Concept Paper
On
Electric Vehicles Mobility – DHI &DST

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Acronyms

Sl. No.	Acronym	Details
	BEV	Battery Electric Vehicle
	CoE	Centre of Excellence
	DCFC	Direct Current Fast Chargers
	DHI	Department of Heavy Industries
	DST	Department of Science and Technology
	EV	Electric Vehicle
	EVSE	Electric Vehicle Supply Equipment
	FAME	Faster Adoption and Manufacturing of Electric Vehicles
	G2V	Grid to Vehicle
	GoI	Government of India
	ICV	Internal Combustion Engine Vehicles
	MNRE	Ministry of New and Renewable Energy
	IM-TAG	Inter-Ministerial Technical Advisor Group
	MoP	Ministry of Power
	NMEM	National Mission for Electric Mobility
	NEMMP	National Electric Mobility Mission Plan
	RE	Renewable Energy
	STU	State Transport Undertaking
	TPEM	Technology Platform for Electric Mobility
	ULB	Urban Local Body
	UNFCCC	UN Framework Convention on Climate Change
	V2G	Vehicle to Grid
	WHO	World Health Organization
	xEV	Hybrid & Electric Vehicles

1 Executive Summary

Transport sector is the major consumer of fossil fuel, accounting for 70% of the total Diesel consumption and almost entirely (99.6%) of petrol consumption. India spent $76 Billion on crude oil import in FY16. According to the World Health Organization (WHO), India has 13 of the world's top 25 most-polluted cities. The objective is to control the rise in fossil fueled IC Engine Vehicles from Urban Areas, because their heavy concentration in a small area can cause significant air pollution problem. Alternate green fuel and electric vehicles can play a positive role in terms of reduction in local pollution and noise and in improving energy security.

The Electric mobility mission is primarily an urban mobility focused initiative, with priorities being the reduction of local pollution in the city areas, and for overall reduction in the fuel bill for the country, much of which is imported. EVs offer enormous benefits over all other types of vehicle technology. Air-quality benefits from electric buses with zero tail-pipe emissions, can be attributed to a reduction in local air pollution compared with conventional diesel and CNG buses. Electric buses are half as loud as diesel buses.

The NMEM/ FAME initiative is expected to get a major push by the Government as it meshes well with the major development priorities currently envisaged which are the 'Make in India', and the national commitment to clean environment, world class infrastructure and public health through the "Swatch Bharat" and "Smart Cities" Programs. Government of India launched National Electric Mobility Mission Plan (NEMMP) in 2013 with a target of 6 to 7 million EVs on Indian roads by 2020.

Even though EVs demonstrate significant benefits in terms of environmental impact and energy security, their main competition still remains with conventional Internal Combustion Engine Vehicles. One of the major road blocks for the EV operation is their high acquisition cost. It is estimated that by 2020, 2–4 MW of extra power generation capacity and an investment of INR 10–INR 20 crores may be required to build 300–400 charging terminals for buses and for building the overall EV charging infrastructure. India has a potential of 8, 96,602 MW of Renewable energy. The achievement is only 38,822 MW. Huge untapped RE potential is available in India. Other gray areas are battery and EVSE technology, safety issues etc. Domestic companies might be able to reduce costs by manufacturing buses locally. Intelligent planning and strategic implementation of buses and EVSE will reduce the costs further. Cheaper financing options and subsidies by the government can also make the BEV market attractive.

Many reputed bus manufactures with EV manufacturing capability viz., Ashok Leyland, JBM, Mahindra & Mahindra, KPIT have established manufacturing facilities in India. BEVs have been

successfully tried by the STUs in some of the cities. The Global EV Outlook report, published by the Electric Vehicles Initiative (EVI), estimates that the global EV stock in 2014 was more than 6, 65,000 vehicles, while the annual sales number for EVs was 113,000 in 2013. The report also concluded that overall EV sales are growing rapidly – 70% growth in 2013, 53% growth in 2014 and 58% in 2015 and increasing further in 2016.

The National Mission for Electric Mobility (NMEM) was initiated in April 2015 with clear objectives in market creation (consumer subsidy) and technology development to enable the knowledge and supply chain for "make in India" initiative. The market creation will depend on the charging infrastructure and on advances in vehicle and battery technologies.

In order to achieve the objectives under the NMEM, the DHI-DST Technology Platform for Electric Mobility (TPEM) was instituted. The main activity of TPEM is to develop two dozen Projects with participation of vehicle manufacturers, researchers and component companies, Institutions, associations, Private Sector organisations through six identified TPEM Groups. Department of Science and Technology, Govt. of India, considering the capability and experience of DIMTS in conducting various studies in the mobility sector, intended to invite proposals from DIMTS for carrying out the Driving Cycle & Traffic Pattern studies mandated under TPEM Group- 3. The objective is to understand of Indian road conditions, particularly, road traffic scenario, vehicle driving cycles and driver behaviour that will have a significant bearing on the way xEVs are used towards an effective design and successful implementation of xEVs (Hybrid & Electric Vehicles). Road and traffic conditions therefore need to be studied thoroughly for contextualizing the design of xEVs and supporting charging infrastructure deployment. This work would provide a clear understanding of traffic in Indian cities, driving cycles and driver behaviour. The identified vehicle segment under the programme are 2W, 3W, 4W (M1 & N1) & Buses in the cities of Delhi, Mumbai, Bangalore covering more than 50% geographic areas (covering all traffic density patterns, both peak & off-peak).

2 Background

Growth of the Indian economy has resulted in an increase in demand for transportation and also an increase in number of daily commuters. Currently, roads carry almost 85% of the country's passenger traffic and more than 60% of freight. By 2020, India is projected to become the world's third largest automobile market. Transport sector is the major consumer of fossil fuel, accounting for 70% of the total Diesel consumption and almost entirely (99.6%) of petrol consumption. India spent $76 Billion on crude oil import in FY16.

India spent $76 Billion on crude oil import in FY16.

The share of transport related emissions is projected to increase from 9.4% in 2009 to 16% in 2035. According to the World Health Organization (WHO), India has 13 of the world's top 25 most-polluted cities, with the capital city of Delhi having 7.5 million vehicles with almost 1,400 vehicles being added every day. As per the climate action plan submitted by India to the UN Framework Convention on Climate Change (UNFCCC), the national Goal for reducing GHG emissions intensity has been specified. By 2020, the GHG levels have to be brought down to reach 20-25% below 2005 levels – and among the major initiatives taken by the Government, the two important ones to mention in the current context is the ambitious Renewable Energy (RE) target of 175 GW, and the National Electric Mobility Mission Plan 2020 (NEMMP-2020) announced in January 2013.

By 2020, the GHG levels have to be brought down to reach 20-25% below 2005 levels

3 Objective

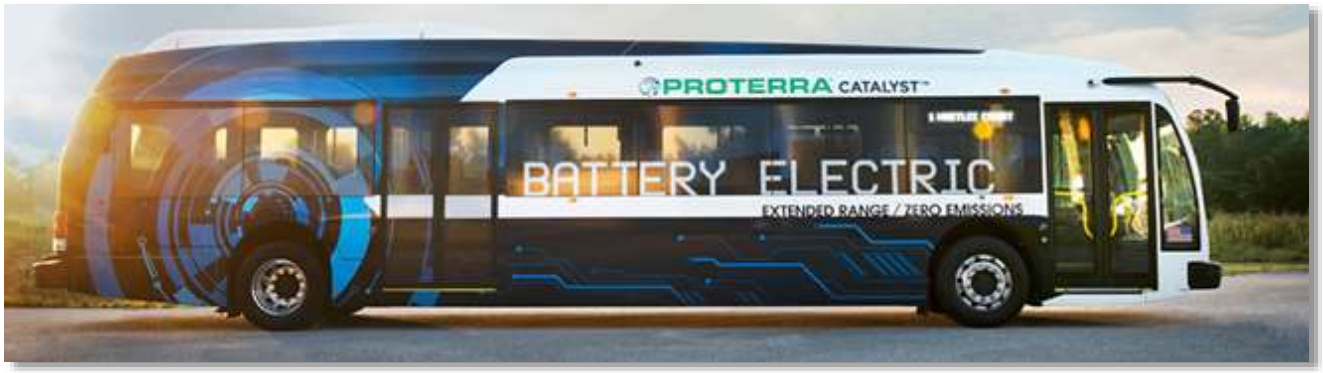
The pollutants from IC Engine Vehicles are accentuated because of the intense urbanization in India, with half the population expected to move to urban areas in the next 30 years, and this is a very large population to be considered. Vehicular pollution accounts for more than 60% of total urban pollution. The objective is to control the rise in fossil fueled IC Engine Vehicles from Urban Areas, because their heavy concentration in a small area can cause significant air pollution problem. Alternate green fuel and electric vehicles can play a positive role in terms of reduction in local pollution and noise and in improving energy security. The Electric mobility mission is primarily an urban mobility focused initiative, with priorities being the reduction of local pollution in the city areas, and for overall reduction in the fuel bill for the country, much of which is imported. Major cities like Delhi, Mumbai etc., need to explore immediate alternate to ICVs for public transport operation. Cities must plan for the induction of EVs and allied infrastructure on priority.

Vehicular pollution accounts for more than 60% of total urban pollution.

4 Why Electric Vehicles

EVs are powered by electricity and propelled by traction motors. In conventional vehicles, Internal

Combustion Engines (ICEs) and fossil fuels are used instead of traction motors and an electricity source. EVs can use electric energy from on-board sources such as a battery or an electricity generator connected to the ICE, or off-vehicle energy sources such as overhead lines. EVs have applications in road and rail transportation, surface and underwater



transport, and electric aircrafts. Even though EVs demonstrate significant benefits in terms of environmental impact and energy security, their main competition still remains with conventional Internal Combustion Engine Vehicles (ICEVs). This is mainly attributed to a well-established supply chain and ease of operation of ICEVs, which give it an edge over EVs. It is important to analyze and overcome the short comings and pain points for quick adoption of EVs in a large scale. EVs offer enormous benefits over all other types vehicle technology, a few of which are discussed below:

5 Benefits

5.1 Air Quality: India is the fourth largest GHG emitter in the world. The transport sector is one of the largest emitters of GHG and contributes 7.5% of the total national CO2e (carbon dioxide equivalent) emissions. It contributed about 142 Mt of CO2e emissions in 2007 as against 80 Mt in 1994. Road-based transport contributes about 87% of the total transport emissions. According to a report prepared by the Task Force on National Greenhouse Gas Inventories of the Intergovernmental Panel on Climate Change (IPCC), GHG emissions (from the transport sector) due to fuel combustion include carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), and pollutants such as carbon monoxide (CO), Non-Methane Volatile Organic Compounds (NMVOCs), sulfur dioxide (SO2), PM and oxides of nitrate (NOx).

The transport sector is one of the largest emitters of GHG and contributes 7.5% of the total national CO2e (carbon dioxide equivalent) emissions

Exposure to high levels of air pollutants can have adverse health impacts. Of all the other ambient air pollutants, the health impacts of PM2.5 (particles of size less than 2.5 µm) are more significant. It is considered the primary cause of respiratory and cardiovascular diseases leading to premature

death. The Global Burden of Disease, 2010, report estimated that ambient air pollution was responsible for approximately 3.2 million deaths globally and 0.627 million deaths in India.
A shift to BS V fuel standards would lead to a further reduction in air pollution. However, there is a cost constraint for adopting BS V fuel standards. A few news reports indicate that the estimated investment (cost for upgradation of fuel quality to BS V) ranges from INR 25,000 crores to INR 80,000 crores.

Cost for upgradation of fuel quality to BS V ranges from INR 25,000 crores to INR 80,000 crores.

Air-quality benefits from electric buses can be attributed to a reduction in local air pollution compared with conventional diesel and CNG buses. Electric buses contribute to zero tail-pipe emissions, which are a major source of air pollution in urban areas. The introduction of electric buses will be beneficial in urban areas, where local air pollution is a concern. Introduction of electric buses becomes favorable in regions where the grid has a major share from renewable energy. When the electric buses are charged using electricity generated by renewable energy, the benefits are way beyond the local air quality. Electric buses combined with renewable electricity will ensure the future reduction in fossil fuel demand and a way forward for cleaner technologies and fuels.

5.2 Noise: Noise pollution is linked to a number of health issues, including stroke, hypertension, dementia and coronary heart disease. In addition to these concerns are the less serious but more prevalent issues of annoyance and sleep disturbance. Further still, one can also consider the effects of excess noise pollution on economic productivity; it not only causes health problems, but also decreases economic efficiency.
Electric buses are half as loud as diesel buses. Such a significant reduction in noise “at the source” has the potential to have a significant impact on well-being.

5.3 Energy Security: India has been an importer of crude oil, and the increasing and fluctuating crude oil prices have had a direct impact on the balance of the payment situation. As India is heavily dependent on crude oil imports for transport fuels on an average of 74%, this price volatility poses a severe threat to India’s energy security

5.4 Other advantages of electric buses:

- Improved hill climbing capabilities (especially trolleybuses).
- No idling motor energy losses. (ie: at bus stops or stopped at traffic signals)
- Better overall performance and less vibration which results in a faster, more comfortable, smoother and hence, more attractive journey experience for passengers.
- For bus operators, faster journeys reduces the fleet size
- Less vibration results a longer vehicle life.
- Lower and more predictable operating costs - compared to the 'volatile' price and availability of imported fossil and other liquid fuels.
- Fewer moving parts makes for simpler and cheaper maintenance.
- Regenerative braking which allows them to use their motors as generators and recycle energy either into the batteries, capacitors or overhead wires instead of wasting it as friction / heat via the

brake pads. Typically regeneration brings energy savings of around 25% - 30%, depending in vehicle, duty cycles and the weather.

- Lower overall lifetime costs - although the initial investment in vehicles and infrastructure will make electric buses appear to be a more expensive option than simply operating more EVs will justify the investment.
- With battery electric buses recharging the vehicles during off-peak hours (typically overnight) eliminates any issue of capacity for electrical generation.

6 The Government Initiatives

The NMEM/ FAME initiative is expected to get a major push by the Government as it meshes well with the major development priorities currently envisaged which are the 'Make in India', and the national commitment to clean environment, world class infrastructure and public health through the "Swatch Bharat" and "Smart Cities" Programs. In fact Electric Mobility is a major thrust area for the Smart Cities Program, and large fleets of EV have a major role to play in balancing resources in the system with a large component of Renewable Energy

6.1 National Electric Mobility Mission Plan 2020

Government of India launched National Electric Mobility Mission Plan (NEMMP) in 2013 with a target of 6 to 7 million EVs on Indian roads by 2020. As India continues its rapid economic development, the demand for automobiles is expected to grow. These automobiles are set to increase CO2 emissions and crude oil demand for the nation as a whole. NEMMP2020 is an initiative taken by the Department of Heavy Industries (DHI) that aims to accelerate the growth of the electric and hybrid components of the automotive sector. It focuses primarily on fast-tracking the manufacturing and introduction of EVs in India. The benefits of this Plan are numerous. Most notably, such an initiative has the potential to reduce CO2 emissions and the dependence on crude oil. In addition, growth in this industry will make India a significant player in the global EV market.

Government of India launched National Electric Mobility Mission Plan (NEMMP) in 2013 with a target of 6 to 7 million EVs on Indian roads by 2020.

The vision statement of the NEMMP states that the aim of the policy is to encourage reliable, affordable and efficient adoption of EV technology through government and industry collaboration. The Plan makes an assessment regarding the uptake of EVs in India. It proposes that about 6–7 million EVs can be sold in India by 2020.

Potential adoption of EVs in India by 2020

Vehicle/Technology Segment	Potential for EVs (2020) (Million Units)
BEVs (battery-electric vehicles) (2 wheelers)	3.5–5
EVs (hybrid-electric vehicles) (4 wheelers bus, LCVs)	1.3–1.4

Other BEVs (3 wheelers, 4 wheelers, bus, LCVs)	0.2–0.4
Total	5–7

The Plan estimates that for BEVs the investment requirement would be about INR 13,500–INR 13,850 crores, whereas for buses that investment would be about INR 500–INR 550 crores.

6.2 National Mission on Electric Mobility (NMEM)

The National Mission for Electric Mobility (NMEM) was initiated in April 2015 with clear objectives in market creation (consumer subsidy) and technology development to enable the knowledge and supply chain for "make in India" initiative. The market creation will depend on the charging infrastructure and on advances in vehicle and battery technologies. So the technology program has two fold objectives:

• Short term deliverable to support the fleets supported with consumer subsidy under the Mission; and

• Long term program to enable the gradual reduction of the subsidies; which depend on achieving global competence in at least a few technology areas.

6.3 FAME India - Faster Adoption and Manufacturing of (Hybrid & Electric) Vehicles in India

(FAME) programme was launched with government support to the tune of Rs.800 crore for the first two years

Faster Adoption and Manufacturing of Electric Vehicles (FAME) programme was launched with government support to the tune of Rs.800 crore for the first two years beginning April 2015. It comprises of a consumer-incentives component that targets the rollout of 6 –7 million hybrid and EVs by 2020, creation of adequate charging infrastructure and a focused effort to strengthen technology capability of the automotive industry to develop and manufacture EV and Hybrid EV.

The FAME scheme is intended to provide financial incentives to support the NEMMP, which promotes the development and uptake of EVs in India. Phase-1 of the scheme will be implemented over a 2-year period, i.e., FY 2015–2016 and FY 2016–2017, commencing from April 1, 2015. An overall allocation of INR 795 crores will primarily be used for implementing demand incentives.

The cities covered under FAME include those covered under the "Smart Cities" initiatives, major metro agglomerations (Delhi NCR, Greater Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad and Ahmedabad), all cities with populations greater than 1 million and cities of the North-Eastern states. The scheme will target all vehicle sizes and types (from hybrid to fully electric).

Previous incentives came in the form of assistance for vehicle purchase and reductions in taxes, and they were sometimes provided by the state government. In the FAME India Scheme, the demand incentive will be disbursed through an e-enabled framework and mechanism set up under the DHI. The scheme envisages the setting up of adequate public charging infrastructure to install

confidence among EV users, through active participation and involvement of various stakeholders including government and non-government agencies. Interlinking of renewable energy sources with charging infrastructure, smart grid, use of Information and Communication technology, etc., will be encouraged. Demand incentives will be based on a combination of vehicle size, fuel efficiency and battery type. Details of demand incentives are provided in Table below:

Vehicle Segment	Minimum Incentive (INR)	Maximum Incentive (INR)
Two-wheeler, scooter	1,800	22,000
Motorcycle	3,500	29,000
Three-wheeler	3,300	61,000
Four-wheeler, cars	11,000	1,38,000
LCVs	17,000	1,87,000
Bus	30,00,000	66,00,000
Retro Fitment Category	15% or 30,000 if reductic in fuel consumption 10%–30%	30% of Kit price or 90,000 reduction in fuel consumption more than 30%

India becomes member of EVI

The Electric Vehicles Initiative (EVI) is a multi-government policy forum dedicated to accelerating the introduction and adoption of electric vehicles worldwide. In 2010, EVI was one of several initiatives launched under the Clean Energy Ministerial (CEM), a high-level dialogue among Energy Ministers from the world's major economies. EVI members include Canada, China, Denmark, France, Germany, India, Italy, Japan, Korea, the Netherlands, Norway, Portugal, South Africa, Spain, Sweden, the United Kingdom and the United States. The International Energy Agency facilitates and co-ordinates the collection, analysis and dissemination of EVI data.

6.4 National Green Tribunal (NGT)

The NGT interventions with respect to vehicle air pollution cases, including restriction of old vehicles and restriction on the number of vehicles. In the eco-sensitive area of Rohtang Pass, Himachal Pradesh, in an attempt to reduce the impact of air pollution, the NGT has ordered the banning of diesel vehicles and has also restricted the number of vehicles to 1,000 per day for a period of 3 months. It has also ordered an environment tax of INR 1,000 for petrol vehicles and INR 2,500 for diesel vehicles entering the tourist area. As a pollution mitigation measure, the Tribunal suggested the state government to explore CNG vehicles. In NCR, Delhi, the NGT ordered heavy diesel vehicles more than 10 years old off the road. In an attempt to mitigate air pollution, the Tribunal also ordered the regional transport authorities to not register diesel vehicles that were older than 10 years old and petrol vehicles older than 15 years old.

6.5 Bureau of Energy Efficiency (BEE)/Star Ratings

In early 2014, the BEE notified fuel economy standards, i.e., Corporate Average Fuel Consumption Standards (CAFC), for passenger cars. However, currently, convergence with existing process preferences are toward fuel quality and emission upgrades. The provision of testing will be consequently introduced for enforcement purposes. The efforts of BEE towards reduction in the

average fuel consumption and environmental pollution of new vehicles introduced in the Indian market, is an encouraging factor for the EV market.

6.6 National Auto Fuel Policy, 2003, Auto Fuel Vision & Policy, 2025

The National Auto Fuel Policy 2003 specifies the fuel standards to be implemented in the country. Currently, the fuel standards implemented adhere to BS III standards and there has been talk of implementing BS V fuel standards. A move from BS III to BS V would lead to a reduction in sulphur content and PM2.5 emissions.

Auto Fuel Vision & Policy 2025 committee recommended imposing a "High-Sulphur Cess" of 75 paise per liter on BS III automotive fuels.

The constraint for adopting low-sulfur fuel is the cost of fuel quality upgradation to produce BS V fuel (10 ppm Sulphur). In this context, the Auto Fuel Vision & Policy 2025 committee recommended imposing a "High-Sulphur Cess" of 75 paise per liter on BS III automotive fuels. It also recommended a "Special Fuel Up-gradation Cess" of 75 paise per liter on automotive fuels. A total cess to a tune of INR 74,000 crores was proposed to fund the cost estimates required for fuel quality upgradation.

6.7 Atal Mission for Rejuvenation and Urban Transformation – AMRUT

Yet another policy that can be a finance vehicle in the transition toward public transport through adoption of EVs is the AMRUT scheme. Under this scheme, the central government proposes to spend INR 1 lakh crores during its tenure (2014–2019). Projects selected under the scheme would have special focus on urban infrastructure development. Like its predecessor – the National Urban Renewal Mission – which financed the purchase of buses by city transport corporations, which led to a rejuvenation of public transport in Indian cities – AMRUT presents itself as an ideal platform for city bus transport corporations to leapfrog technologies and contribute positively toward air quality, energy security and job creation through the adoption of EV technology.

6.8 National Heritage City Development and Augmentation Yojana – HRIDAY

Yet another scheme that has been launched in tandem with the initiatives mentioned above is HRIDAY. The duration of the HRIDAY scheme would be 4 years starting December 2014. The objective of this scheme is to preserve the rich and diverse natural heritage areas. This scheme will be implemented by the centre with 100% funding by the central government. Cities will be required to prepare a Heritage Management Plan for identified projects for availing assistance under this scheme.

6.9 Smart City Mission (SCM)

The Smart Cities Mission Statement and Guidelines released by the Ministry of Urban Development (MoUD) identifies large number of infrastructure elements, where "sustainable development" and "public transport" are also listed. GoI in consultation with respective state transport departments and Urban Local Bodies (ULB) may issue orders for mandatory adoption of EVs for 12 listed smart

Cities. Thus, adoption and deployment of EVs can become a significant strategy in potential smart cities.

SNo.	Initiatives	Key Points	Budgets
1	**National Electric Mobility Mission Plan 2020**	▪Target of 6 to 7 million EVs on Indian roads by 2020. ▪Plan has the potential to reduce CO2 emissions and the dependence on crude oil.	Estimates investment would be about INR 13,500–INR 13,850 crores for BEVs. For buses alone, investment would be about INR 500–INR 550 crores.
2	**National Mission on Electric Mobility (NMEI**	▪Short term deliverable to support the fleets supported with consumer subsidy under the Mission; and ▪Long term program to enable the gradual reduction of the subsidies; which depend on achieving global competence in at least a few technology areas.	
3	**FAME India - Faster Adoption and Manufacturing of (Hybrid & Electric) Vehicles in India**	▪The FAME scheme is intended to provide financial incentives to support the NEMMP, which promotes the development and uptake of EVs in India. ▪Previous incentives came in the form of assistance for vehicle purchase and reductions in taxes, and they were sometimes provided by the state government. In the FAME India Scheme, the demand incentive will be disbursed through an e-enabled framework and mechanism set up under the DHI	Government support to the tune of Rs.800 crore for the first two years beginning April 2015. An overall allocation of INR 795 crores will primarily be used for implementing demand incentives
4	**National Green Tribuna (NGT)**	▪NGT has ordered the banning of diesel vehicles and has also restricted the number of vehicles to 1,000 per day for a period of 3 months. ▪In NCR, Delhi, the NGT ordered heavy diesel vehicles more than 10 years old off the road.	Imposed an environment tax of INR 1,000 for petrol vehicles and INR 2,500 for diesel vehicles entering the tourist area.
5	**Bureau of Energy Efficiency (BEE)/Star Ratings**	▪The efforts of BEE towards reduction in the average fuel consumption and environmental pollution of new vehicles introduced in the Indian market, is an encouraging factor for the EV market.	
6	**National Auto Fuel Policy, 2003, Auto Fuel Vision & Policy, 2025**	▪The fuel standards implemented adhere to BS III standards and there has been talk of implementing BS V fuel standards. A move from BS III to BS V would lead to a reduction in sulphur content and PM2.5 emissions.	▪ The Auto Fuel Vision & Policy 2025 committee recommended imposing a "High-Sulphur Cess" of 75 paise per liter on BS III automotive fuels. It also

			recommended a "Special Fuel Up-gradation Cess" of 75 paise per liter on automotive fuels. ▪ A total Cess to a tune of INR 74,000 crores was proposed to fund the cost estimates required for fuel quality upgradation.
7	**Atal Mission for Rejuvenation and Urba Transformation – AMRUT**	▪ National Urban Renewal Mission – which financed the purchase of buses by city transport corporations, which led to a rejuvenation of public transport in Indian cities – AMRUT presents itself as an ideal platform for city bus transport corporations to leapfrog technologies and contribute positively toward air quality, energy security and job creation through the adoption of EV technology. ▪Finance vehicle in the transition toward public transport through adoption of EVs is the AMRUT scheme. ▪Financed the purchase of buses by city transport corporations, which led to a rejuvenation of public transport in Indian cities.	▪ Under this scheme, the central government proposes to spend INR 1 lakh crores during its tenure (2014–2019).
8	**National Heritage City Development and Augmentation Yojana - HRIDAY**	▪The duration of the HRIDAY scheme would be 4 years starting December 2014. ▪The objective of this scheme is to preserve the rich and diverse natural heritage areas.	This scheme will be implemente by the centre with 100% funding by the central government.
9	**Smart City Mission (SCM)**	▪Includes "sustainable development" and "public transport" in the cities. ▪GoI may issue orders for mandatory adoption of EVs for 12 listed smart Cities.	

7 Challenges, Barriers and Opportunities

In spite of the many positive benefits related to the electric bus technology, certain challenges remain. Primary among these are costs and safety concerns. Currently, the Electric Vehicle (EV) technology is associated with significant capital costs, with the battery component constituting about half of the total manufacturing costs. Safety is yet another important parameter, and the biggest concern is that of a fire hazard. However, with a good Battery Management System (BMS), rigorous implementation of standard operating procedures, and customization of bus fleet, both safety and cost aspects can be effectively addressed. Electric buses have already been deployed on a large scale globally, and the technology is mature and evolving continuously.

7.1 High acquisition costs

High capital costs of BE buses are one of the major barriers in their mass adoption. More than 50% of the cost of the vehicle goes towards the battery pack itself. The charging unit, motor and drive system, air-conditioning, hi-tech low floor/semi LF bus body designing, ITS features, light weighting of the vehicle to counter the battery weight make it further expensive. EVs, recently launched by some of the reputed manufacturers are costing almost three times that of the high-end - fossil fueled urban buses with very similar features. BE buses can break even with respect to the diesel buses in 10–14 years given their low running costs (INR/km). The reason for the high costs of BE buses is the battery cost, which is still higher than the target benchmark cost that has been determined in several studies of the battery industry. At the benchmark cost of the battery, the mass production and adoption of BEVs will be economically feasible. The prices of LIBs and the overall EV technology are slowly reducing.

Another reason for the high costs of BE buses is that India does not have an indigenous manufacturing facility for BE buses. In future, domestic companies might be able to reduce costs by manufacturing buses locally. Intelligent planning and strategic implementation of buses and EVSE will reduce the costs further. Cheaper financing options by the government can also make the BEV market attractive. Effort is being made to bring the cost of vehicles to a comparable range by indigenizing and mass production under the Make in India policy. The initial cost can also be brought down by downsizing the battery

BE buses can break even with respect to the diesel buses in 10–14 years given their low running costs (INR/km).

pack through selection of proper technology, such as rapid or flash charging system. The vehicle cost per passenger in case of electric trolley buses with overhead electric power system are very low in comparison to BEVs. Electric trolley buses are more suitable for Electric Bus Rapid Transit System (EBRTS) due to limited access to the road network.

Financial support by the Govt. of India under the NMEM and FAME will make the use and operation of Electric vehicles more affordable and economically viable.

An articulated Cristalis (left) on one of the high profile Trolleybus Rapid Transit routes in Lyon. Similar vehicles (right) are also used in the Swiss cities of Lucerne (Lüzern) & St Gallen

7.2 Challenges related to batteries (related to price, range, performance, etc.)

The batteries used in EVs need to have high energy density due to automotive light-weighting requirements. This means they should be able to store more energy per unit volume or weight of the battery. This is crucial for attaining higher range (mileage) per charge without having to bear enormous battery weights. Hence, the EV battery type and design differ from those used in grid applications (because they are stationery); the battery pack does not have to be light-weight. Other important parameters for a battery technology to qualify for EV applications include reliability, long cycle life, low cost and safety. Since it is difficult to find all these features in a single battery system, the typical practice is to optimize the performance mix as per the EV variant. A battery functions optimally within certain operating windows of temperature, voltage, structural changes (during charge–discharge) and few other parameters. These operating windows are specific to each battery system.

Owing to their capacity and lifespan, LIBs are the preferred choice for EVs. However, these batteries have a high cost. Factors such as technology innovation and scale of production can impact almost 90% of the LIB cost. In the case of technology, identifying cheaper raw materials and safe chemistries could reduce the cost of batteries.

One of the option is to attach battery trailer without compromising the passenger cabin space

7.3 Battery Safety Issues

The batteries in BE vehicles are required to handle high power and to have high energy capacity under different operating conditions. The safety and performance of the battery should be given the highest priority in BE vehicles. The performance of the battery depends upon its operating conditions such as temperature, charging /discharging current, State of Charge (SoC), etc. On the other hand, factors that can affect the safety of a battery include mechanical abuse of the battery, overcharging and battery failures at extreme temperatures (Casey 2015). It is crucial to maintain a balance between the performance and safety of the batteries.

7.4 The charging station and the Electric Vehicle Supply Equipment (EVSE).

Lack of charging infrastructure is a major impediment to India's BEV adoption. Lack of a continuous supply of good-quality power for charging is also a challenge for higher BEV penetration in the market. According to the NEMMP, the additional demand for electricity to charge all BEVs in India is expected to be about 1 GW by 2020. India already has a peak electricity shortage of 3.7%, with regular power outage a concern in many cities. Therefore, consumers are sceptical about buying BEVs. The government should now step in to cover the current deficit by establishing appropriate power management and additional generation infrastructure for BEV charging.

Important issues regarding the development of charging infrastructure to deploy BE buses in India are:

- Development of a continuous-power-supply roadmap by utilities and transport agencies
- Connections for normal and fast charging at bus depots and in public locations.

An investment of INR 10 to INR 20 crores may be required to build 300–400 charging terminals for buses and for building the overall EV charging infrastructure.

Even low levels of EV adoption can strain the existing infrastructure at certain pockets of EV concentration and Discoms need to proactively prepare to address EV integration issues rather than reactively dealing with grid reliability problems as they arise. Advance actions need to be taken to manage the impact of high-capacity EV charging that will have on the grid. Either significant new infrastructure needs to be added to the distribution infrastructure or these new EV loads need to be managed to avoid overlapping with existing residential usage patterns. Discoms need to take an active role in planning and implementing appropriate EV charging management solutions so that they are well-positioned to be benefitted from the coming massive change in transportation. It is estimated that by 2020, 2–4 MW of extra power generation capacity and an investment of INR 10 to INR 20 crores may be required to build 300–400 charging terminals for buses and for building the overall EV charging infrastructure.

The additional demand for electricity to charge all BEVs in India is expected to be about 1 GW by 2020.

Plug-in EVs like PHEVs and BEVs require physical connections with Electric Vehicle Supply Equipment (EVSE) at the charging station. On the other hand, HEVs are charged using regenerative braking and an ICE. As explained in a previous section of this chapter, the

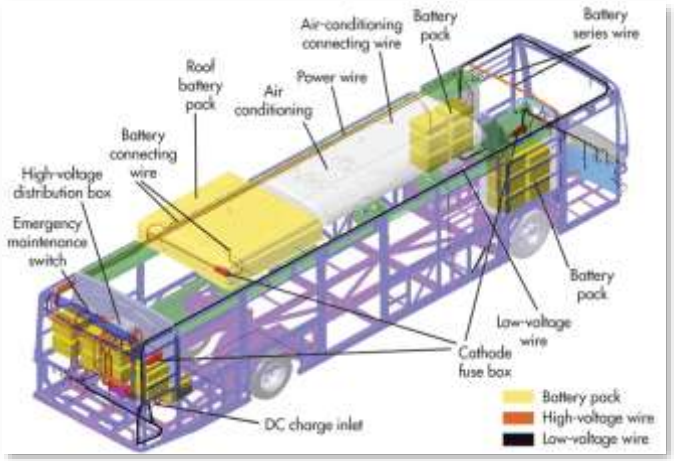
regenerative braking system converts a vehicle's kinetic energy into electric energy, which charges the battery. In conventional vehicles, this energy gets wasted as heat. HEVs do not require external charging equipment like EVSE. EV charging systems are classified into Pantograph, Plug-in and Induction type. Deciding the right type of infrastructure is very important in view of interoperability and cost effective. City can choose any one type of charging technology or in combination (opportunity charging). Besides high investments, planning of sizing, sitting, ownership, safety, security etc., are big challenges for efficient operation of EVs.

It is important to set up a robust charging infrastructure to enable large-scale penetration of plug-in EVs of all types keeping in mind the huge NMEM targets. The EV market is expanding globally due to governments promoting/boosting clean transportation as a policy (incentivizing EV manufacture and purchase). According to a research report, plug-in EVs will constitute 2.4% of the global light-weight vehicle fleet by 2023. The electric bus market is forecast to grow at a CAGR of 28% and reach approximately 34,000 units by 2020. As a consequence, the share of EV-Charging (EVC) stations is expected to grow from more than 1 million units in 2014 to more than 12.7 million units in 2020 (Business Wire 2015).

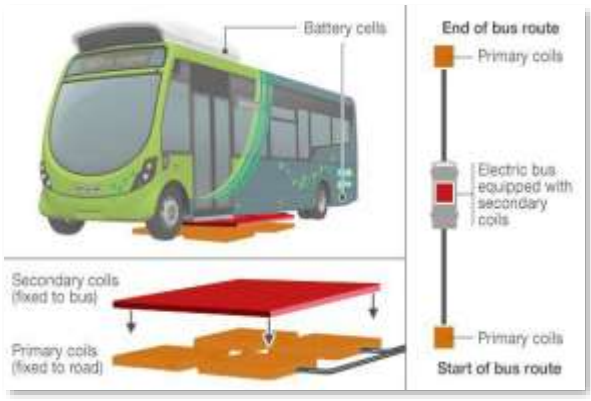
Conductive charging requires a physical connection between the EV and EVSE at the charging station. This technology has been historically the most popular option for accessing grid electricity for various charging applications.

Inductive or Contactless charging:

This is a relatively new technology that has emerged in recent years. Inductive charging uses an electromagnetic field to enable the exchange of energy between the EV and the charging station. In this method, no physical contact is needed between the energy source and the vehicle. Inductive charging works by using an induction coil placed within a charging station to create an electromagnetic field. A second induction coil, placed on the EV, takes power from the electromagnetic field and converts it into an electrical current that is used to charge the on-board battery. The advantages of such wireless charging systems include safety (no exposed conducting surfaces, hence no electric



Conductive Charging System



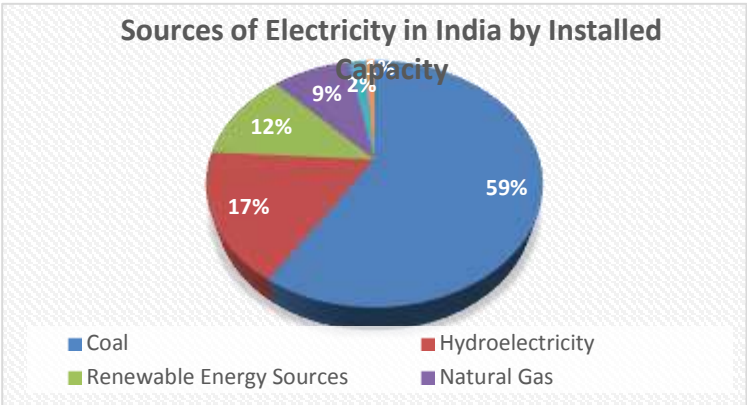
Inductive Charging System

shock), no cable needs, high reliability, low maintenance (automatic, minimum intervention required), reduced risk of theft and long product life due to less wear and tear. Figure 2.11 shows an induction charging schematic of a prototype all-electric bus introduced in London in 2015.

Battery Swapping: Battery swapping refers to the replacement of a discharged battery with a charged battery. The stand-by charged batteries at the swapping centers are not owned by the vehicle owners; these are leased or rented out. This practice is gaining popularity due to quick turnaround. However, swapping is expensive due to the requirement of an increased number of stand-by batteries and a huge space for their storage, and the need for sophisticated equipment such as robots at the service stations for handling a high volume of swapping operations.

7.5 EV charging: Impact on Grid

How the Grid works: An electricity grid consists of a mix of different types of power plants along with the transmission and distribution network. The power plants are the generating elements of the grid and operate to meet the base load and peak demand of a region. The base-load power plants, like coal plants, operate continuously to meet the minimum load and are cost-effective. The peaking plants, like hydro and gas-based plants, on the other hand, are operated during peak-demand hours and, hence, are costly. Unlike the base-load power plants, the peaking plants have the advantage of having a quick response time and can be turned



on and off at short notice. The peak-load profile of a region determines the total installed capacity required to serve that area, whereas the hourly load is met with the most optimal mix of power plants; it could be just the base-load plants or these along with a few peaking generators.

7.6 Impact of EV charging on Grid infrastructure

The number of EV buses within a bus fleet would to a significant extent determine the charging requirements, which in turn would determine the energy requirement and additional power plants (if necessary). An analysis of load profile can show whether some plants that are not being used during off-peak hours can fuel the EV fleet. Some loads like consumer (residential and office) electricity demands are instantaneous and need to be catered to in real-time. However, an EVC schedule can be controlled since the vehicle travel time is temporally separate from the time of battery charging. Typically, electric vehicles are charged most economically during off-peak hours and preferably using base-load plant supplies. This will keep the electricity cost low.

The other scenario could be if a large EV fleet is to be charged during peak-load hours. This will require the addition of new generators and will involve considerable infrastructure investment. A thorough grid supply-and-demand analysis will need to be carried out along with EV fleet economics to arrive at the optimum plant mix for a particular region. Typically, the practice is to match the EV recharge demand with base plants.
To summarize, before an EV fleet is added to an area, a detailed sub-station- and feeder-level study should be done to assess the local distribution network capacity and congestion probability due to recharging needs and patterns. The benefits provided by the EV adoption need to be determined keeping in mind the overall regional grid profile and electric transport policy landscape.

7.7 Supply chain: BE Bus and Components

The acceptance of any new product in the market depends upon the ease of availability of the product along with auxiliary components. Therefore, the development of a robust supply chain to sustain continuous production and consumption of the product is critical for its success. One of the major challenges for any new automotive technology manufacturer is to evolve a sustainable supply chain strategy keeping in mind the impact of this decision on the vehicle performance in a global operating environment. To develop and maintain a good supply chain, auto companies adopt such steps as setting up clear sales targets for the BEV before strategizing the supply chain, systematic flow of information between various departments of the company, robust supplier integration, continuous assessment of the product and the supply chain, updating the supply chain strategy according to the feedback from the market assessment etc.

The sales numbers of BEVs are very small compared with those of conventional fuel-based vehicles. Globally, very few manufacturers supply BEVs, which are limited to select few cities. Except BYD, all other BE bus manufacturers have comparatively small production numbers. Therefore, there is a lack of a well-established supply chain for vehicles and their components. This increases costs and also creates apprehension among customers about the standardization and availability of support equipment. The Ministry of New and Renewable Energy (MNRE) had launched an incentive program in 2010 to promote EVs. It led to a remarkable increase in the sales of two-wheeler BEVs. But over the past two years, many two-wheeler BEV manufactures in India have shut down their businesses because of the receding demand. Current owners of these electric

two-wheelers will have to find alternate sources to get replacement parts for their vehicles. In the light four-wheeler BEV segment, the only manufacturer in India, Mahindra &Mahindra, is also facing the problem of low demand. In the case of the BE bus segment, only a few buses have been sold in India and none of them are mass produced domestically. The low-demand scenario is creating a negative impact on maintaining a good supply chain.

One of the proposed solutions for the supply chain issue of BE buses is to have long-term contracts with the suppliers to provide multiple vehicle units. This will ensure suppliers are available to service the vehicle in operation. In addition, warranty claims and parts for replacement can be seamlessly obtained from the manufacturers. For instance, municipal and state transport agencies can have long-term contracts with BE bus manufacturers that can demonstrate the feasibility of BE buses to private companies. Moreover, consumer organizations can consider procuring vehicles from well-established vendors with proven track records. This might incur some additional costs initially, but might save future expenses by reducing the failure rates of batteries and vehicles, and defaults on warranty claims and services.

7.8 Depot Infrastructure

The important issue is the electricity connections. The rated capacity of the current electricity connection and load line, installed at bus depots, might not be compatible to set up EVSE. For example, simultaneous operation of multiple fast chargers will require a three-phase connection and high-tension-line installation. Therefore, the solution again is collaboration between the electricity supply (utility) companies and transit companies to establish EVSE in the depots and a strategic network of EVSE across the city. Moreover, the present depot infrastructure may not be sufficient for the maintenance and repair of the EVs with new and advance technology. Upgradation of Depots and workshops of the STUs, set up of service station by the OEMs along with required plants and machinery need to be considered beforehand.

7.9 Skill Set for Operation and maintenance

The life and performance of the EVs are dependent on the quality of maintenance and operational skills. Moreover, EVs are connected to high volt electric supply and hence safety during the operation and repair is a big concern. These vehicles need to be handled by highly skilled workers with proper technical knowhow. Generation of adequate number of EV drivers and maintenance staff will remain as a big challenge unless sufficient care taken beforehand.

8 Drivers for growth of Electric vehicles in India

8.1 Policy objectives

- Master plans for most cities in India target 60-80 per cent public transport ridership by 2025-2030 (Centre for Science and Environment).
- Government of India launched National Electric Mobility Mission Plan (NEMMP) in 2013 with a target of 6 to 7 million EVs on Indian roads by 2020.
- Faster Adoption and Manufacturing of Electric Vehicles (FAME) programme was launched with government support to the tune of Rs.800 crore for the first two years beginning April 2015.

- Govt. of India in consultation with respective state transport departments and Urban Local Bodies (ULB) may issue orders for mandatory adoption of EVs for 12 listed smart Cities.

8.2 Market size

- India is the 2nd largest two-wheeler market (80 million in 2010) in the world after China.
- Two-wheelers will continue to remain mode of choice in 2035 (UNEP, DTU and IIM-A).
- Many reputed bus manufactures with EV manufacturing capability have established manufacturing facilities in India.
- India has more than 17 lakh registered buses.
- **Projected Domestic Sales of Commercial Passenger Vehicles during 2016 – 17**

Commercial passenger vehicles maximum mass not exceeding 7.5 tonnes- 62,858
Commercial passenger vehicles maximum mass exceeding 7.5 tonnes- 79,751
Total Commercial Passenger Vehicles- 142,609

Source- Report of the Sub-Group on Passenger and Freight Traffic Assessment and Adequacy of Fleet and Data Collection and Use of IT in Transport Sector in the Twelfth Five Year Plan (2012-17)

8.3 Environmental

- Thirteen out of 20 cities in the world with highest air pollution are in India
- Low carbon scenario with 'highest' EV penetration shows 50 percent drop in PM 2.5 by 2035 (UNEP, DTU and IIM-A)
- In an attempt to mitigate air pollution, the NGT also ordered the regional transport authorities to not register diesel vehicles that were older than 10 years old and petrol vehicles older than 15 years old.

Low carbon scenario with 'highest' EV penetration shows 50 percent drop in PM 2.5 by 2035

8.4 Allied opportunities

- With the Government of India targeting **100 GW of solar by 2022**, electric vehicles can improve reliability and utilization of renewable by acting as storage.
- India has a potential of 8, 96,602 MW of Renewable energy. The achievement is only 38,822 MW. Huge untapped RE potential is available in India (MNRE)

With the Government of India targeting **100 GW of solar by 2022**, electric vehicles can improve reliability and utilization of renewable by acting as storage.

9 The Indian Context

The Indian automobile industry is one of the fastest growing globally. Both volume and exports have been consistently rising over the past 10 years. According to the National Electric Mobility Mission Plan 2020 (NEMMP 2020), by 2020 the annual demand for passenger vehicles, commercial vehicles and two-wheelers in India will be 10 million, 2.7 million and 34 million units, respectively, making India the third largest vehicle market in the world. While the NEMMP aims to make India a global manufacturer of EVs, the domestic market for EVs appears to be promising.

Few of the initiatives taken recently to promote Electric vehicles in the country is discussed below:

9.1 Bangalore Metropolitan Transport Corporation

The country's first electric bus was launched in Mar 2014 by BMTC on a three month trial. The BYD bus, which is air-conditioned has the capacity to seat around 41 passengers and the upfront cost of the electric bus is Rs 2.7 crore as against Rs 90 lakh of an AC high-end bus. The operational cost was around Rs 7 per km as against Rs 18 per km incurred by the latter. The bus weighs 18 tons and has a length of 12,267 mm, width of 2,550 mm and has a height of 3,486 mm. The bus needs at least six hours to charge it fully to run for 250 km.

Bangalore Metropolitan Transport Corporation proposed exemption of road tax and VAT for electric vehicle. Project shelved due to non-availability of fund.

9.2 Delhi Transport Corporation

DTC in Delhi made an extensive trial of the same BYD bus for a total km of 16915 during March to July 2016.The trial showed encouraging results of operational cost of only 17.25 INR per km as against 65.oo INR for the low floor CNG buses.

9.3 Mumbai Metropolitan Regional Authority (MMRDA)

Apr 2015 – Floated RFP for 25 AC electric / hybrid buses from Bandra Kurla Complex to 3 railway stations.

9.4 New Delhi Municipal Corporation

Proposes to operated three-wheeler electric vehicles from Metro stations

9.5 Ather Energy

IIT Madras based start-up Ather Energy, is ready with its first prototype and aiming to launch a smart redefined electric scooter in 2016 that will be manufactured at a company-owned production plant in Bengaluru. The startup, which unveiled its prototype in February 2016, plans to build expansive charging infrastructure in the near future.

10 Electric bus manufacturers in India

10.1 Ashok Leyland

Ashok Leyland, manufactured India's first electric bus ”Circuit” designed and engineered entirely in India, created specifically for Indian road and load conditions. The bus is introduced in lines with National Electric Mobility Plan which aims at a 20% penetration of electric/hybrid vehicles by 2020. Apart from zero tailpipe emissions and lower noise pollution the bus offers reduced running costs to the operator.

The Circuit series of buses is another testament to Ashok Leyland's commitment to leverage India's technological innovation to deliver relevant and best-in-class solutions for India and the world.

The electric bus will have a minimum seating capacity of 35 to a maximum of 65, and can run up to 120 kilometres on a single recharge under standard test conditions. The bus will cost between INR1.50 to 3.50 crore, and depends on the batteries and seats. The Circuit buses can be manufactured in all the seven manufacturing facilities owned by the company. Currently, these buses are being manufactured in Alwar, Rajasthan and Viralimalai facility in Tamil Nadu.

10.2 Build Your Dream (BYD)

China's leading bus maker Build Your Dreams (BYD) has finally decided to assemble e-buses in India. For this, the Shenzhen headquartered company has joined hands with Smart Dreams in India, which is led by Singapore-based entrepreneur B K Modi. With pollution problems rising faster than anticipated by various experts, the company will bring in pure electric buses in the first phase, which can be followed by cars as BYD and Smart Dreams have already offered 2 buses to Delhi Transport Corporation (DTC) for a trial run. Backed by investment veteran Warren Buffet, BYD has an electric bus manufacturing facility in South California, US. Currently, the electric bus by Smart Dreams & BYD is powered by fully recyclable lithium ion battery that has 4,000 recharging cycles and can clock 250 kms on a fully charged battery. For a complete charge, the bus has to be at a halt for minimum of 5 hours.

In order to reduce cost, Smart Dreams and BYD have already finalized a facility to assemble the electric buses in Modi Citi near Moradabad, Uttar Pradesh and targeting at least 50% localization from the very start of production. Over the next 3 to 5 years, the duo also have plans to further take this number to 75% by indigenizing the battery itself riding the tech expertise in making rechargeable batteries of BYD. With a rising thrust on smarter transport in India, both STUs in metro cities and also the upcoming smart cities will be on the radar for the group which has currently refrained from sharing the investment that will go into the project. The company is already talking to the major STUs in the country and hopeful of bagging good orders from them. However, he opined that to promote the use of e-vehicles in India.

10.3 KPIT

The Smart Electric Bus, an indigenous technology developed by the India headquartered global technology company, KPIT was launched at the Indian Parliament on the 21st of December. It is a versatile system and a variety of existing buses can be converted to electric buses.This full electric system for buses can be deployed to create new intelligent electric buses, as well as convert existing conventional fuel buses.

10.4 JBM Electric bus

Exceptionally quiet, emission-free, distinguished by its modern design and guaranteeing low operation costs – discover the benefits of the JBM Solaris ECOLIFE 9mElectric, India's first 100%

low floor Electric bus. Crafted to 9 metres in length, ECOLIFE 9m Electric is a fully low-floor battery powered green vehicle with state of the art electric drive technology that ensures hassle free and comfortable commute for the passengers. ECOLIFE 9m Electric stands out distinctly by virtue of its attractive exterior and interior styling coupled with a series of innovative and cutting-edge design solution

.

Offering a completely flexible solution, the ECOLIFE 9m Electric offers the ability to adjust the charging system of the bus to an operator's or city's infrastructure. ECOLIFE 9mElectric fits in perfectly with any urban environment as it traverses narrow streets swiftly and silently, and keeps the air fresh and clean in crowded city centres. The different battery sizes and other customisations offered by JBM Solaris enable the bus's range to be tailored to the requirements of virtually any route. This further optimises the purchase and operating cost of the vehicle and the number of people that can be carried.

10.5 Mahindra

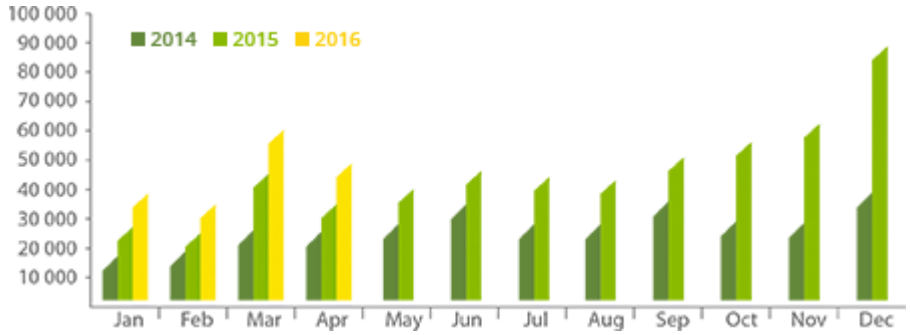
Mahindra e_2o is India's only 100% electric car perfect for city drive. The All-Electric Mahindra e_2o comes with a range of 120 km and maintenance free lithium ion batteries. Loaded with state of the art technology like telematics and remote diagnostics, the e_2o is the world's first connected car with smart phone controlled features.

Perfect City Car- Mahindra e_2o makes your city drive a breeze with a host of convenient features like clutch-free drive, easy home charging, smallest turning radius, hill-hold and great manoeuvrability. Clever to the core– with our patented iEMS system that boasts of 10 on-board computers that enables remote diagnostics and round the clock monitoring of the vitals of the car, Mahindra e_2o is clever to the core.

11 The Global Context

The Global EV Outlook report, published by the Electric Vehicles Initiative (EVI), estimates that the global EV stock in 2014 was more than 6, 65,000 vehicles, while the annual sales number for EVs was 113,000 in 2013. The report also concluded that overall EV sales are growing rapidly – 70% growth in 2013, 53% growth in 2014 and 58% in 2015 and increasing further in 2016. The global percentage share of Battery Electric Vehicles (BEVs) in the total number of EVs sold is increasing every year – 49% in 2012, 54% in 2013 and 57% in 2014. China is currently operating 36,500 electric buses as compared with a negligible number of electric buses in India. The graph below indicates Increase in no. of EVs, globally sold during the last three year.

The Global EV Outlook report, published by the Electric Vehicles Initiative (EVI), estimates that the global EV stock in 2014 was more than 6, 65,000 vehicles



Increase in no. of EVs sold during the last three year (Global)

Include electrics (EVs), plug-in hybrids (PHEVs), and also light-commercial electric vehicles.

11.1 Amsterdam

By 2040, the City of Amsterdam expects that nearly all kilometers driven will be powered with electricity generated by windmills, solar panels and biomass plants. The canals will be filled with silent electric boats. Cargo will be transported over the road and water using electric power. The city will even smell better and sound quieter thanks to electric transport. Fossil fuels will be unnecessary when travelling in the city. Harmful emissions will be dramatically reduced, as will the costs of electric transport. All of this will make Amsterdam an attractive city in which to live, work and play—all thanks to developments that are being put in motion today. By 2015, Amsterdam is expected to have 10,000 EVs on the roads. More and more electric cars are being produced, and although they are currently more expensive than traditional vehicles, their prices will fall as the market for them increases.

11.2 Berlin

Released in March 2011, the Action Plan for Electro-mobility Berlin 2020 set forth three main goals: 1) Improve the quality of life for the population by utilizing electro-mobility's potential to reduce noise and tailpipe emissions. 2) Sustainably strengthen the economy and establish new jobs for skilled workers. 3) Boost the development of new technologies and services and market them in an "international electro-mobility showcase."

Since 2008 the Federal Ministries of Economics and Technology; Transport, Building and Urban Development; Environment, Nature Conservation and Nuclear Safety; and Education and Research, which all are leaders in electro-mobility, have supported numerous electro-mobility projects in the capital region Berlin-Brandenburg. Since 2009, the Berlin-Potsdam region has been one of eight model regions around Germany to receive support for practical projects. Brandenburg

and Berlin plan to meet 100 percent of their electricity needs with renewable energies by 2020 and 2030, respectively.

11.3 Rotterdam

The Rotterdam Electric Program's main goal is to create the right conditions to speed the introduction of EVs in Rotterdam, the third largest port city in the world. The goal is to reach 1,000 EVs within five years and 200,000 EVs by 2025.

The Rotterdam Electric Program supports the first 1,000 EV owners with an electric charging point. On private property, a charging point is partly subsided. Rotterdam is installing charging points at strategic locations in the city center and public parking areas. The city center of Rotterdam will be the icon area for EVs, where air quality is a big issue and therefore there are more opportunities for reductions to be achieved. Innovation is also part of the Rotterdam Electric Program–continued development of EVs will be supported by Rotterdam, stimulating innovative initiatives and pilot projects.

11.4 Nagasaki

In 2009, the **Nagasaki** Prefecture established the Nagasaki EV&ITS Consortium, a collaborative effort by industry, academia and government to promote EVs and intelligent transportation systems (ITS) throughout Nagasaki. The introduction of electric vehicles on the Goto Islands makes it possible to experience a society where EVs operate widely in daily use. This unique project offers an opportunity to consider what such a society needs, including charging infrastructure, effective operating methodologies, and services. The goal of the EV&ITS project is to create "Driving Tours of the Future" by incorporating EVs and ITS technology into the local tourism industry.

Nagasaki is working with local residents to develop new ideas such as tourist services with navigational guidance, new EV development by local industries, the utilization of renewable energy such as solar or wind power, and the establishment of a system for regional smart grid integration with EVs. The goal is to help create new businesses and industries, and revitalize the local economy and society. The project was launched to strengthen collaboration between local industries and universities, creating a Nagasaki-originated global standard and a Nagasaki-originated regional business model. To help achieve the "Driving Tours of the Future," Nagasaki Prefecture is resolved to have the Goto Islands listed as a UNESCO World Heritage Site for its commitment to ecological preservation, and leverage its special status as an island group.

11.5 Hamburg

With more than 350 BEVs already in operation at the end of 2011, the **City of Hamburg** and many partners from industry, local enterprises and public entities have made a strong contribution to the German Federal Government's plans to establish the country as the prime market for e-mobility and as the global lead supplier in electric cars and components.

Hamburg's trade and industry have a clear commitment to green their daily operations. The vital network of corporate partners with their commercial fleets offers a unique chance to share knowledge on how to gradually incorporate EVs into conventional fleets. The situation in Hamburg indicates a sound demand for more vehicles in the years to come, helping to reach a critical mass in development and production. Moreover, EV deployment poses quite a number of new challenges for urban planning strategies and transportation policies. The Hamburg Senate, the local state government, launched an ambitious masterplan in November 2011. This not only includes the extension of the ongoing implementation strategy but also maps out several assignments to the municipal entities, such as promoting EVs in municipal fleet procurement, installing charging spots at public buildings, and considering EV-driven concepts in tender procedures, for example, offering public plots.

With regard to charging infrastructure, Hamburg has constituted three binding rules: 1) charging stations on public ground have to be in line with urban layout and city architecture; 2) they have to be accessible for all EV users without implying a customer relationship between provider and user ("discrimination-free") and; 3) they focus on 100 percent green energy from renewable sources. This clear commitment to power electric vehicles exclusively with electricity from additional renewable sources is best practice in environmental policy and will boost acceptance of this new technology.

11.6 China

Rapid urbanization and the resulting increase in demand for public transport systems seem to have made China the largest market for passenger buses in the world. The country sold 3,374 units of electric buses by 2011 and is anticipated to reach more than 12,000 units, making the share of electric buses more than 14% by 2018. According to the "Strategic Analysis of the Chinese Hybrid and Electric Transit Bus Market" report, total bus sales will be more than 80,000 by 2018 and it will further strengthen China's domination in the global transportation market (PR Newswire 2012). According to "China Bus Industry Report, 2015–2018", hybrid buses are no longer part of the national subsidy scheme. Therefore, hybrid buses lost the sales and market share in 2014. Hybrid buses constituted only 5.5% of the total new-energy (non-diesel) bus sales and BE buses had the biggest share of 47.5%

in the same segment in 2014. The rise in the market share of BE buses is attributed to technology maturity and enabling policies.

11.7 Helsinki

Finland is the perfect location for e-mobility development due to its top class IT and engineering competence. The country's functional infrastructure and harsh weather conditions create optimal conditions for demanding testing environments.

The Electric Vehicle Systems programme (EVE) was created to support the community of electric vehicle and support system developers with close contacts to international research and business networks. The program also focuses on developing test environments and standards for the industry. Four of the five consortia of the EVE program are focused on passenger traffic and related systems. The fifth develops electric vehicle technologies and services in commercial use. The EVE program takes advantage of the close cooperation of the Finnish research institutes and enterprises to create an outstanding international community of e-mobility businesses.

11.8 Barcelona

Barcelona City transport is mostly public, thanks to integrated multimodal pricing that allows indiscriminate use of bus, metro, tram and train. Non-motorized transport equals 41.7 percent, thanks in part to Bicing, a public bike system, with 35,000 daily uses. Powered two-wheelers (PTW) account for 40 percent of private travel within the city.

The city is pursuing electric mobility solutions as a way to reduce CO2 emissions and noise, reduce oil dependency and improve efficiency, and to provide opportunities for entrepreneurial, technical and economic development.

Promoted by Barcelona City Council, the public-private platform LIVE (Logistics for the Implementation of Electric Vehicles) was created with the objective of supporting the development and promotion of demonstration projects of electric mobility.

Barcelona has more than 300 plug-in electric and hybrid vehicles in its fleet. 50 percent of the fleet in the city is expected to be electric in near future. LIVE, working with supporting institutions, will help consolidate projects relating to transformation of both public and private fleets. LIVE will also work with manufacturers and distributors to create the first prototype units of electric vehicles for Catalonia. TMB (Transports Metropolitans de Barcelona), in an ongoing project in collaboration with SIEMENS, is developing projects for hybridization of buses and minibuses, and implementing 100 percent electric routes in neighbourhoods with mobility difficulties.

11.9 Los Angeles

The City of Los Angeles is often known as the 'car capital of the world, firmly committed to plug-in vehicle technology, building upon the city's historic EV deployment in the 1990s from which there remains a handful of vehicles and 117 public access legacy chargers. The city aims to turn the L.A. into the PEV car capital of the world, and LA is already demonstrating national and international leadership in this space. In Los Angeles, the deployment of plug-in vehicles is grounded firmly in the understanding that this technology will further enable the city to reduce GHG emissions from transportation, improve regional air quality, and drive local and national economic growth.

EVs currently produce 71 percent fewer emissions per mile than gas vehicles; PHEVs produce 48 percent fewer emissions per mile than gas vehicles (both based on California's grid mix). L.A.'s use of renewable energy is growing dramatically, reaching 20 percent in 2010, with the goal of 33 percent by 2020. With a municipally-owned utility, money previously exported through gasoline sales will now remain in the city and region. In addition, in 2010, Los Angeles also became headquarters to two electric vehicle manufacturers: BYD and CODA, and numerous other companies in the EV and EVSE supply chain.

11.10 Stockholm

In May 2011, the Stockholm City Council adopted an EV/PHEV strategy with the goal of becoming a leading EV city and fossil free in the inner-city by 2030 and region-wide by 2050. This initiative is led by the Environment and Health Administration, the Stockholm Parking Company (municipal parking facilities), the Stockholm Traffic Authority (street parking), and the Stockholm Planning and Building Authority (fast charging and aesthetics). The city encourages development of device regulations and standards, such as clearer indoor charging regulations.

Stockholm has been testing the performance of a fleet of 50 EVs throughout Sweden. The first evaluation shows that the EVs perform well and are recommended by 85 percent of the drivers. There are still some challenges remaining, such as attitudes towards EVs, availability of fast charging units, the cost of EVs and the need for new business models.

12 About DIMTS

Delhi Integrated Multi-Modal Transit System Limited (DIMTS) is a company set up by the Government of National Capital Territory of Delhi (GNCTD) and IDFC Foundation with equal (50:50) equity participation and has a specific mandate to plan, prepare, design and implement

projects related to development of multi-modal transportation networks including operation and maintenance of such assets and allied activities.
IDFC Foundation is a not-for-profit initiative of IDFC Ltd., a leading infrastructure financing institution set up in 1997 as an initiative of the Government of India to catalyze financing and development of infrastructure projects.

http://delhi.gov.in/wps/wcm/connect/doit/Delhi+Govt/Delhi+Home
http://www.idfc.com/foundation/our_firm/overview.htm

With the Chief Secretary Govt. of Delhi as its Chairman the DIMTS Board consists of eminent personalities from sectors of national and global leadership around Urban Challenges and delivery. Our Executive Director Mr. M Ramsekhar IAS [1988] has worked extensively in the areas of urban development, industrial and economic development, infrastructure, transport, and governance across the public and private sectors.

Focused on the urban mobility space, DIMTS' core competencies reside around:

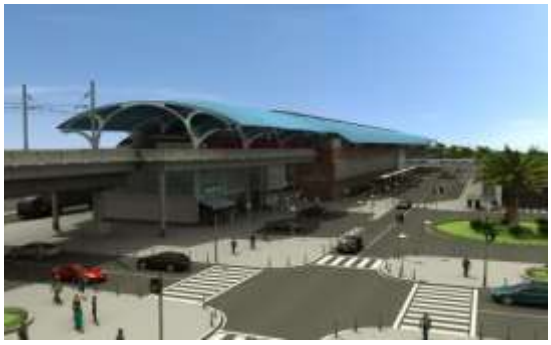
- Urban Public Transport Planning & Operations,
- Project Management & Public Asset life-cycle creation,
- Public Transport concession management & Sensitivity analysis
- IT & e-enabled initiatives across the mobility sectors
- Engineering, design & construction management

With the stated objective of creating an environment of reliable, safe, convenient and delightful end-user experience within the mobility sectors, and given our profile, DIMTS has often had the responsibility of working as an extended arm for various Federal & State Governments, Transport Units and policy bodies in India both at the national and state levels.

DIMTS is also engaged with several multi-lateral funded organisations such as the World Bank, ADB, UNOPS as well as Exim Bank for various initiatives on Governments projects nationally as well as internationally. Currently we are executing Project across multiple States in India and five countries abroad.

A brief listing of few of our Projects of your relevance:

I. **Feasibility study and detailed project report for two corridors:** DIMTS has prepared the reports for (1) Delhi- Ghaziabad-Meerut: 90 kms, (2) Delhi- Sonepat- Panipat : 108 kms. This system is expected to integrate and connect the National Capital Region of Delhi with the other modes of transport such as bus and metro as well.



RRTS – Station Design

I. **Haryana Mass Rapid Transport Corporation Limited (HMRTC):** Consultancy services for Institutional Design and Strategy for the Construction and Operations of Metro Rail Project.

II. **Ranchi:** DPR, Feasibility Study and Bid Process Management for Metro Rail/ LRT.

III. **Nagpur Municipal Corporation:** Signed an agreement with DIMTS to plan and implement the bus rapid transit system in 5 major roads of Nagpur city with the total length of 67.3 Km length under the JNNURM scheme with following scope:

- Detailed Project Report Preparation
- Detailed Working Drawing Preparation
- Bid Process Management
- Project Management Services

Scientific Route Planning

Step 1: A route is selected for operation on the basis of:

- Distance of Origin Point from Depot – Optimization of Dead km
- Service catering to Rural Areas
- Route length – optimization of service plan
- **Step 2:** Tentative loading pattern is checked from Cube Voyager Model – Selection of frequency of operation
- **Step 3:** Route Survey is undertaken for recording Latitude/ longitude of bus stops

• **Step 4:** Timetables/ Memos prepared

IV. Transport Department, Govt. of Delhi Implementation of Corporatisation of Private Stage Carriage Buses [Cluster Bus]. Currently, 1500 buses are being operated under 9 clusters and monitored live using state of the art embedded digital technology and back end Control Room operations. This ensures higher level of service delivery and operational efficiencies.

V. PUNBUS has appointed DIMTS as Project Management Consultant (PMC) for their Integrated Depot Management System Project to cover all the functions of 18 depots across Punjab, 21 bus stands and head office of PUNBUS & Punjab Roadways. The deliverables includes assessment of current practices around Depots, Fleets, Administration, Personnel and commercial areas of the STU and deliver a bid process management to on-board IT based solutions towards measurable efficiencies.

VI. MoRTH [Ministry of Road transport and Highways, GoI] programme for 'Security of Women in Public road transport' (under Nirbhaya Scheme). DIMTS's role encompasses on Programme Management and providing assistance for Implementation of National Level Vehicle Security and Tracking System.

VII. PMC for GPS based tracking system for all commercial vehicles in Himachal Pradesh by Govt. of Himachal Pradesh.

VIII. Development of GPS/GPRS system in Para-Transit Vehicles by Transport Dept. Govt. of Delhi for approx. 1.10 lac vehicles including buses, taxis, auto-rickshaws, public service vehicles, etc.

IX. Bid Process Management for supply of 3700 Low Floor A/C and Non A/C DTC buses by the Transport Dept. Govt. of Delhi.

X. Development of Urban Public Transport System and Integrated Facilities in the cities of Brazzaville and Pointe-Noire, Republic of Congo.

XI. M/s Shakti Sustainable Energy Foundation has appointed DIMTS to carry out a study to identify Policy Road Map for Improvement in City Bus Systems in 12 cities across the country representing various characteristic.

13 Department of Science and Technology – The objects and key responsibility

Department of Science & Technology (DST) was established in May 1971, with the objective of promoting new areas of Science & Technology and to play the role of a nodal department for organising, coordinating and promoting S&T activities in the country.

Some of the major responsibilities of DST are listed below:

- ❖ Formulation of policies relating to Science and Technology.
- ❖ Matters relating to the Scientific Advisory Committee of the Cabinet (SACC).
- ❖ Futurology.
- ❖ Coordination and integration of areas of Science & Technology having cross-sectoral linkages in which a number of institutions and departments have interest and capabilities.
- ❖ Undertaking or financially sponsoring scientific and technological surveys, research design and development, where necessary.
- ❖ Support and Grants-in-aid to Scientific Research Institutions, Scientific Associations and Bodies.
- ❖ Matters concerning domestic technology particularly the promotion of ventures involving the commercialization of such technology other than those under the Department of Scientific and Industrial Research.
- ❖ All other measures needed for the promotion of science and technology and their application to the development and security of the nation.

14 DST Mandate and proposed Intents

14.1 The National Mission for Electric Mobility (NMEM) was initiated in April 2015 with clear objectives in market creation (consumer subsidy) and technology development to enable the knowledge and supply chain for “make in India” initiative. The market creation will depend on the charging infrastructure and on advances in vehicle and battery technologies. So the technology program has two fold objectives:

• Short term deliverable to support the fleets supported with consumer subsidy under the Mission; and
• Long term program to enable the gradual reduction of the subsidies; which depend on achieving global competence in at least a few technology areas.

14.2 In order to achieve the objectives under the NMEM, the DHI-DST Technology Platform for Electric Mobility (TPEM) was instituted with the objective of:

- To develop technologies & products that specifically address India needs,
- To develop a global competitive edge in select technologies of Electric Mobility.
- To strengthen the industry technology capability sufficiently so as to be able to reduce and wean off the consumer subsidy program for electric vehicles in the near future.

14.3 Department of Science and technology will administer the Technology Platform for Electric Mobility (TPEM) and coordinate organization of IM-TAG deliberations, and undertake follow up activities as decided by the IM-TAG.

14.4 To strengthen the industry technology capability sufficiently so as to be able to reduce and wean off the consumer subsidy program for electric vehicles in the near future.

14.5 **Main goal** of TPEM is to develop technologies & products that specifically addresses India's needs, for rapid development of Electric Mobility and to develop a global competitive edge in select technologies of Electric Mobility.

14.6 **The main activity** of TPEM is to develop two dozen Projects with participation of vehicle manufacturers, researchers and component companies, Institutions, associations, Private Sector organisations. To serve the purpose, six activity TPEM Groups (TG) have been identified as under:

TG-1: Lithium ion Battery - The activities will include design & development of indigenous electrode materials, Cell fabrication, integration with Battery Management System (BMS), prototype battery module/ pack and testing & validation.

TG-2: Charging Infrastructure – To deal with identification of priority areas in Innovative EV Charging Solutions and risk reduction, Device and Hardware Development for the charging station, Software Development and Communication Protocol, Grid Development, Technology pilot for communication channel & protocol between the vehicles, charging stations and control station, setting up of standards and interoperability etc.

TG-3: Driving Cycle & Traffic Pattern- For undertaking segmented studies for different categories of vehicles in various cities in India, Indian road conditions, particularly, road traffic scenario, vehicle driving cycles and driver behaviour for successful implementation of EVs.

TG-4: Motors & Drives - The purpose is to develop both motor and power electronic drive as required for electric vehicle operation. It should indicate the type of motor, the innovation and its suitability for electric vehicle.

TG-5: Ultra-capacitor - Recommendations are yet to be firmed up.

TG-6: Light weighting - Develop and test lightweight solutions encompassing vehicle body structure as well as chassis and all other sub-systems such as powertrain, suspension, steering and braking systems, energy storage systems (i.e. mainly batteries, associated packaging and electronics), and other miscellaneous mechanical and electrical hardware, which can be integrated into an optimally designed xEV that will meet customer requirements in terms of aesthetics, functional performance (in attributes such as ergonomics, aerodynamics, vehicle dynamics, NVH, durability, crashworthiness, etc.) and cost, as well as comply with applicable government regulatory requirements.

14.7 The Intent

With the mandates above, the Department of Science and Technology, Govt. of India, considering the capability and experience of DIMTS in conducting various studies in the mobility sector, intended to invite proposals from DIMTS for carrying out the Driving Cycle & Traffic Pattern studies mandated under TPEM Group- 3.

15. The Scope

The scope of the project under the TPEM Group no.3 - Driving Cycle & Traffic Pattern for which Project proposals are invited are described below

15.1 Objectives

Effective design and successful implementation of xEVs (Hybrid & Electric Vehicles) needs an understanding of Indian road conditions, particularly, road traffic scenario, vehicle driving cycles and driver behaviour that will have a significant bearing on the way xEVs are used. Road and traffic conditions therefore need to be studied thoroughly for contextualizing the design of xEVs and supporting charging infrastructure deployment. This work would provide a clear understanding of traffic in Indian cities, driving cycles and driver behaviour.

15.2 Proposed Projects

The scope of the current research component would include undertaking segmented studies for different categories of vehicles in various cities in India. The study would be conducted by both using telematics equipment and traffic surveys. The data collection exercise would be conducted over a period of 1 year, covering winter, summer & monsoon.

15.2.1 Information to be captured

a. Traffic pattern (route, day, time & season).
b. Start, stop & idling (time & numbers).
c. Speed profile (Average speed, acceleration, deceleration and cruise).
d. Trip information: No of trips/ day, distance covered/ trip.
e. Parking information: Duration & location of parking, Type of parking.
f. Driver behaviour: Use of clutch, accelerator, brakes and air conditioner.
g. Ambient Weather Information.
h. Electrical Load: End of trip State-of-Health (SOH)-Battery.

15.2.2 Phase 1 Studies.

a. Vehicle Segment: 2W, 3W, 4W (M1 & N1) & Buses
b. Cities: Delhi, Mumbai, Bangalore
c. Coverage: > 50% geographic (covering all traffic density patterns, both peak & off-peak)
d. Sample size for each category of vehicle: To be proposed (Minimum 10)
e. Vehicles to be used for study: Should be < 3 years old / 40,000 kms

16. Project Plan

A shift to an electric bus fleet necessitates an understanding of the technology. The design of an electric bus and the necessary infrastructure depend on the application scenarios. The battery size depends on the drive cycle, terrain features and other operating conditions. The battery system preference depends on the operating conditions of the vehicle. The cost is determined by the bus and the battery size, battery type and carrying capacity. Thus, having a fundamental understanding of the technology landscape and application scenarios is important. Understanding future developments and industry expectations will give a sense of the direction in which the electric bus sector is heading.

The proposed project plan to carry out the studies in the identified cities under TPEM Gr. 3, is as under:

Activity	Study Requirement
1.Research & study	
Study of EV industry in India	• Study of available documents & secondary data analysis • Research & Knowledge Gathering • Discussion /Meetings with experts and various stakeholders(DHI, DST, MORT&H, MNRE, VMs, STUs, Component manufacturers, Software developers) • Study on Feedback reports along with all stake holder (Ex:- MOP, DISCOMS and other stakeholders)
Review of Global Practices	• Operation models • Best Practices • Technology • Policies adopted to promote EV
Review of Acts, Rules an policies effecting operation of EV in India	• Study, understand and analysis of applicable acts, rules, Schemes & policies. Government Notification
Route identification an feasibility study	• Secondary data • survey • existing study reports • Traffic pattern • Trip information

	• meetings with stake holders
Impact on Grid	• Detailed sub-station- and feeder-level study to assess the local distribution network capacity and congestion probability due to recharging needs and patterns. • Overall regional grid profile and electric transport policy landscape. Demand**,** on peak and off peak, various power sources.
Cost Benefit Analysi Framework	• Total number of buses and distances travelled (per route), public transport modal share, fare structure, over heads, AMC, fuel tariff, Average mileage, life of vehicle, Existing and future plans for EVs. • The benefits provided by the EV adoption
	2.POLICY
Barriers and Opportunities	• Analysis of Barriers, road blocks and pain points **(**High initial cost, huge investment for charging infra, road blocks and prevailing non-favorable Acts, high taxes and duties) • EV vs other fueled vehicles. Merits & demerits • Gather and highlight EV supportive points as opportunities (carbon credits, DHI schemes, subsidies, environmental issues, fuel policies)
Policy changes	• Suggest policy changes to support EV operation. (Changes in electricity act, subsidies on rolling stock, power re-sale policies, exempt/reduce taxes and duties for spares, MV tax exemptions/holidays, make in India, mandate EVs in certain cities)
Business Models- Advertisin policy	• Commercial models for promoting faster adoption of EVs • Incentive mechanism for third party owners and Operators of Charging Stations by the DISCOMS as a percentage of the EV charging revenue.

	• Grid balancing and ancillary services to the DISCOMS which can also be compensated to the Charging Stations Owners/Operators
Standardization and Interoperability	Identify roadblock for standardization of charging infrastructure.
Tariff Designing	• Monetization mechanism of electricity used by EVs for charging and billing of services and the software that takes care of Bill-to-Cash Management for Electro-mobility. • Software applications to manage the charging, billing, driver access, and administration of an EVSE program. • Designing of flexible pricing engine including prepaid and Real time tariff mechanism for EVs during surplus generation and surplus demand (G2V or V2G technologies).
	3.Technology
Geospatial Analysis	• Requirement of GIS map of the city and electricity infrastructure • Simulation of data provided by DISCOM, STUs and other concerned stake holders for Electric Mobility Planning • Identifying types of charging stations at strategic locations • Geo-Spatial Analysis for EVSE Infra Structure creation
Route Mapping	• Parking information. • Ambient Weather Information. • Data required for key electricity supply challenges for electrification of public transportation
Charging Station	• Identification of EVSE Physical components, such as internal electronics, controllers, cord, EV compatible plug and telecommunications devices to share data and enable network connections. • Electrical Load: End of trip State-of-Health (SOH)-Battery

	• Sizing • Siting (Location Identification)
EV technology for the selected city	• Vehicle Segment: 2W, 3W, 4W (M1 & N1) & Buses • City identification: Delhi, Mumbai, Bangalore • Coverage: > 50% geographic (covering all traffic density patterns, both peak & off-peak) • Sample size for each category of vehicle: To be proposed • Vehicles to be used for study: Should be < 3 years old / 40,000 kms • Based on the study, recommend suitable technology for the city.
Depot, Workshop for repair and maintenance	• Bus Chargers at bus depots, bus stops, parking lots • Development of depot infrastructure • Safety measures
4.Capacity building	
Training	Training for driving, vehicle repair & maintenance, Charging, Battery maintenance. Skill development for quality and efficient maintenance.
Maintenance & Inventory management	• Knowhow of different type of Vehicle Technology. AMC support by OEMs for vehicle repair & maintenance, availability of fast moving spares, capacity building for store inventory.
Safety measures	• Safety measures during the charging, parking, operation and repair. • Manual for Dos and Don'ts
Operation	• Driver behaviour. • Traffic pattern (route, day, time & season). • Start, stop & idling (time & numbers). • Speed profile (Average speed, acceleration, deceleration and cruise).