow, fast and rapid chargers. These business model was developed considering the existing electricity tariff in Maharashtra. The model provided the end-user pricing of EV charging to customers at above mentioned 6 locations using slow, fast and rapid charging.
- Developed Total Cost of Ownership (TCO) modelling for different models of 2W and 4W. This was done to draw comparison between EV and its ICE variants
- Conducted the survey of existing and potential users of EV for their preference of charging, charging locations, preferred time for charging, etc.
- Analysed the feedback obtained from the survey to develop and understand the important parameters for establishing charging infra.

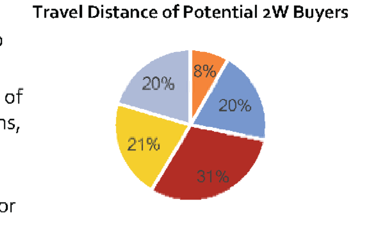
Results

- The study guided the client in developing right business model for estimating the end-user pricing to the customers who will be charging their vehicle at the mentioned 6 locations. It also helped client understand the user preference for charging speed, charging location and EV economics awareness to the people.

Pricing Components & Mechanisms for EV Charging

Location category	Independent house	Housing Society/ flats		Office		On-road, public parking space	Public Charging station	Mall Charging
Electricity cost	✔	✔	✔	✔	✔	✔	✔	✔
Capex recovery	✘	✘	✔	✘	✔	✔	✔	✔
Service Fee	✘	✔	✔	✘	✔	✔	✔	✔
Parking Fee	✘	✘	✘	✘	✘	✔	✘	✔

Travel Distance of Potential 2W Buyers



	e-2W	ICE-2W
Avg. purchase cost (Rs. lacs)	0.61	0.55
Avg. fuel (petrol or electricity) cost (Rs./km)	0.31	2.05
Avg. running cost savings per year (Rs. lacs)	0.11	-
Avg. total cost of ownership (Rs./km)	2.61	3.77
Avg. distance covered in one full charging (kms/full-charge)	60	220

3 Case Study — Study on Infrastructure and Enabling Environment for Electric Transport in SAARC countries

Market Study | **EV**

Client: A Think Tank supporting sustainable energy solutions development

Client Objective

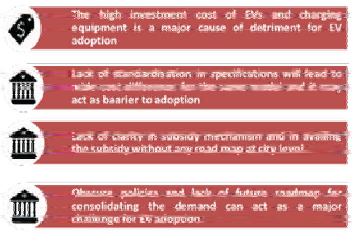
- The client wanted to assess the readiness of EV in SAARC Member States in terms of policy, technology, commercial and institutional aspects. Based on this, implementable action points will be developed to facilitate EV penetration in SAARC member states.

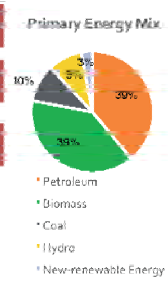
Solution Approach

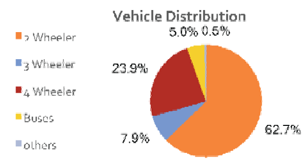
- The readiness assessment of the Member States in terms of countries economic parameters, energy sector, automobile local manufacturing and transport sector overview, capacity building of related stakeholders, skill development, private participation and investment etc. was assessed.
- The existing scenario for the SAARC Member States in terms of government plans and policies, EV usage, charging infra deployments, pilot project existing or planned, key challenges (for existing pilot projects: responsible authorities, EV model, battery type and specification, motor rating, charging standard and communication protocol followed was studied. This was followed by analysing the propositions of EV for each of the Member State.
- Recommendations in terms of vehicle segment being converted to EV on priority, policy measures like PPP, single window facility and SEZ for EV manufacturing etc., to attract investment and incentive provision to accelerate EV deployment, probable business models, ToU tariff etc. was made to facilitate EV deployment in Member State.

Results

- The study guided the client in assessing the EV readiness of the SAARC Member States. The assessment helped them to build right recommendations or action points for enabling EV penetration in the Member States







Raising and Engaging strong EV Community through Workshops, Conferences, Webinars, Whitepapers

ENGAGEMENT

EV Workshop – Helping organizations build their EV entry strategy

Coverage

- Value chain
- Technologies - EVs, Batteries, Chargers
- Market – Global and National
- Players, Projects & Strategies
- Policies & Regulations
- EVs TCO and Charging Costs
- Business Models

To benefit,

Infra companies looking to diversify into the EV space, Utilities, Oil and Gas Companies, Lubricant Manufacturers, Mobility Providers, Manufacturers of electrical equipment, Battery Manufacturers, Large cab service providers, Private parking owners, SEZ and business park contractors, Energy consultants, and others

Download *EV Worksop Brochure*

EV Conferences and Workshops

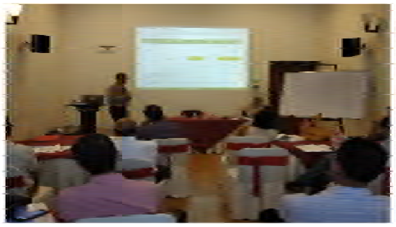
Participating, program managing and organising EV panel discussions, conferences and workshops

Rahul Bagdia spoke at the **EV India Charging Conclave 2018 at New Delhi**, where he shared his insights on EV Charging, Battery Swapping, Battery Manufacturing and more

Kunjan Bagdia co-moderated a session on 'Fast & Slow Chargers: Infrastructure Requirement and Impact on Grid' at **The EV India Charging Conclave, 2018**

Rahul Bagdia moderated a panel at **UMI 2018, Nagpur** for a UNEP study, which looked into the feasibility and pricing for different EV charging options and recommended a deployment roadmap for Pune City

pManifold, in association, with VIA organized half day EV workshop in Nagpur with focus on opportunities for SMEs. The workshop was attended by 30+ participants from diverse sectors of automobile servicing and spare parts companies, manufacturing companies, solar contractors etc.



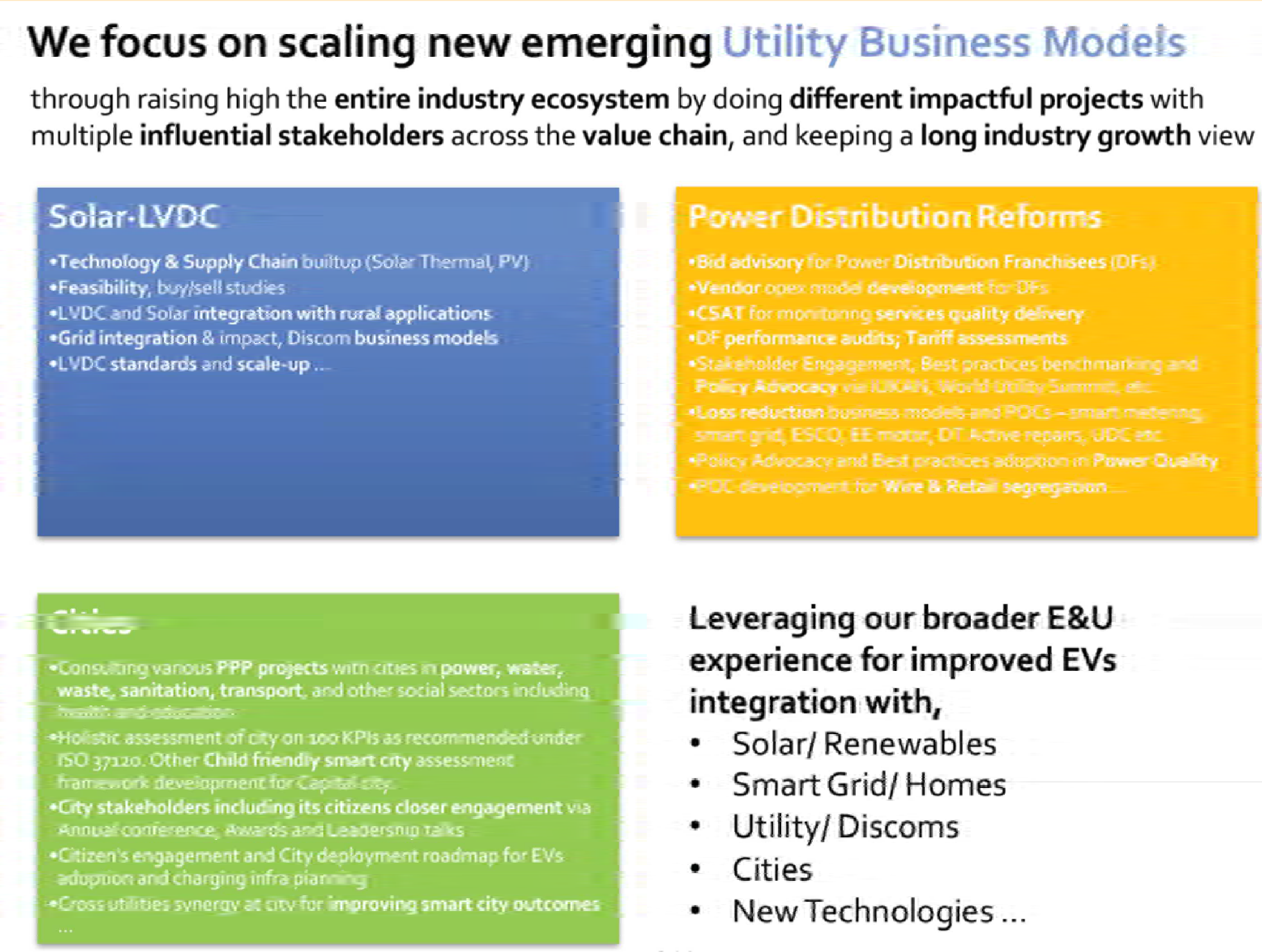
pManifold organized a day-long EV Business Opportunities Workshop for SMEs at Nagpur. The workshop helped participants learn EV engineering and economic fundamentals, and draw an association to their existing capabilities that they can leverage in the new

EV Webinar Series *'India Charging Ahead'*

Spreading knowledge by discussing most pertinent issues through engaging best of EV Experts

Topics	Speaker Organisations	Key Discussion Points	Link
Choice of EV Charging Connectors and Standards for India	• Tata Motors • TE Connectivity	EV Charging & Connectors Standards for India (AC & DC), Vehicle Design & Manufacturing considerations, Cost Economics	Link
E-3W Fleet: New Emerging Market Segment in India	• SmartE • Sun Mobility	New Product, technology, Business Model & Financing Innovation in 3W, Case Study, Pathways & Interventions	Link
EVs Battery System Design: Pack Assembly, Thermal Management, BMS & Integration	• GrinnTech • Ashok Leyland	Battery Pack & its elements, their design, Battery Thermal Mgmt. Practices (advantages & challenges), Various test results of LIBs, India expected market share in Battery & BMS	Link
e-Buses Transition: Viability for STUs?	• HRTC • UMTC	Business proposition for e-bus to STUs, Business models for STUs to finance & operate e-bus (including charging), city level integration, etc.	Link
...			

OTHER RELATED ENERGY & UTILITIES EXPERIENCES



Presentation by Shri Sunil Kumar Agarwal, Deputy Director, NTPC

Profile

Mr. Sunil Kumar is working as deputy manager in NTPC Ltd., India's largest energy conglomerate and leading power generator. Mr. Sunil has completed PGDM in power management from NTPC School of Business (Supported by IIM Ahmedabad) in 2017-18. His undergraduate degree of B Tech was in Mechanical Engineering from NIT Silchar in 2007-11. He has completed leadership development course from Judge Business School, Cambridge University, U.K. He is BEE certified energy manager and green belt in Six Sigma from ISI Pune. He has published three research papers in Electric vehicle charging infrastructure development domain from IIM Ahmedabad. His article "India's shift from conventional transport to electric vehicles" was published from world renown "Intelligent Transport" magazine.

Abstract

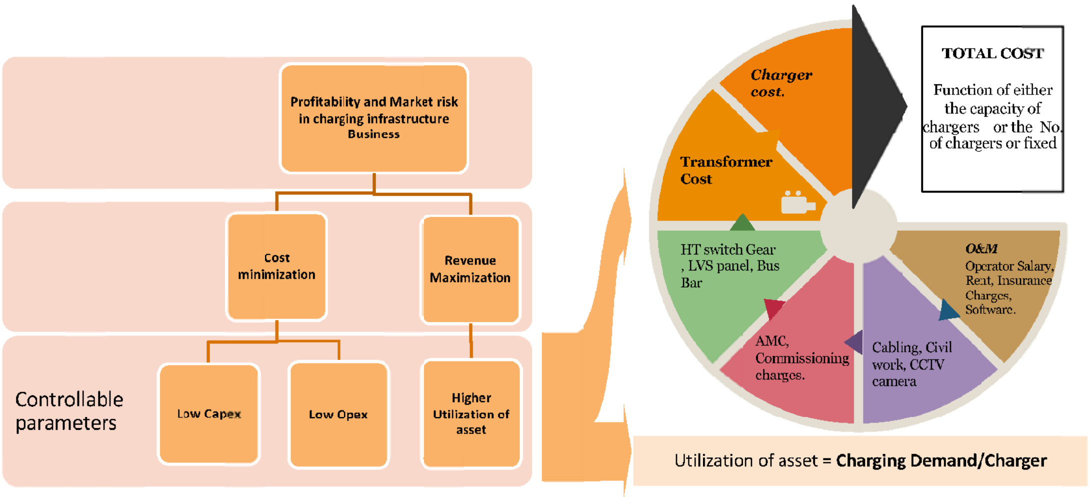
The adoption rate of electric vehicles depends on two major factors- charging infrastructure availability and total cost of ownership (TCO) of vehicles. Recently released Electric Vehicle policies of the states of Delhi and Kerala have identified the importance of charging infrastructure development as the prime requirement for fast adoption of electric vehicles and have proposed extending various incentives for installation of charging infrastructure. However, the investment in developing the charging infrastructure is constrained due to the market risk involved with this investment, mainly the high upfront capital expenditure, demand risk, and technology obsolesce risks. To manage and decrease these risks, the optimum capital cost of charging asset and best utilization of charging infrastructure of electric vehicles are the most critical factors. The following points may be discussed on the topic- "Charging Infrastructure readiness, evolution & swapping of batteries and changing skill set"

1) Understanding of Charging infrastructure for the electric vehicle. (Evolution, Basic technical details of various types), 2) Current status of the charging infrastructure development in Indian cities vis a vis that of cities in developed countries., 3) Challenges in developing charging infrastructure requirement for Indian cities. 4) Recent research works, which may support in tackling the challenges of developing charging infrastructure requirements.

Electric Vehicle Charging Infrastructure Optimization

SUNIL KUMAR
Sunilmail.ind@gmail.com
7588018261

Charging Infrastructure Investment



Research Objectives

01 Objective: **To find out the optimum number of chargers to be installed at charging location that would minimize the charging infrastructure cost.**

02 Objective: **To find out the optimum capacity of chargers to be installed at charging location that would minimize the charging infrastructure cost.**

03 Objective: **To find out the affect of charging infrastructure cost on the total cost of ownership.**

04 Objective: **To find out the optimal location to install charging infrastructure to maximize the asset's utilization**

Electric Bus:

Electric Cars:

Research Methodology: Electric bus and Electric Car

Secondary Research- Identification of research gap

Data Collection and analysis –

Navi Mumbai Municipal Transport (NMMT), City and Industrial Development Corporation of Maharashtra (CIDCO)

Primary Research –

Personal Interview, Survey

Model Formulation and Validation-

Mixed Integer Linear Programming (MILP) model & GIS modelling

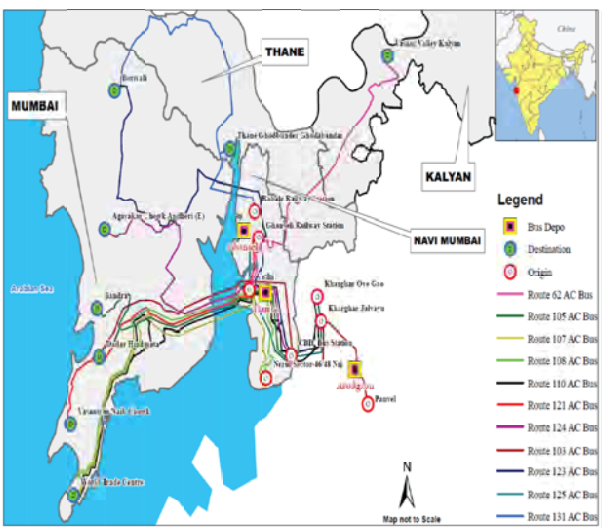
For reference of my work-

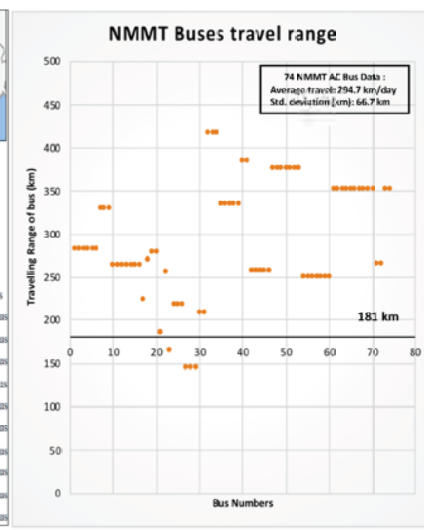
https://www.intelligenttransport.com/transport-articles/73491/india-framework-electric-vehicle/ - Article Published in "Intelligent Transport Magazine, U.K"
https://web.iima.ac.in/faculty-and-research/research-and-publication.html&rnpid=14596 - Working paper published - W. P No. 2018-12-01
https://web.iima.ac.in/faculty-and-research/research-and-publication.html&rnpid=14597 - Working paper published - W. P No. 2018-12-02
https://web.iima.ac.in/faculty-and-research/research-and-publication.html&rnpid=14598 - Working paper published - W. P No. 2018-12-03

Secondary research outcome and research gap: Electric Bus

- Low travel range of Electric bus (181 km).
- Higher battery capacity higher cost of bus.
- Long recharging time of electric bus.
- Overnight and opportunity charging.
- Energy requirements of the buses at bus stop = f (specific energy consumptions (kWh/km), state of charge (SOC))
- Charger requirement at any bus stop= f (Idle time at bus stop, energy requirement of bus, Availability of next charging station

Data Collection and Analysis : NMMT, Navi Mumbai





Mixed Integer Linear Programming (MILP) model development: Opportunity Charging

1 Phase 1 — One bus, multiple bus stop, one trip
2 Phase 2 — One bus multiple trip
3 Phase 3 — Multiple buses Multiple trips

$$Minimize \ \sum_i \sum_t Z_{it} C_t$$

Subject to:

$$EP_{inb} \le \sum_t Z_{it} P_t K_{inb} \qquad \forall\, i \in I,\ n \in N, b \in B$$

$$EB_{inb} = B\_cap \qquad \forall i = 1, n = 1, b \in B$$

$$EB_{inb} = EA_{i-1nb} - E_{i-1nb} \qquad \forall\, i > 1, n \in N, b \in B$$

$$EA_{inb} = EB_{inb} + EP_{inb} \qquad \forall\, i \in I,\ n \in N, b \in B$$

$$EB_{inb} = EA_{In-1b} - E_{In-1b} \qquad \forall\, i = 1, n > 1, b \in B$$

$$EA_{inb} \le B\_cap \qquad \forall\, i \in I,\ n \in N, b \in B$$

$$EB_{inb} \ge B\_low \qquad \forall i > 1, n \in N, b \in B$$

$$Z_{it} \in \{0,1\} \qquad \forall\, i \in I,\ t \in T$$

Set

- I: Set of bus stop numbers, indexed by i
- N: Set of trip numbers, indexed by n
- B: Set of bus numbers, indexed by b
- T: Set of charger types, indexed by t

Parameters:

- C_t: Cost of charger type t
- P_t: Power rating of charger type t (kW)
- K_{inb}: Idle time of bus b at station i in trip n
- E_{inb}: Energy required/lost by bus b in traveling from bus stop No. i-1 to i in trip n
- B_cap: Rated capacity of the battery (324 kWh = 19,440 kW-minute)
- B_low: Reserve capacity of the battery (20% of 324 kW)

Decision Variables:

- Z_{it}= 1 If charger type t is installed at station i, 0 Otherwise

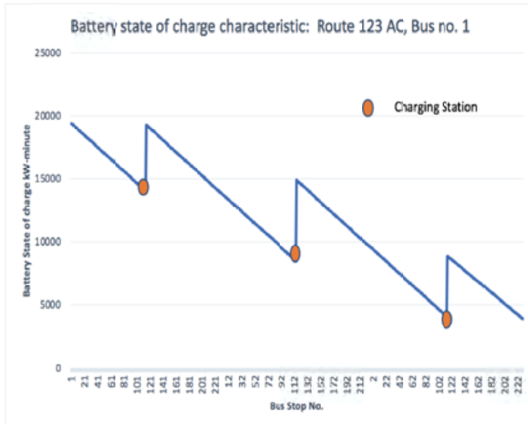
Auxiliary Variables:

- EP_{inb}: Energy powered to the battery of bus b at station i in nth trip
- EB_{inb}: Energy level of the battery of bus b just before arriving at stop i in trip n
- EA_{inb}: Energy level of the battery of bus b just after leaving stop i in trip n

Results: Opportunity Charging

Input parameter for 123 AC route: 25 Charger types (From 20-500 kW), Total 7 buses- 2 buses 3 trips and 5 buses 2 trips,116 station between origin and destination.
Solved Using- AMPL software, cplex solver 12.8, in MacBook Air laptop with 1.6 GHz Intel Core i5 processor, and 8 GB of RAM under a Mac OS version 10.12.6.

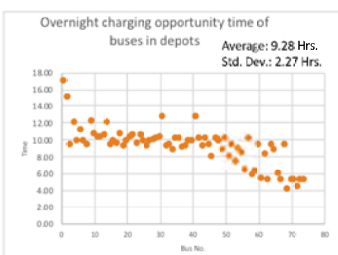
Route 123 AC

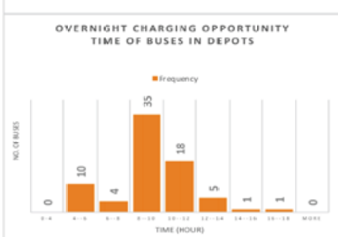


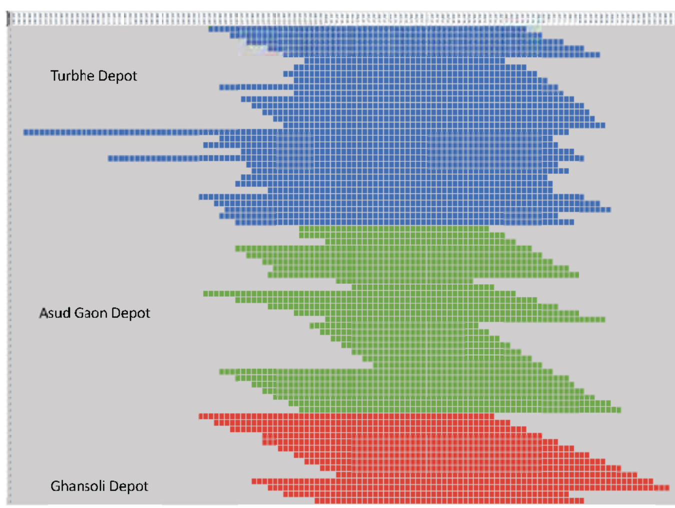
Opportunity Charging Output for 12 routes of Navi Mumbai Buses

Route	No. of Chargers required at origin station	Charger capacity(kW) required at origin station	No. of chargers required at destination station	Charger capacity(kW) required at destination station
123 AC	0	0	1	220
125 AC	0	0	1	160
131 AC	0	0	1	260
105 AC	0	0	1	300
107 AC	1	40	1	60
108 AC	1	100	0	0
62 AC	1	140	0	0
110 AC	1	80	0	0
121 AC	0	0	1	40
103 AC	1	340	1	300
114 AC	0	0	0	0
124 AC	0	0	1	20

Depot Charging: Data analysis and Primary research







Mixed Integer Linear Programming model development: Depot Charging

$$Minimize \sum_t \sum_c C_t Y_{tc}$$

Subject to:

$\sum_t \sum_c \sum_s X_{btcs} = 1$	$\forall b \in B$
$\sum_b X_{btcs} \leq 1$	$\forall t \in T, c \in C, s \in S$
$X_{btcs} \leq Y_{tc}$	$\forall b \in B, t \in T, c \in C, s \in S$
$ST_{tcs} = \left(\frac{E}{P_t}\right) \cdot \sum_b X_{btcs}$	$\forall t \in T, c \in C, s \in S$
$SA_{tcs} = \sum_b X_{btcs} \cdot A_b$	$\forall t \in T, c \in C, s \in S$
$SD_{tcs} = \sum_b X_{btcs} \cdot D_b$	$\forall t \in T, c \in C, s \in S$
$SS_{tcs} = SA_{tcs}$	$\forall t \in T, c \in C, s \in S \mid s = 1$
$SS_{tcs} \geq SA_{tcs}$	$\forall t \in T, c \in C, s \in S \mid s > 1$
$SS_{tcs} \geq SC_{tcs-1} - (\max(D_b)) \cdot (1 - \sum_b X_{btcs})$	$\forall t \in T, c \in C, s \in S \mid s > 1$
$SC_{tcs} = SS_{tcs} + ST_{tcs}$	$\forall t \in T, c \in C, s \in S$
$SC_{tcs} \leq SD_{tcs}$	$\forall t \in T, c \in C, s \in S$
$\sum_b X_{btcs} \leq \sum_b X_{btcs-1}$	$\forall b \in B, t \in T, c \in C, s \in S \mid s > 1,$
$Y_{tc} \leq Y_{tc-1}$	$\forall t \in T, c > 1$
$X_{btcs} \in \{0,1\}$	$\forall b \in B, t \in T, c \in C, s \in S$
$Y_{tc} \in \{0,1\}$	$\forall b \in B, t \in T, c \in C, s \in S$

Set

B: Set of bus numbers, indexed by b
T: Set of charger types, indexed by t
C: Set of charger numbers, indexed by c
S: Set of slot in the charging sequence, indexed by s

Parameter

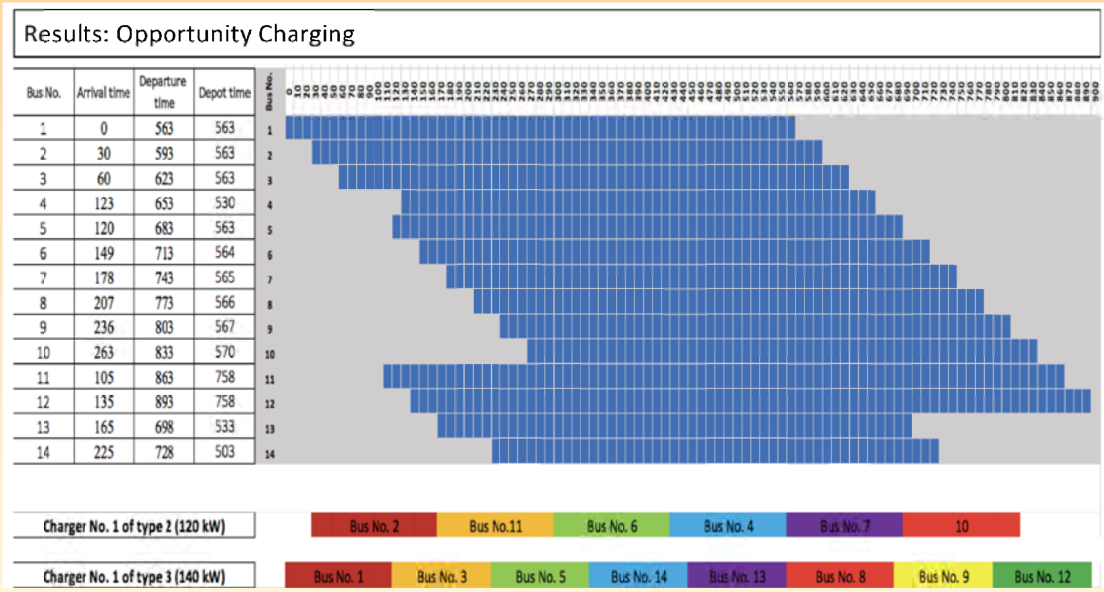
C_t: Cost of charger type t
P_t: Power rating of charger type t
E: Energy to be charged at the depot 15,552 kW-minute (80% of 324 kWh)
A_b: Scheduled arrival time of bus b at the depot
D_b: Scheduled departure time of bus b at the depot

Decision variables

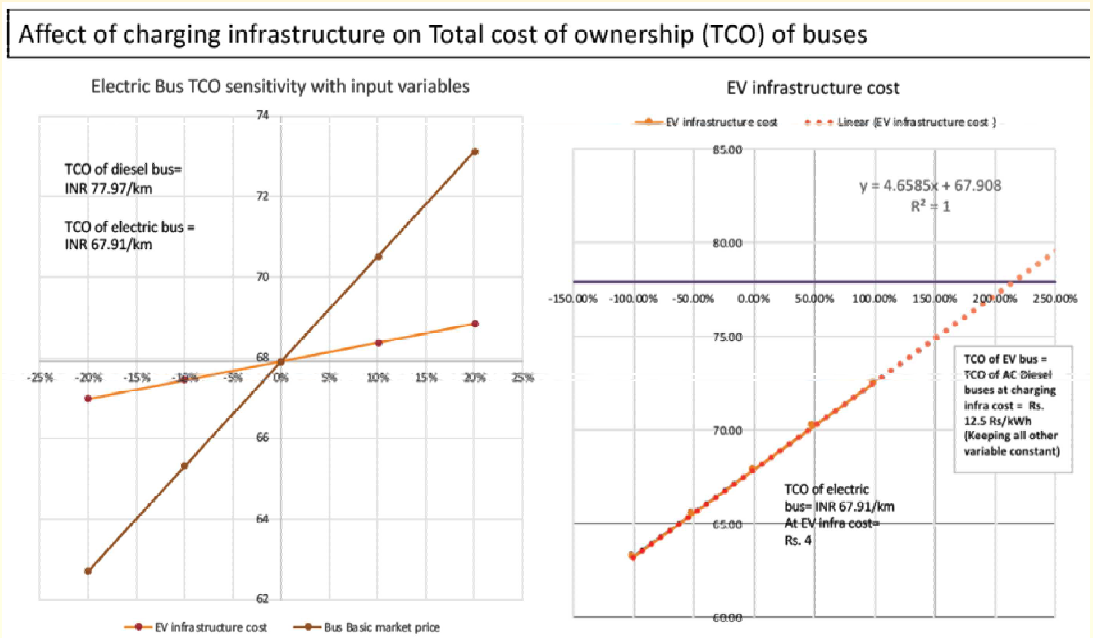
X_{btcs}: = 1 if bus b is charged by charger c of type t in slot s in the sequence, 0 otherwise
Y_{tc}: = 1 if charger c of type t is installed at the depot, 0 otherwise

Auxiliary variables

SA_{tcs} : Scheduled arrival time at the depot of the bus charged by charger c of type t in slot s in the sequence
SD_{tcs} : Scheduled departure time from the depot of the bus charged by charger c of type t in slot s in the sequence
SS_{tcs} : Charging start time of the bus charged by charger c of type t in slot s in the sequence
SC_{tcs} : Charging completion time of the bus charged by charger c of type t in slot s in the sequence
ST_{tcs} : Charging duration of the bus charged by charger c of type t in slot s in the secuence



Bus No.	Arrival time	Departure time	Depot time
1	0	563	563
2	30	593	563
3	60	623	563
4	123	653	530
5	120	683	563
6	149	713	564
7	178	743	565
8	207	773	566
9	236	803	567
10	263	833	570
11	105	863	758
12	135	893	758
13	165	698	533
14	225	728	503



Electric Cars

- Home Charging -50-80 %.
- Office or workplace charging -20 %.
- Public Charging: very small share -5%
- Intercity corridor charging: Only in developed market. Location optimization not required
- Commercial vehicle charging demand depends on its travel pattern.
- GIS system enables to combine geographical data with non spatial data.

Data Collection : NMMT, Navi Mumbai

Data Source:

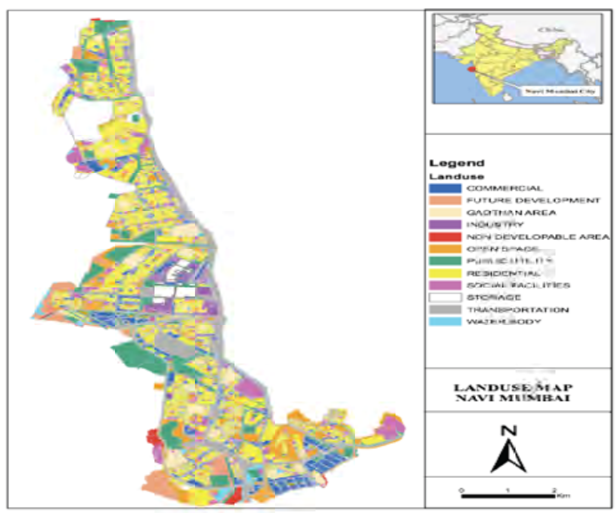
1) Land use data : CIDCO
2) Demographic Data :CIDCO

Study Area-

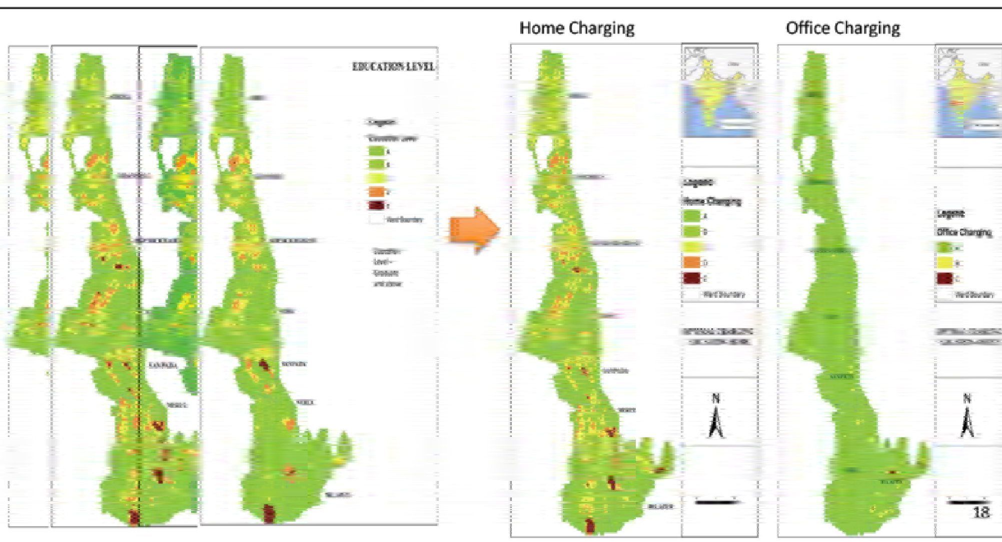
•Seven residential and commercial wards of Navi Mumbai.

•Grid Size- 100m*100m

*It is assumed that demographic ratio did not change with time.



Home and office Charging: Methodology and Results



Conclusion and discussion

Sl. No.	Project objectives	Applicability
1	Allocation of the charging infrastructure in the city.	1) Installing the charging infrastructure at suitable location to lower risk involved for long term. 2) More accurate assessment of demand would provide decision making easy for investment.
2	Optimization of bus charging infrastructure.	1) Higher profitability through optimizing/decreasing infrastructure cost.
3	Total cost of ownership analysis.	1) Decreasing total cost of operation for bus operator, resulting increase in profitability and therefore early transition from conventional to electric vehicle.

Presentation by Shri Vivek Mishra, Executive Director, Meghraj Capital Advisors Pvt. Ltd.

Profile

Vivek Mishra, an Electrical Engineer with Masters in Finance and a Cost Accountant from Institute of Cost Accounts of India, has more than thirty years of consulting, regulation and operational experiences in Generation, Transmission and Distribution of Power Sector. He has also worked in Renewable Energy and Energy Access space. Vivek has worked in the related areas of Policy, Regulations, Reforms, Transactions, Procurement, Strategy, Commercial Agreements and Business Processes structuring Vivek apart from India has also worked in in Nepal, Sri Lanka, Maldives, Bangladesh, Uganda and Solomon Islands. Vivek is presently Executive Director with Meghraj Capital Advisors and previously he has worked in various capacities with Mercados-EMI, KPMG, MPERC, UPERC, UPSEB and GAIL.

Abstract

In the presentation emphasis has been placed on notifying a regulation which comprehensively addresses the tariff and other regulatory issues so that various commercially feasible and competing business models are facilitated. This will help in the quick development of charging stations in the state as envisaged in the policy issued by MoP. The regulation may clearly state that both public and private charging stations can source power from the grid either from the incumbent Distribution Licensee or third party sources. The Charging Stations may be permissible under the off-grid mode as well. The regulation may facilitate bilateral exchange for Charging stations sourcing power from RE Sources with the grid either under banking or net metering arrangement. The presentation proposes the standards to be followed while permitting interconnectivity with the grid and the safety standards to be adhered. The presentation also indicates the tariff principles and the tariff structure that can be adopted for determination of tariff for grid connected charging stations. The last section of the presentation proposes the contractual framework for RE connected Charging Stations.

MEGHRAJ

Meghraj Capital

Investment Banking || Infrastructure Consulting

Technosphere of EVs, Charging Infrastructure, Power Demand Estimation & Pricing Issues - Tariff, pricing & regulatory intervention

February 04, 2019

Vivek Mishra

Infrastructure Consulting Services

- Infrastructure consulting
- Offices in Mumbai, Ahmedabad, Delhi & Nairobi
- Range of services for private companies, governments and development finance institutions
- Team with experience of international projects

- Meghraj Capital Advisors is an infrastructure consulting firm operating from offices in Mumbai, Delhi and Nairobi
- We offer infrastructure-related management consulting services to clients that include **private sector companies, central governments, state governments and development aid agencies** including Asian Development Bank, World Bank, USAID, DFID, GIZ as well as UN organisations which include UNDP, UNIDO and UN-Women
- In addition to India and Kenya, we are working on international assignments **in Afghanistan, Bangladesh, Malaysia, Nepal, the Maldives, the Caribbean, Oman and Uganda**
- We have **completed more than 165 assignments** for clients, and pride ourselves on the level of **repeat business** we win:
  - Multiple assignments for Asian Development Bank, DFID, and World Bank

Infrastructure Consulting Services

Clients include:

- Asian Development Bank
- Department for International Development, UK
- The World Bank
- UNDP, UNIDO, UN Women
- USA Agency for International Development
- Rural Electrification Authority, Kenya
- Ministry of Urban Development, Govt of India
- Shakti Sustainable Energy Foundation
- Chief Minister's Office, Govt of Madhya Pradesh
- Forum of Regulators, India
- Maharashtra Electricity Regulatory Commission
- PwC, Deloitte, India

Sectors

- **Energy**
  - Conventional power
  - Renewable energy
  - Energy efficiency
- **Climate Change and Sustainability**
  - Climate change mitigation
  - Climate change adaptation
  - Monitoring & evaluation
  - Corporate social responsibility
- **Urban Infrastructure**
  - Solid waste
  - Water supply
  - Sanitation
  - Land use
- **Transportation Infrastructure**
  - Roads
  - Airports
  - Ports

Service Offering

- Planning
- Sector Reforms
- Policy Advisory
- Regulatory Advisory
- PPP Advisory
- Private Sector Participation
- Institutional Development
- Organisational Development and Capacity Building
- Market Development
- Programme Management
- Performance Improvement
- Feasibility Study
- Due Diligence
- Monitoring & Evaluation

Contents

Regulation…….more appropriate (1/2)

1. **Scope:**

    1. No license required for setting up the charging station,
    2. New and existing charging stations for charging or swapping the batteries,
    3. Both the grid connected sources(Discom sourced and through open access sourced) and off grid (Captive generation),
    4. All types of Chargers-AC/DC
    5. Both Private charging station and Public charging station are allowed,
    6. Possibility of Bilateral Exchange with grid for own source EV charging Station-Banking/Net Metering/Gross Metering

Regulation…….more appropriate (2/2)

6. Choice of connection for Private consumption:

   Proposition 1: *Separate connection be given for commercial uses of charging station as per the terms and conditions of the Distribution Supply code or prescribed regulations.*

   Proposition 2: *For self consumption, existing connection shall be used; however for consumers with more than 10 kW of sanctioned load may apply for separate EV connection. If existing connection is used for electric vehicle charging then tariff applicable is as per existing connection..*

7. All the electric vehicle charging stations irrespective of own or public consumption above 50kW capacity must be connected at HT level,

8. Business models allowed:

   a) Discom through third party: PPP models (Similar to DF)

   b) Discom on their own: may be required to set up a different entity under the provision of Other Business

   c) Third Party Owned: Any Private party can set up charging stations.

Permissible Sources of Electricity

1. Model A-Grid Connected:

   a) Power from Discoms

   b) Long term/Short term power from Third party Including RE sources

   c) Charging Stations with Integrated Solar Roof top

   d) Captive or Group Captive mode

2 Model B-Off Grid arrangement:

   a) Distributed Generating Stations/Mini-Grids

   b) Charging stations with Integrated Solar Roof top

Technical Framework

1. Technical Standards applicable for EVCS:

The technical standards as defined by BIS, etc.,.

2. EVCS Interconnection to Grid:

The inter-connection with the Discom's electrical system shall comply with the CEA (Technical standards for connectivity of the distributed generation resources) Regulations, 2013,

3. Metering

1. Adhere to the standards and provisions specified in the CEA (Installation and operation of meters), Regulations 2006 Installation & operation of meters shall be in conformity with relevant Regulations notified by CEA.
2. Allow meters capable of net metering at charging stations meant for public consumption or RE based charging stations.

4. Safety Measures

The equipment to comply with the CEA(Measures of safety and Electrical Supply) Regulations, 2010 .

Operational Framework (1/3)

1. **Tariff determination principles :**

    1. Appropriate amendment in tariff schedule for personal/captive charging (including allowing charging for non-commerical use),
    2. Tariff determined for single point of delivery for Discom sourced charging station (Owned by either Discom or Third party), which can be both prepaid and post paid,
    3. Tariff for the Charging station as MoP directive,
    4. Sourcing power through open access, existing UPERC (Terms and Conditions for Open Access) Regulations, 2004, ***Proposition**: Provision for exemption of transmission charges, wheeling charges, surcharges for power Sourced from RE Generation, Permit open Access for requirement less than 1 MW*
    5. **Tariff Structure:** Tariff structure applicable for separate connection:
        1. Tariff to be two part: Demand charge (kVA or kW) and energy charge---greater leeway for demand variation.
        2. ToU component to be included to mitigate Grid impact (peak demand charging).
        3. Tariff at LT to be certain % higher than at HT level

Operational Framework (2/3)

2. **Tariff determination principles applicable for supplying power to grid by charging stations:**

    ***Tariff Structure:** Irrespective of the time of discharge to the grid, flat preferential tariff to be applicable.*

    ***Proposition 1**: Provision for banking of RE during over supply and draw back during under supply*

    ***Proposition 2:** Allow discharge of not more than a predefined % of the electricity drawn from grid*

    ***Proposition 3**: Allow discharge during peak and off peak session of not more than that consumed during the respective peak , off-peak session during billing cycle. Or*

3. The cost for inter-connection with the interconnection point -borne by charging station.

Operational Framework (3/3)

4. Discom to plan for network roll out and extension as per the priority for roll out EV Public Charging Infrastructure decided as per MoP Guidelines
5. The Cost of Network development and extension to be either through tax or rate payer
6. Detailed Guidelines and procedure (along with appropriate timelines) for providing service connections to be developed,
7. Technical restrictions on providing connections to Public/Private Charging Stations to be specified
8. For the Off grid based electric vehicle charging station as mutually agreed.

Commercial Framework (1/2)

1. Renewable Purchase Obligation

Applicable for Renewable energy based charging stations

1. ***Proposition 1***: *The existing UPERC (Promotion of Green Energy through Renewable Purchase Obligation) Regulations, 2010 and amendments thereof applicable.*
2. ***Proposition 2***: *The Renewable Purchase Obligation and relevant clauses in UPERC(Promotion of Minigrid Renewable Energy Generation and Supply) Regulations, 2016 and amendments thereof applicable for Electric Vehicle charging station or battery swapping station with RE based captive generation plant.*

2. Renewable Energy Certificate Mechanism

Applicable for Renewable energy based charging stations

1. The applicability of the REC shall be regulated in accordance with the CERC(Terms and Conditions for Recognition and issuance of Renewable Energy Certificate for Renewable Energy Generation)Regulations, 2010 and amendments thereof. (And)
2. The existing UPERC (Promotion of Green Energy through Renewable Purchase Obligation) Regulations, 2010 and amendments thereof applicable.

UPERC – Uttar Pradesh Electricity Regulatory Commission
CERC – Central Electricity Regulatory Commission

Commercial Framework (2/2)

3. Energy Accounting and settlement

Applicable for energy transactions between charging station and Discom

1. The billing cycle shall be monthly basis for post paid electricity connections.
2. The charging station with RE based captive generation plant shall raise invoice against the electricity injected into the grid at the interconnection point during the billing cycle and the same shall be reimbursed by the Discom at applicable tariff as per the terms of PPA.
3. The Discoms shall raise invoice against the net electricity consumed by the charging station installed for public consumption and aggregator of fleet of electric vehicles during the billing cycle and the same shall be paid by the respective entities as specified by the UPERC.

3. **Power Purchase Agreement-**For Banking, Gross and Net Metering arrangement
4. **Data Base**-Information to be provided by the charging stations and the date base to be maintained by the Discom to be specified

Presentation by Shri Sushovan Bej, Consultant, Ernst and Young LLP

Profile

Tanmay Nag, part of Ernst and Young's Renewables and Electric mobility team has been working with central governmental organizations on technological aspects of electric mobility including EV charging standards and possible policy frameworks for promotion of EVs in India.

Prior to EY, he also has a prior experience of working on Electric vehicles, as a part of his under-graduation. His work titled 'Small Scale Electric Vehicle Public Transport (SSEPT)' focusing on developing micro-mobility solutions was recognised for research by Technical University of Germany. Tanmay is a recipient of Finolex Founder Shri P.P. Chhabria Award for Social Contribution.

Abstract

The presentation briefs on the projection of electric mobility ecosystem including electric vehicles, charging infrastructure and the associated energy requirements. It further suggests ways for government to play a facilitative role to promote electric mobility at the state and central level.

Electric Vehicle Charging Infrastructure in India: How can the Government play a facilitative role?

Considerations and way forward

Conference on **'Technosphere of EVs, Charging Infrastructure, Power Demand Estimation & Pricing Issues'**

04 February 2019, Lucknow

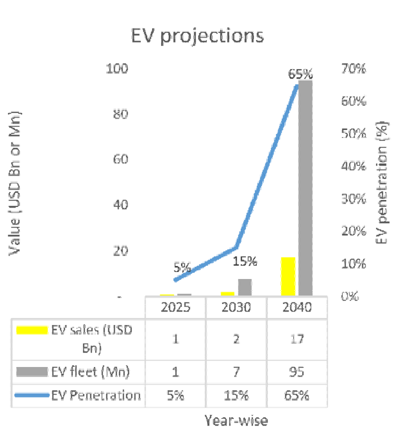
The better the question. The better the answer.
The better the world works.

EY Building a better working world

Support for public charging infrastructure to precede EVs and a clear government intention for private sector uptake have been a key growth driver for EV adoption globally

Country	Key Policy levers for electric mobility market proliferation							
	EV Policy	Tax Holidays	Unregulated Tariff	Utility Involvement in deployment	EV Purchase Incentives	Incentives for Public charging infra	Time of Use Tariff	Indirect Incentives (Access to reserved lanes)
California	✓	✓	✓	✓	✓	✓	✓	✓
China	✓	✓	X	✓	✓	✓	✓	✓
Japan	✓	✓	X	✓	✓	✓	✓	✓
Germany	✓	✓	✓	✓	✓	✓	✓	✓
Finland	X	✓	✓	✓	X	✓	✓	X

Electric mobility disruption presents a $27Bn capital investments opportunity by 2030, with an estimated $11Bn* in revenue to power utilities



Infrastructure projections and investment required

Parameter		2025	2030	2040
Home chargers	Quantity (Mn)	1	7	85
	Investment ($ Bn)	0.5	4	54.5
Superchargers	Quantity (Mn)	0.02	0.1	1
	Investment ($ Bn)	0.7	5.1	50
Destination chargers	Quantity (Mn)	0.04	0.2	3
	Investment ($ Bn)	0.09	0.7	8.2

Plant & Factory projections and investment required

Parameter	2025	2030	2040
Vehicle plants ($ Bn)	1	4	40.2
Giga-factories ($ Bn)	2	10	100.5
Service Centers ($ Bn)	0.7	4	50

Benefit to Power Utilities

Parameter	2030
Electricity demand from EVs (Twh)	69.6
Expected revenue from electricity demand from EVs ($ Bn)	11

Source: Morgan Stanley and *EY Analysis

EY

Indian electric mobility market is at a nascent stage; however state policies and public transport tenders are set to accelerate growth in the market

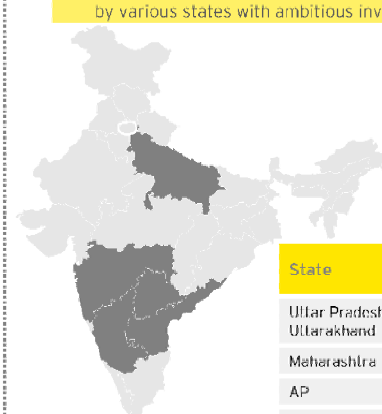
India has a sizable stock of e-3W and e-2W; with growth expected in public transport and logistics segments

- 6,800 e-cars
- 0.4m e2Ws
- 1.8m e-rickshaws

The numbers are certainly miniscule compared to the overall automotive fleet in India

States	Target for buses
Uttar Pradesh	100% by 2030
Delhi	1,000 by 2019, 50% by 2023
Telangana & Maharashtra	300 each by 2019
Andhra Pradesh	100% by 2029
Karnataka	100% by 2030

Market acceleration is expected on account of EV policies by various states with ambitious investment targets



State	Investment target
Uttar Pradesh and Uttarakhand	Private investments
Maharashtra	25,000 Cr
AP	30,000 Cr
Karnataka	31,000 Cr
Telangana	30,000 Cr

Source: SMEV, SIAM, EY analysis

Support for public charging infrastructure to precede EVs and a clear government intention for private sector uptake have been a key growth driver for EV adoption globally

Country	Key Policy levers for electric mobility market proliferation							
	EV Policy	Tax Holidays	Unregulated Tariff	Utility Involvement in deployment	EV Purchase Incentives	Incentives for Public charging infra	Time of Use Tariff	Indirect Incentives (Access to reserved lanes)
California	✓	✓	✓	✓	✓	✓	✓	✓
China	✓	✓	X	✓	✓	✓	✓	✓
Japan	✓	✓	X	✓	✓	✓	✓	✓
Germany	✓	✓	✓	✓	✓	✓	✓	✓
Finland	X	✓	✓	✓	X	✓	✓	X

National-level facilitation and city-level coordination will be necessary for realizing availability and accessibility of reliable public charging infrastructure

Electric Mobility

EV Charging Infrastructure

- Requires an availability of accessible and affordable locations
- Requires an availability of grid and power infrastructure
- There is currently no existing business case for public charging infrastructure

Electric Vehicles

- Private sector/OEMs have in place robust business cases to integrate EVs into their product portfolios

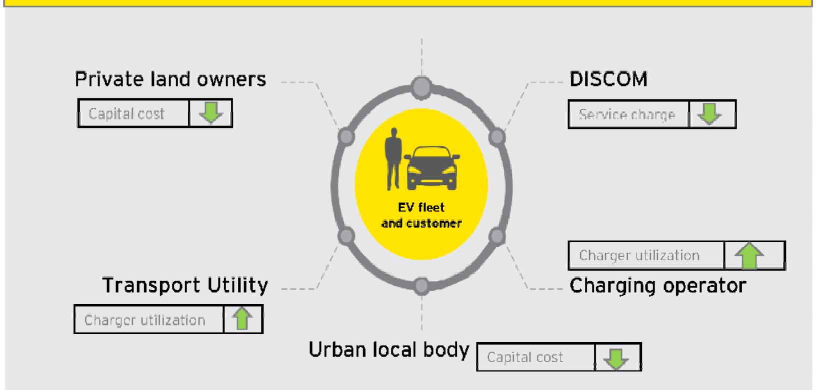
Dependent on **collaborations** between **City Municipalities, Distribution Licensees and OEMs of Charging Infra OEMs**

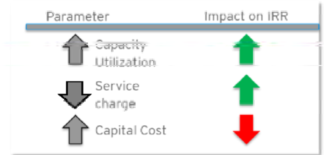
Dependent on **Government Initiatives** for improving utilization of chargers

Source: EY Analysis

In India, development of EV charging infrastructure will initially require a city-led bottom-up approach led by private investors

City-level partnerships have the potential to reduce cost to consumers, capital cost and increase charger utilization





- Accessible space is a major cost component for charging station operators that can be optimized through city-level collaborations and can enhance overall business viability and timeliness of deployment.
- Collaboration and an integrated project preparation at the city-level is the key to reduce overall expenditure and achieve efficacy of public procurement.

Short to long-term adoption of charging infrastructure type will evolve differently across vehicle segments in India

Category	Segment	Short Term (2018-19)	Medium term (2020-22)
3Ws (Auto rickshaw and e-auto)	Fleet	Slow charging	Battery swapping / Fast charging / Range extension
E-buses	Fleet	Slow charging/ Fast charging	Battery swapping / Fast charging
Cars (4 Wheelers)	Private	Slow charging	Slow charging / Fast charging
	Fleet	Fast charging	Fast charging
2W	Private	Slow charging	Fast charging / Range extension
	Fleet	Slow charging	Battery swapping / Fast charging / Range extension

Considerable power sector developments at centre and state level are driving charging infrastructure proliferation in India

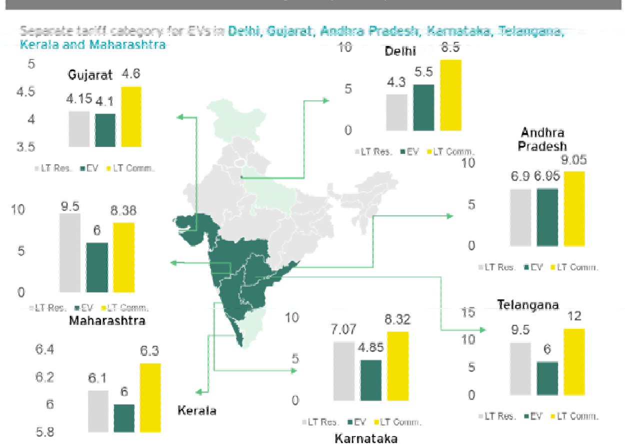
Central level developments

1. Charging of batteries of electric vehicles through charging stations **does not require any license** under the provision of electricity act 2003*
2. CEA includes **charging stations in "Technical standards for connectivity of the distributed generation resources" regulations, 2013** and "Measures relating to safety and electric supply" regulations, 2010 thereby increasing prospects for V2G technology

Draft amendments to Tariff Policy 2016:

- Tariff shall be less than or equal to the average cost of supply determined based on AT&C loss level of 15% or actual, whichever is lower
- **single part tariff** for this purpose in the initial 3 years

State level regulatory developments



Source: https://powermin.nic.in/sites/default/files/webform/notices/Clarification on charging infrastructure for Electric Vehicles with reference to the provisions of the Electricity Act 2003.pdf

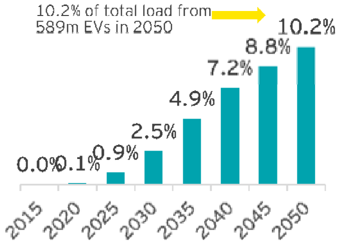
Growing EVs will have an impact on the electricity load, but definitely in the realm of being managed by the present regulatory and future technology infrastructure

Generation

Electrification of transport will bring new load to the system, coinciding with increasing deployment of renewable capacity connected to the grid.

Percentage of electricity demand attributed to growing EVs, India

10.2% of total load from 589m EVs in 2050



Network

Load fluctuations:

- EV charging can cause grid frequency fluctuations
- Can be tackled if time of charging is optimized through time-of-use charging incentives

Need for grid re-enforcements:

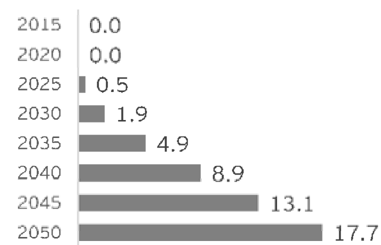
- Grid are the critical link to integrate EV demand and require capex investment to modernize the grid
- Smart grid will help with multiple aspects of EV integration:
  - Smart Charging
  - Demand response and V2G
  - Data analytics

Retail

Behind-the meter storage capabilities

By 2050, EVs on road will provide total energy storage* capacity of an estimated **17.7TWh** in India

India's total energy storage capacity from EVs on road (in TWh)



Utilities can adopt new business models to tap new opportunities arising from increased electricity demand through EV charging

1 Install and maintain model
Utilities can install and maintain the public EV chargers while the participants like housing complexes or shopping malls will own and operate them.

4 Subscription model
Utilities can own and operate charging infrastructure in this model. They can charge a subscription fee from customers for using their charging facility.

2 Build, own and operate model
Utilities could build, own and operate the charging stations and offer customers the facility to charge their EVs at special rates

5 Pay per use
Utilities will own the infrastructure but third party will build, operate and maintain the stations. Third party shall share revenue as per the footfall

3 Own and operate model
Utilities can own and operate the charging infrastructure which is built by a third party.

6 Cloud services
Utilities can provide IT services to customers who own EV fleets to help them better manage their network.

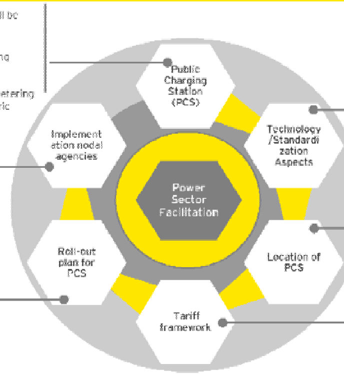
The Government has to play a facilitative role to develop a technology-agnostic and transparent charging infrastructure market for crowding-in private sector capital in India

Ministry of Power taking an active stance to facilitate the sector announced guidelines to set up charging infrastructure in India

- Setting up PCS will be a de licensed activity and anyone will be free to set up charging stations
- Allowed electricity through open access
- Existing methodologies for providing connection, processing applications, metering and wiring can be facilitated as per guidelines of CEA as mentioned in supply codes, Metring regulations 2006, Functional requirements of Advanced metering infrastructure (AMI), Measures relating to safety and electric supply 2010

- MoP will designate a Central Nodal Agency for the roll-out.
- Every state government will nominate a Nodal Agency for setting up PCS
  - State DISCOM will generally be the Nodal Agency for such purposes

- **Phase I (1-3 years):** All mega cities (+4 mn population).
  - Cities: Mumbai, Delhi, Bengaluru, Hyderabad, Ahmedabad, Chennai, Kolkata, Surat and Pune
  - Corridors: Mumbai-Pune, Ahmedabad-Vadodara, Delhi-Agra, Delhi-Jaipur, Bengaluru Mysuru, Bengaluru Chennai, Surat-Mumbai, Agra-Lucknow, Eastern Peripheral, Delhi-Agra NH-2, Hyderabad ORR
- **Phase II (3-5 years):** State Capitals, UT headquarters



- Technology agnostic approach allowing adoption of any standard as per the requirement of market
- Defined minimum technological requirements and guidelines with mentioned features such as climate control, charging protocol specifications, network management services etc.
- Encouragement of a private sector driven market

- At least 1 charging station in a grid of 3x3 km
- 1 charging station at every 25 km on both sides of road on highways/roads
- Fast charging station at every 200 km and swapping stations at every 100 km on highways for heavy duty vehicles. Within cities such stations shall be located within bus depots, transport Nagars.
- Oil marketing companies will be given preference to set up charging stations
- CEA will create and maintain a national online database of charging stations through DISCOMS

- **Electricity supply to PCS:** Tariff shall be less than or equal to the average cost of supply determined based on AT&C loss level of 15% or actual, whichever is lower
- **Service charge at PCS:** State Nodal Agency shall fix the ceiling of service charges to be charged by PCS
- **Special Tariff Category**: Special tariff category for EV charging has been notified by SERCs of Delhi, Gujarat, Andhra Pradesh, Karnataka, Telangana and Maharashtra

Our recommendations for long-term implementation to focus on encouraging private sector to invest in deployment of public charging infrastructure to enhance customer experience

1. Development of a coherent roadmap for electric mobility transition to provide policy and demand clarity to investors
2. National Service Providers (NSPs) to be created for data management and visibility to DISCOMS
3. Technology-agnostic approach should be considered allowing adoption of any charging standard as per market demand
4. Holistic pre-assessments shall be carried out at city-level for identifying strategic locations considering availability of real estate & reliable power supply
5. Instead of capital subsidies, innovative co-financing or other leveraging mechanisms should be explored to fund charging infrastructure
6. Setting-up of city / state-level EV cell for coordinating inter-department aspects and coordination with the private sector

Source: EY Analysis

EY

Thank You...

Sushovan Bej
Consultant, Electric Mobility & renewable Energy
Sushovan.bej@in.ey.com
+91 901 366 8048

EY

Appendix

The better the question. The better the answer.
The better the world works.

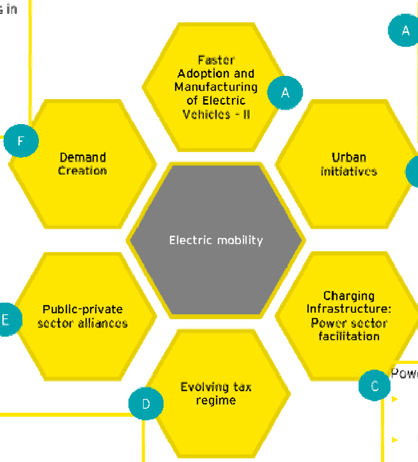
EY
Building a better working world

Six key initiatives FAME II, Urban facilitation, Power sector facilitation, Evolving tax regime, Public private sector alliances and Demand aggregation are attributed for the current offtake of Electric mobility in India

India has witnessed four demand aggregation models in the electric mobility sector -

- EESL led demand aggregation
- PSU & city administrators led
- Private sector led
- City-led under FAME program

- Tata Power and Mahindra collaborated with the Government of Maharashtra to deploy EVs and EVSE in the state.
- PGCIL collaborated with L&T Hyderabad Metro Rail (HMR) to set up charging stations in metro premises.
- FORTUM and IOCL collaborate to set up charging infrastructure in Hyderabad.
- Smart-e in collaboration with Kinetic green, DMRC,PhonePe, Rajasthan Electronics & Instruments Ltd (REIL) and Exicom is deploying e-mobility ecosystem in Delhi



A

- The NLMMP targets were supported by fiscal incentives of ₹ 795 crores ($ 114 Mn) through FAME scheme.
- As a part of Government's investments for demand creation, incentives are provided to buyers, which can be availed upfront at the point of purchase.
- The scheme is expected to be renewed as FAME II focusing on city level public sector fleet electrification

B

- To facilitate city level developments three key programs Smart cities, AMRUT and Light house were launched. There are 100 smart cities, 500 AMRUT cities and 1 Light city (Pune) approved by the government.
- Smart cities and AMRUT focus on a holistic development and Light House initiative will focus on a 'Shared', 'Electric' and connected mobility developments in the city.
- MoH&UA notified that Residential and commercial complexes will have to allot 20% of their parking space for electric vehicle charging facilities

C

Power sector entities have taken an active stance in electric mobility -

- Ministry of Power declared EV charging to be a service rather than sale of electricity, facilitating the private sector participation.
- MoP is drafting a policy on charging infrastructure covering technological, regulatory and implementation aspects
- Statutory bodies BEE, CEA, CERC, SERC are enabling the sector by exploring/forming safety provisions, tariff categories, standards, business models etc.

D

Tax initiatives to promote fully electric vehicles:

- GST reduction on Fuel cell vehicles: 28% to 12%
- GST reduction on Li-ion battery: 28% to 18%
- Hybrid vehicles have been kept in the same category as luxury cars and will be taxed at the peak rate of 28% plus a cess of 15%

Source: EY Analysis and News article compilation

EY

Electric mobility is expected to help the Indian power sector realize net cost and revenue benefits

Aspect	Net revenue benefit	Net cost benefit
Supply-side (power utilities)	▸ Higher power demand ▸ Lower cross subsidization ▸ Revenue diversification through development, operations and maintenance of EV charging infrastructure	▸ Higher PLF for thermal plants ▸ V2G technologies can provide grid-balancing support to DISCOMs ▸ Smarter interface between customer and DISCOM to result in lower T&C losses
Demand-side (utility consumers)	▸ Second-life EV batteries for captive and public charging infrastructure ▸ Recycled EV batteries can be used for solar energy storage	▸ Reduced cost of batteries for power back-up ▸ Better integration of distributed renewable generation

- Source: EY Analysis https://www.ey.com/Publication/vwLUAssets/EY ev adoption potential impact in India july 2016/$FILE/EY ev adoption potential impact in India july 2016.pdf

EY

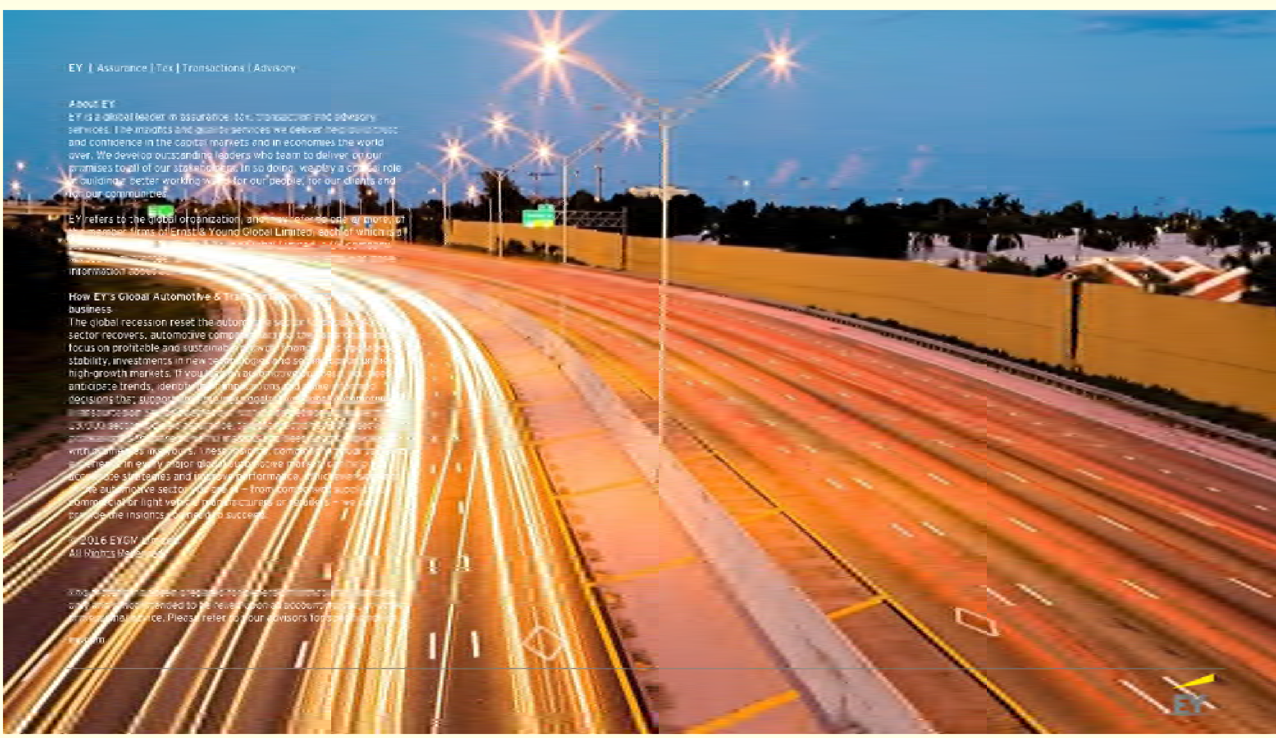
Studies have shown that projected growth in Electric mobility is unlikely to create a substantial adverse impact on the grid in India

With approximately 5000 MW of EV related additional load expected to come on to the system, at the national grid level*, the impact is negligible. This is equivalent to approximately 1.5% of the total current installed capacity (more than 330 GW as on 31 July 2017)

Fast Charging	Slow Charging
▸ Based on EV charging profiles considered; a baseline 50% loaded commercial feeder can safely absorb up to 20% of additional EV load from fast charging. ▸ The residential feeder, can safely handle a ratio of 60%:40% from Residential load and EV load (fast charging) respectively. ▸ However, the peak co-incident charging scenario showed that a loading of around 20% from fast chargers should be the threshold. ▸ This implies that should such high loading conditions occur, the distribution licensees should build resilience by network expansion.	▸ Impact from slow charging on both the feeders was observed to be negligible.

Source: Forum of Regulators - Study on Impact of electric vehicles on the grid; * NEMMP targets- 6 million EVs by 2020

EY



Presentation by Shri Himanshu Chawla

Tariff, Pricing & Regulatory Intervention-Strategic Roadmap

(UPERC)

Presentation by

Himanshu Chawla, Dy. Director (DERC)

New Delhi __January, 2019

WHY ELECTRIC VEHICLES ??

FUEL/DATA	PETROL	DIESEL	ELECTRICITY
Rate	70 Rs./Litre	60 Rs./Litre	7.75 Rs./kWh
FIXING PER MONTH COST OF TRANSPORATION AS RS. 5000/-			
Consumption	71 Ltrs.	83 Ltrs.	645 kWh
Range/Month (kms)	1065	1660	3623

INCREASINGCOSTOFVEHICLE

Source: Paper on Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market *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 15 kmpl for petrol and 20 kmpl diesel.*

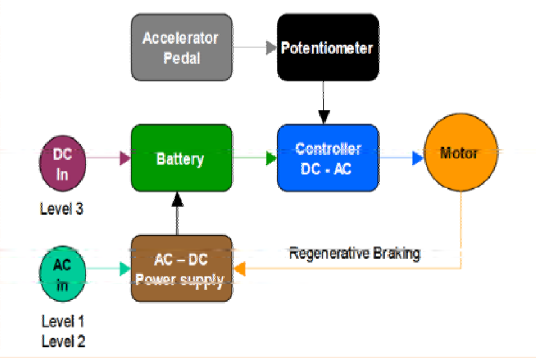
E-VEHICLE CHARGING STATIONS ISSUES BEFORE THE REGULATORS

- INFRASTRUCURAL REQUIREMENTS
- ELEMENTS OF TARIFF
- TARIFF TO CHARGING STATION
- TARIFF TO END USER

INFRASTRUCURAL REQUIREMENTS

INFRASTRUCURAL REQUIREMENTS ...1/2

- Charging infrastructure includes Hardware & Software that ensures ELECTRICAL ENERGY is transferred from GRID TO VEHICLE



EV – Electric vehicle PHEV and BEV

PHEV - Plug in Hybrid Electric Vehicle An electric hybrid vehicle with rechargeable batteries that can be restored to a full charge by connecting to an external power source

BEV Battery Electric Vehicle Vehicle that uses one or more electric motors for propulsion and uses rechargeable batteries as the sole power source

INFRASTRUCURAL REQUIREMENTS ...2/2

- CATEGORISED
  - LOCATION, POWER LEVEL AND CHARGING TIME

PARTICULARS	LEVEL 1	LEVEL 2	LEVEL 3
VOLTAGE	120 V	240 V/208V	DC or 480 V AC
MAX CURRENT	AC upto 12A	AC upto 32 A	400 A
MAX POWER	1.4 kVA	7.7 kVA @ 240V 6.7kVA @ 208V	
CHARGING TIME	15+ Hour	4-6 Hours	15-30 minutes

Source: Paper on **Electric Vehicles – Charging Stands & Infrastructure by Mark Clapper, GE Specification Engineer**

ELEMENTS OF TARIFF

&

TARIFF OF CHARGING STATIONS

ELEMENTS OF TARIFF

- ENERGY CHARGES → Variable Cost of Distribution Licensee
- FIXED CHARGES → Fixed Cost of Distribution Licensee
- TIME OF DAY
- INCENTIVE FOR AUTOMATED DEMAND RESPONSE

EXTRACT OF FOR REPORT – Sept 2017 on EVs

Primary rationale for proposing TOD structure for EV charging is that most generation assets in the country are backed-down during the night lean period. EVs can utilize stranded assets, resulting in capitalizing fixed charges paid by the distribution licensees to generators.

FORUM OF REGULATORS

EXTRACT OF REPORT ON EVs

*" Except for Maharashtra and Delhi, none of the Regulatory commissions have set-up a separate EV charging category. EV tariff proposed in **Maharashtra is same as that of the commercial sector tariff** and a **flat rate of INR 5.50 per unit** has been fixed for charging stations for e-rickshaw and e-vehicles **by Delhi Electricity Regulatory Commission.**"*

DERC TARIFF ORDER DTD. 31/08/2017

- SEPARATE TARIFF CATEGORY FOR CHARGING OF E-VEHICLES
  - NO FIXED CHARGES to Promote
  - ENERGY CHARGES based on Marginal cost
  - 2.50% DISCOUNT ON ENERGY CHARGES (Supply @ 33/66kV)
  - 4% DISCOUNT ON ENERGY CHARGES (Supply @ 220 kV)
  - Time of Day Tariff → 20% Rebate during OFF PEAK Hours (0300-0900 hrs)

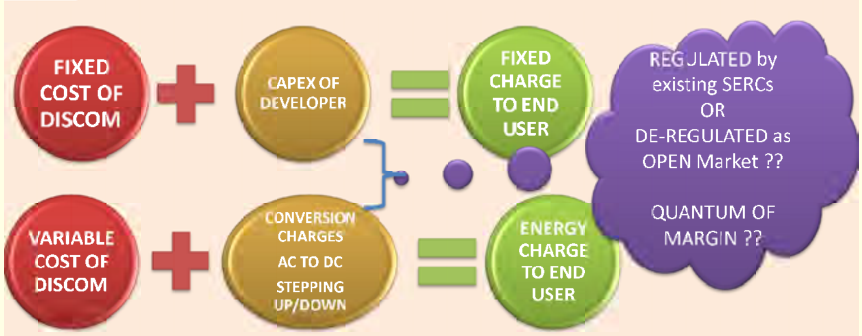
E-VEHICLES CHARGING STATION	FIXED CHARGES	ENERGY CHARGES
SUPPLY AT LT	-	5.50 Rs./kWh
SUPPLY AT HT	-	5.00 Rs./kVAh

TARIFF TO END USER

MODELS FOR E VEHICLE CHARGING STATIONS

- Distribution Licensee - owned EV charging infrastructure
- Distribution Licensee Franchised EV charging infrastructure including Public-private Partnerships

TARIFF TO END USER

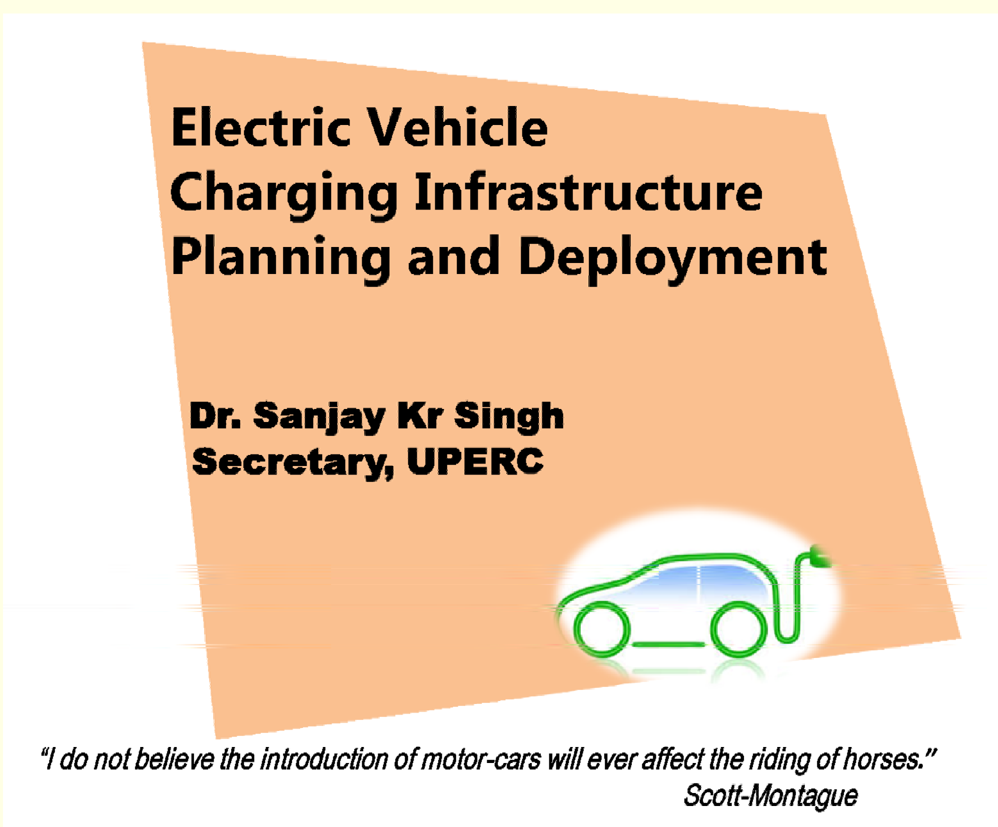


Electric vehicle charging infrastructure planning and deployment Dr. Sanjay Kr Singh, Secretary, UPERC

Profile

Sanjay Kumar Singh, an Electrical Engineer from IIT, BHU with MBA in strategic management from MDI, Gurgaon is a seasoned professional having more than 30 years of experience in the power sector. He has been with power utility for 17 years comprising of 7 years board level experience. He also has 13 years of experience with Electricity Regulatory Commission of Uttar Pradesh there by making significant contribution to the power sector of the State.

Sanjay Kumar Singh also done LLB and Ph.D. in Hindi Literature. Amongst various awards and accolades, he received Gold Medal from Ministry of Personnel, Govt. of India for securing first rank in MBA. His paper on study on Korwa Tribes was adjudged best paper by Anthropological Society of India. He is also a voracious reader.



Introduction

- India through INDC (Intended Nationally Determined Contribution) commits to reduce emission intensity of its GDP by 35%.
- Reduction in Green House gas emissions both from energy & non-energy sectors essential to meet objectives of Paris Agreement.
- Transport Sector accounts for around 23% of global energy related green house gas emissions.
- GoI has committed to completely electrify its public transport by year 2030.
- Department of Heavy Industries (DHI) has come out with EoI in 2017 for availing incentive under "Faster Adoption and Manufacturing of Electric Vehicles" (FAME) for development of multi-modal public transport in million plus populated cities.
- 11 cities have been selected by DHI for allocation of subsidy for implementation of their pilot projects.
- Exemption from acquisition tax, exemption of value added tax, exemption from tolls and ferries, reduced annual road tax, free battery charging at a number of publicly funded charging stations & use of public transport lanes (bus traffic lanes) are kind of policy incentives that Norway has implemented taking its EVs market share to 29% of its total vehicles, which is highest in the world.

Myth of chicken and egg resolved – Now it is accepted that the charging infrastructure needs to be created first so that EV users will have confidence in using EVs.

Key challenges

- It is expected that demand from EV charging infrastructure could equal the demand on existing distribution infrastructure.
- Distribution utilities are still grappling with impact of interruptible variable renewable energy (VRE) sources and addition of a similar load can severely impact the network.
- Land is a major barrier and has been observed as make or break factor for business viability of charging infrastructure operations.
- There is no certainty about growth of EV if faced with competition OPEC decides to slash oil prices

Opportunities

- The peak hours of solar and wind might match with EV charging patterns.
- Power generation with help of Grid connected rooftop Photo Voltaic (GRPV) to cater to demand of EV charging could help address technical losses and stability concerns of distribution utilities.
- With applications such as vehicles to home or vehicle to grid (V2G) that utilizes batteries of EVs as dynamic storage media could result in multiple points of injection of power in distribution network. This can aid grid in enhancing resilience, if the system is designed well.
- Based on various reports, prices of Li-ion batteries are estimated to fall to US \$100 per kWh which hovers around US \$220 as on date. Hence, this will bring parity in cost of conventional vehicles and EVs which will drive consumer preference for EVs even for Heavy Commercial Vehicle Segment.

Adoption trend of electric power trains

- For electrification of powertrains , the vehicle needs to have lower total cost of ownership which includes cost of fuel, maintenance and operations. Further, vehicles with high utilization factor that is higher average running hours in a day or say higher utilization will have ease of transition as EVs have advantage of lower operation costs due to less moving parts and minimal wear and tear.

- Ease of charging at home or offices, in case of 2 wheelers, using a normal socket in 4 to 5 hours makes them easier for adoption. Further the price differential between a petrol two wheeler and its electric counterpart is not wide.

- Fleet of cabs run by aggregators such as OLA and Uber have higher utilization as they cover trips of around 100 km in small cities and 200 km in metros. Apart from fleet of cabs the intra-city buses run by state transport undertakings have similar profiles of communication. Such vehicles with higher utilization and load factors have inherent advantages in shifting to electric power trains.

Taking into account ease of charging, low price differential and utilization factor - two wheelers , three wheelers, corporate & government fleet, cab aggregators and intra-city buses have lower barrier for transitioning to electric power trains.

EV policies of different States

Name of State	EV Policy
Karnataka	▪The Govt. will identify allocate lands wherever for setting up of EV fast charging and battery swapping infrastructure ▪To achieve 100% electric mobility by 2030 in auto-rickshaw, cab aggregators, corporate fleets & school buses. ▪State Transport Corp. to introduce 1000 EV buses during 5 years. ▪Aims to attract investment of Rs.31,000 Crore
Delhi	▪Govt. will be establishing charging point stations based on competitive bidding with up to 100% capital subsidy
Maharastra	▪Common charging points in residential areas, societies, bus depots, public parking areas, railway stations and fuel pumps etc. will be allowed ▪Commercial public EV charging eligible for 25% capital subsidy (subject to Rs.10 lakh /station) for 1st 250 commercial EV charging station. ▪Petrol pumps allowed to set up charging station subject to safety standards.
Andhra Pradesh	▪Providing capital subsidies to automakers and charging equipment manufacturers. ▪Aims to attract investment of Rs. 30,000 crore.
Gujarat	▪Under Formation
Uttar Pradesh	▪1000 EV buses will be introduced by the State by 2030, in phases ▪Government will provide 100% road tax emptions for EVs purchased in UP. ▪Incentive for manufacturing lithium batteries with higher mileage /charge. ▪Also to incentivize manufacturing of hydrogen powered fuel cells and solar powered cells as alternative clean energy source.

ERCs have taken initiative of making EVs a viable proposition by introducing separate tariff category

State	Type	Monthly Fixed Charge	Energy Charge	TOD (no separate analysis)
Karnataka	LT	Rs. 50/kW/month	Rs. 4.85/unit	NO
	HT	Rs. 180/kVA/month		
Delhi	LT	NA	Rs. 5.5/kWh	Above 25 kW, (+)20% on energy charge during peak hours and (-)20% on energy charge during off-peak hours
	HT		Rs. 5/kVAh	
Maharashtra	LT	Rs. 70/kVA/month	Rs. 6/kWh	NO
	HT			
Andhra Pradesh	LT	NA	Rs. 6.95/kWh	6AM to 10 AM & 6 PM to 10PM (Peak) Rs. 8/kWh 10PM to 6AM (Off-peak) Rs. 5.95/kWh
	HT			
Gujarat	LT	Rs. 25/kW/month	Rs. 3.05/kWh	NO
	HT	Rs. 25/kVA/month	Rs. 3/kWh	
Telangana	LT	NA	Rs. 6/kWh	6AM to 10 AM & 6PM to 10PM (Peak) Rs. 7/kWh 10PM to 6AM (Off-peak) Rs. 5/kWh
	HT			
Madhya Pradesh	LT	Rs. 100/kVA/month or Rs. 125/kW/month	Rs. 6/kWh	NO
	HT	Rs. 120/kVA/month	Rs. 5.90/kWh	

- Tariffs are lower than commercial & industrial consumers but slightly higher than domestic consumers so that EV user utilize public and work place charging without burdening the residential infrastructure.
- CPOs could evolve innovative pricing mechanism such as Rs./min, Rs./hr & Rs./ km of charge to avoid benchmarking of prices with residential tariffs.

Higher vehicle utilization, ease of charging and lower price differential drives transition of 2 wheeler and 3 wheeler segments to electric in india

Vehicle	Route predictability	Vehicle utilization	Price differential	Policy interventions	Ease of charging
Two wheeler	Neutral	Neutral	Favourable	Neutral	Favourable
Three wheeler	Favourable	Favourable	Favourable	Neutral	Favourable
Cars & SUVs	Neutral	Neutral	Un -favourable	Neutral	Neutral
SCV	Neutral	Favourable	Neutral	Un -favourable	Neutral
LCV	Neutral	Favourable	Un -favourable	Un -favourable	Un -favourable
M&HCV	Neutral	Favourable	Un -favourable	Neutral	Un -favourable

Neutral | Favourable | Un -favourable

- **For charging of 2 wheelers & 3 wheelers, existing infrastructure can be used .**
- **High power charging technology still not settled and in an absence it takes long waiting time- LCV and M&HCV difficulty in charging.**
- **Higher battery size leads to high price differential but for SCVs FAME subsidy is available.**

Infrastructure assessment of power distribution infrastructure availability & resilience

- Assessment of existing margins in distribution transformer levels
- Load flow analysis
- Access to reliable power
- Existing type of point of connection
- Applicable tariff structure
- Grid integration for vehicle to grid (V2G) implementation
- Renewable power purchase obligation

Variants of EV charging infrastructure

- **Public Charging Stations:** Stations available for public use and are not dedicated to any particular consumer category. Located at highways, parking, shopping zones, fuel stations etc. AC chargers, below 100VDC semi-fast & fast DC chargers are suitable for installation at public charging stations.

- **Private Charging Stations:** Captive charging stations (as deployed by EESL in govt. buildings). These stations are restricted to certain vehicles that are allowed to be parked at residential societies, offices etc. AC chargers, below 100 VDC semi-fast DC chargers can cater to captive charging needs without straining the existing power infrastructure.

- **Fleet Charging Stations:** Charging stations dedicated to fleet charging (OLA/Uber/buses of SRTCs). These stations could be operated at bus depots or dedicated parking locations of fleet operators. AC chargers, below 100 VDC semi-fast DC chargers and fast DC chargers are essential for sustenance of fleet operations.

- **Battery swapping stations:** A battery swapping station is a place where a vehicle's discharged battery can be immediately swapped for a fully charged one, eliminating the waiting period for charging. Swapping is a suitable model for public transport such as in case of 3 wheelers and intra-city buses which ply on fixed routes and for limited trip lengths.

Overview of EV charging infrastructure

- As per norms EV charging infrastructure needs to be deployed every 9 sq. Km in cities and 25 km on highways to enable the EV ecosystem. The charging station deployed at such locations needs to be technology agnostic and have provision for charging any EV and hence should have charging point as per Bharat Charger Specification as well as global specifications such as *ChadeMO (Japanese Standard)* and Combined Charging System(European Standard).

- The operators of charging stations are called Charge Point Operators (CPOs). These operators establish the charging infrastructure and provide all services to end consumers. They arrange land, incur CAPEX for deployment of charging station, pay for energy charges to Discoms and recover all of that from EV users.

Swapping is a strong proposition for Indian transport sector

- Battery swapping could be the silver bullet for India to accelerate adoption of EVs for public transport

- Vehicles operators to procure vehicle without batteries

    - Capital costs could be equal or less than equivalent ICE vehicle costs with enhanced efficiency

- Treat battery ownership, swapping, charging as separate business ensuring

    - Operation costs (cost per km) is no more than that for ICE vehicles

Industry reports estimate about 4.6 crores of EVs on road by year 2030 – 65% of total EVs to be electric 2 and 3 wheelers

SEGMENT	TECHNOLOGY	YEAR		
		2020	2025	2030
Motorcycles & Scooters	Non-EV	10409000	9260000	0
	EV	7352000	14035000	26514000
Auto rickshaws	Non-EV	616000	0	0
	EV	646000	2364000	4072000
Cars & Jeeps	Non-EV	3538000	3932000	0
	EV	26000	1592000	15911000
Total	**Non-EV**	**14563000**	**13192000**	**0**
	EV	**8024000**	**17991000**	**46497000**

Assumptions for calculation of UP centric EV based electricity demand

- ✓ The model developed envisages to forecast demand of power for UP to cater to charging requirement of EVs.
- ✓ **The year on year growth assumed for auto industry has been considered to be 9%, as per industry reports.**
- ✓ It has also been assumed (based on industry reports) that the battery capacity will improve by 10% in each segment for same price.
- ✓ **Considering EV30@30 target, it has been assumed that by year 2030, 30% of total annual sales of vehicles will be electric**

.

- ✓ For forecasting demand of power, cumulative sales of EVs has been considered by adding sales of EVs for current year with total sales till previous year. This has been done as all the vehicles on roads will avail charging services.
- ✓ **To determine the demand of power to cater to charging needs of EV following assumptions has been undertaken**
  - ❑ **All the vehicles need charging at least once in a day.**
  - ❑ **80% of charging requirement is met by slow AC chargers while 20% is met by fast DC chargers for Cars & SUVs and Commercial Vehicles**

Assumptions for calculation of UP centric EV based electricity demand

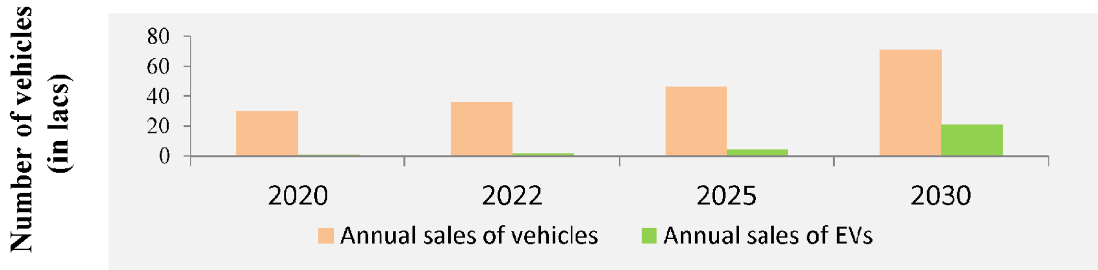
Vehicle Segments	Battery Capacity (in kWh)	Frequency of charging in a day	Hours of charging in a day
Two wheelers	1	1	6
Three wheeler	5.76	1	8
Cars & SUVs	15	1	6
Commercial vehicles	125	1	6

Assumptions on charging behavior across the day

Vehicle segments	6AM to 10AM	10AM to 6PM	6PM to 11PM	11PM to 6AM
Two wheelers	10%	20%	40%	30%
Three wheeler	10%	20%	5%	65%
Cars & SUVs	10%	30%	40%	20%
Commercial vehicles	10%	20%	5%	65%

- Two wheelers are mostly private vehicles and mostly plugged in after working hours for charging
- Three wheelers will require charging during afternoon for top-up to cater to evening traffic of passengers.
- Cars and SUVs are also private vehicles but due to requirement of longer distances to commute will require significant charging for top-up during office hours in parking
- Commercial vehicles will require charging similar to 3 wheelers

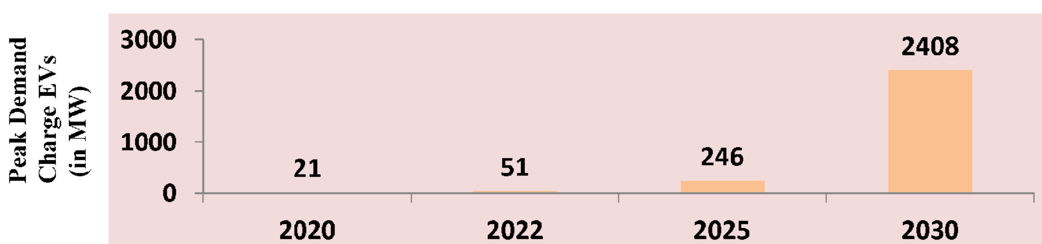
UP may witness sales of 21 lacs EVs, even if only 30% of all vehicle sales in year 2030 is electric



EV segments	2020	2022	2025	2030
Two wheelers	72,112	142,794	277,382	1,600,453
Three wheeler	16,225	26,774	36,984	213,394
Cars & SUVs	1,803	8,925	51,778	298,751
Commercial vehicles	-	-	3,698	21,339
Total Electric Vehicle Sales	**90,140**	**178,492**	**369,843**	**2,133,937**
% of total vehicle sales	**3%**	**5%**	**8%**	**30%**

30% has been considered taking a conservative approach to Niti Aayog's model of transformative scenario of 100% public fleet and 40% private fleet transition to Electric.

It has been estimated that with 30% sales of EVs in year 2030 a demand of 2,408 mw will be required to be met which is about 15% of current demand of 16,400 Mw

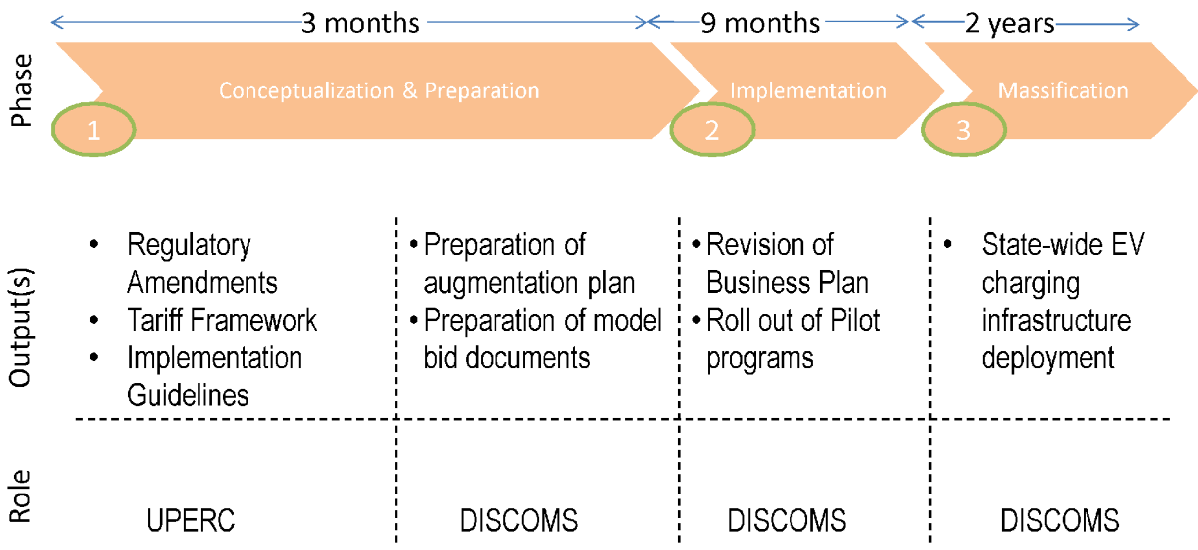


EV segments battery capacity	2020	2022	2025	2030
Two wheelers (kWh)	83,479	182,245	409,820	3,017,893
Three wheeler (kWh)	108,187	196,826	314,739	2,317,745
Cars & SUVs (kWh)	31,308	170,862	1,147,495	8,450,094
Heavy vehicles (kWh)	-	-	682,954	5,029,733
Total annual battery capacity addition (MWh)	**222**	**549**	**5,613**	**18,815**

Analysis shows that peak demand for charging EVs will be during night hours

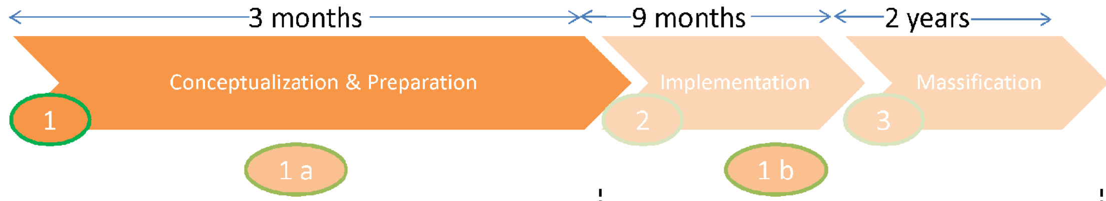
Time Slot	2020	2022	2025	2030
6AM to 10AM	0	0	86	787
10AM to 6PM	13	37	186	1790
6PM to 11PM	15	46	216	2017
11PM to 6AM	21	51	246	2408
Peak demand of the day (MW)	21	51	246	2408

Charging infrastructure for EVs needs phase-wise approach to plan and scale the infrastructure judiciously



As-is assessment of regulatory framework and distribution network are to be undertaken in first phase

Phase



Activitie(s)

1 a

- Review of EV chargers and their applications
- Assessment of supply code and standards for grid connectivity
- Assessment of regulations
- Development of business models
- Determination of tariff
- Industry consultation
- Workshops for sensitization

1 b

- Assessment of existing distribution infrastructure
- Load flow analysis at select nodes
- Develop analytical models for DISCOM
- Identification of locations for deployment
- Preparation of Business Plan
- Consultation and collaboration with industry and other govt. agencies for pilot study

Output(s)

1 a

- Regulatory Amendments
- Tariff Framework
- Implementation Guidelines

1 b

- Preparation of augmentation plan
- Preparation of model bid documents

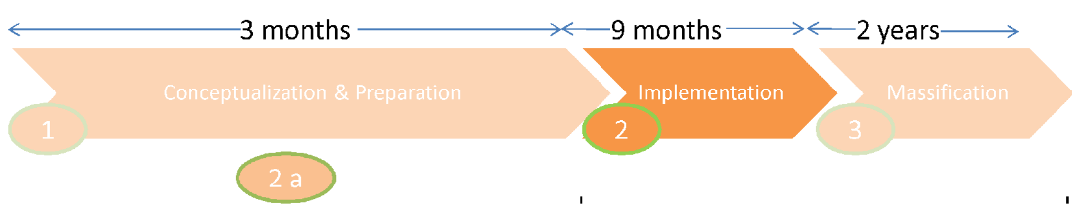
Role

UPERC

DISCOMS

Roll-out of pilot programs to test the business models and revision of business plan as per the use cases is essential

Phase



Activitie(s)

- Procurement of EV chargers for pilots
- Bid and Program management of pilot
- Deployment of charging infrastructure in area near substations (at city and highway) or under control of substation, bus depots, etc.

Output(s)

- Revision of Business Plan
- Roll out of Pilot programs

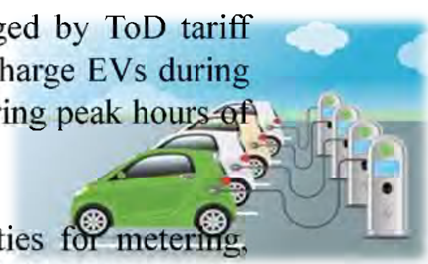
Role

DISCOMS

In the final phase the charging infrastructure needs to be scaled across the State by collaboration with other parties

	3 months	9 months	2 years
Phase	1 Conceptualization & Preparation 3 a	2 Implementation	3 Massification
Activitie(s)	• Identify locations in cities and major highways to deploy charging infrastructure • Develop locations ensuring availability of power • Bid process and Program management	• Bidding out developed locations for deployment and operations of charging infrastructure on BOOT	
Output(s)	• State-wide EV charging infrastructure deployment		
Role	DISCOMS		

Summary



- Charging behavior of EV users needs to be managed by ToD tariff mechanisms so that consumers are incentivized to charge EVs during peaking hours of renewables and avoid charging during peak hours of grid

- Hence, EV chargers needs to have smart capabilities for metering, billing and payments or could be integrated with existing smart meter installed at consumer premise

- Use of high power DC fast chargers for charging batteries of EVs can add stress on the existing infrastructure. Hence, operators of charging stations need to subscribe to services of network service providers (NSPs) so that DISCOMs get the visibility of charging infrastructure operations

- The Discoms need to work on revising their business plans to take into account investments required for supporting and/or deploying EV charging infrastructure

Summary

- **The fast EV chargers need to be smart and grid responsive (shed load in cases of lower grid frequency)**

- **DISCOMs need to empanel network service providers to host location of charging stations and give visibility to EV users as well. NSPs will provide seamless pricing, billing and payment options as value added features.**

- **Bidding process can de-risk private sector investment as access to land and power is assured. The bidding can be done on basis of maximum price that CPOs would charge to EV users or through VGF mechanisms.**

UP ELECTRICITY REGULATORY COMMISSION

Niyamak Bhawan, Vibhuti Khand, Gomti Nagar

army printing press
www.armyprintingpress.com
Lucknow (0522) 6565333