ELECTRIC MOBILITY IN INDIA
Accelerating Implementation
April 2021
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This study was conducted under the guidance of a World Bank team comprising of Amol Gupta, Senior Energy Specialist; Defne Gencer, Senior Energy Specialist; Kavita Saraswat, Senior Power Engineer; and Rohit Mittal, Senior Energy Specialist.

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>2W</td>
<td>Two-Wheeler</td>
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<td>3W</td>
<td>Three-Wheeler</td>
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<td>4W</td>
<td>Four-Wheeler</td>
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<tr>
<td>ARAI</td>
<td>Automotive Research Association of India</td>
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<tr>
<td>BEE</td>
<td>Bureau of Energy Efficiency</td>
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<td>BEV</td>
<td>Battery Electric Vehicle</td>
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<tr>
<td>BRPL</td>
<td>BSES Rajdhani Power Limited</td>
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<td>BYPL</td>
<td>BSES Yamuna Power Limited</td>
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<tr>
<td>CARB</td>
<td>California Air Resource Board</td>
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<td>CFA</td>
<td>Consumer Federation of America</td>
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<td>CNA</td>
<td>Central Nodal Agency</td>
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<td>CNG</td>
<td>Compressed Natural Gas</td>
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<td>CVRP</td>
<td>Clean Vehicle Rebate Project</td>
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<td>DFI</td>
<td>Development Finance Institution</td>
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<td>DHI</td>
<td>Department of Heavy Industry</td>
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<td>DISCOM</td>
<td>Electricity Distribution Company</td>
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<td>DR</td>
<td>Demand Response</td>
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<td>DRC</td>
<td>Democratic Republic of Congo</td>
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<td>DSM</td>
<td>Demand Side Management</td>
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<td>DST</td>
<td>Department of Science and Technology</td>
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<tr>
<td>DT</td>
<td>Distribution Transformer</td>
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<td>ERC</td>
<td>Energy Regulatory Commissions</td>
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<td>EV</td>
<td>Electric Vehicle</td>
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<td>EVSE</td>
<td>Electric Vehicle Supply Equipment</td>
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<td>FAME</td>
<td>Faster Adoption and Manufacturing of Hybrid and Electric Vehicles</td>
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<td>FICCI</td>
<td>Federation of Indian Chambers of Commerce &amp; Industry</td>
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<td>GCC</td>
<td>Gross Cost Contract</td>
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<td>GIZ</td>
<td>Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH</td>
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<tr>
<td>GoI</td>
<td>Government of India</td>
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<td>GSI</td>
<td>Geological Survey of India</td>
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<td>HVIP</td>
<td>Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project</td>
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<td>ICE</td>
<td>Internal Combustion Engine</td>
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<td>IPDS</td>
<td>Integrated Power Development Scheme</td>
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<td>KABIL</td>
<td>Khanij Bidesh India Limited</td>
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<td>LBNL</td>
<td>Lawrence Berkeley National Laboratory</td>
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<tr>
<td>LCO</td>
<td>Lithium Cobalt Oxide</td>
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<td>LCV</td>
<td>Light Commercial Vehicle</td>
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<td>LFP</td>
<td>Lithium Iron Phosphate</td>
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<td>LMO</td>
<td>Lithium Manganese Oxide</td>
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<tr>
<td>MNRE</td>
<td>Ministry of New and Renewable Energy</td>
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<td>MoEFCC</td>
<td>Ministry of Environment, Forest and Climate Change</td>
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<td>MoHIPE</td>
<td>Ministry of Heavy Industries and Public Enterprises</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>MoM</td>
<td>Ministry of Mines</td>
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<td>MoP</td>
<td>Ministry of Power</td>
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<td>MoRTH</td>
<td>Ministry of Road Transport and Highways</td>
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<td>MUD</td>
<td>Multi-Unit Dwelling</td>
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<tr>
<td>NCA</td>
<td>Lithium Nickel Cobalt Aluminum Oxide</td>
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<tr>
<td>NDC</td>
<td>Nationally Determined Contribution</td>
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<td>NEV</td>
<td>New Energy Vehicle</td>
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<td>NGCM</td>
<td>National Geochemical Mapping</td>
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<tr>
<td>NGPM</td>
<td>National Geophysical Mapping</td>
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<tr>
<td>NIP</td>
<td>National Infrastructure Pipeline</td>
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<tr>
<td>NMC</td>
<td>Lithium Nickel Manganese Cobalt Oxide</td>
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<td>NREDCAP</td>
<td>Non-conventional Energy Development Corporation of Andhra Pradesh Limited</td>
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<tr>
<td>NSP</td>
<td>National Service Provider</td>
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<tr>
<td>OCPI</td>
<td>Open Charge Point Interface</td>
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<td>OCPP</td>
<td>Open Charge Point Protocol</td>
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<td>OSCP</td>
<td>Open Smart Charging Protocol</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<td>OGP</td>
<td>Obvious Geological Potential</td>
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<tr>
<td>OpenADR</td>
<td>Open Automated Demand Response</td>
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<tr>
<td>PCS</td>
<td>Public Charging Station</td>
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<td>PHEV</td>
<td>Plug-in Hybrid Electric Vehicle</td>
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<td>PSB</td>
<td>Public Sector Bank</td>
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<td>PSU</td>
<td>Public Sector Undertaking</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
</tr>
<tr>
<td>RERC</td>
<td>Rajasthan Electricity Regulatory Commission</td>
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<td>RMI</td>
<td>Rocky Mountain Institute</td>
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<tr>
<td>RTO</td>
<td>Regional Transport Office</td>
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<td>RWA</td>
<td>Resident Welfare Association</td>
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<td>SDS</td>
<td>Sustainable Development Scenario</td>
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<td>SECI</td>
<td>Solar Energy Corporation of India</td>
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<tr>
<td>SERC</td>
<td>State Electricity Regulatory Commission</td>
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<td>SEZ</td>
<td>Special Economic Zone</td>
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<td>SIAM</td>
<td>Society of Indian Automobile Manufacturers</td>
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<td>SMEV</td>
<td>Society of Manufacturers of Electric Vehicles</td>
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<td>SNA</td>
<td>State Nodal Agency</td>
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<td>STEPS</td>
<td>State Policies Scenario</td>
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<td>STU</td>
<td>State Transport Undertaking</td>
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<tr>
<td>ToD</td>
<td>Time of Day</td>
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<tr>
<td>ToU</td>
<td>Time of Use</td>
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<tr>
<td>TWh</td>
<td>Terawatt hour</td>
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<tr>
<td>ULB</td>
<td>Urban Local Body</td>
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<tr>
<td>UPS</td>
<td>Uninterruptible Power Supply</td>
</tr>
<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<tr>
<td>V2G</td>
<td>Vehicle-to-grid</td>
</tr>
<tr>
<td>VKMs</td>
<td>Vehicular Kilometers</td>
</tr>
<tr>
<td>ZEV</td>
<td>Zero Emission Vehicle</td>
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</table>
Governments, automotive manufacturers, energy companies, charging infrastructure operators, mobility service providers, technology providers and aggregators across the globe are preparing themselves for a rapid transition from conventional internal combustion engine (ICE) vehicles to electric mobility. Increasing from the current global sales of 2.1 million units in 2019, electric vehicles are expected to account for nearly 57% of all vehicle sales and over 30% of all vehicle fleet by 2040. International experience indicates that the key factors responsible for driving this transition are a) conducive policy and regulatory support across the electric mobility value chain, b) technological advancements (new and improved battery chemistries, automation in retail electricity business) and c) increased customer preference for green mobility options (influenced by rising fuel prices and concerns regarding local air pollution, climate change).

Successful transition to electric mobility is critical for India since it already faces severe air-pollution challenges with half of the 50 most polluted cities being in India. This will also facilitate in reducing the current heavy dependence on oil imports, with close to 84% of oil demand being met through this route. The Government of India is therefore, steadily moving towards a “shared, connected and electric” mobility ecosystem to achieve its stated goals on emissions reductions, energy security and industrial development. It is doing so through wide-ranging policy and regulatory measures to encourage EV adoption, creation of public charging infrastructure and incentivizing domestic EV and battery manufacturing facilities.

An analysis was undertaken by the World Bank to review the development of e-mobility in India, identify remaining challenges and mitigation measures to support India’s electric mobility vision. This report presents the findings of the analysis and lays out a set of recommendations for consideration by different stakeholders.

The key findings and recommendations are summarized below:

- **Range anxiety** (the fear that a vehicle has insufficient range to reach its destination and would thus strand the vehicle’s occupants) would be a critical factor for EV uptake in India. Therefore, charging infrastructure needs to precede the deployment of EVs. Ensuring reliable power supply, adequate grid

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1. The terms electric mobility, electromobility and e-mobility will be used interchangeably in the report. Unless otherwise mentioned, it will refer to road-based commute based on electric vehicles in urban areas, as defined by various Governments globally and wherever applicable.
3. Bloomberg New Energy Finance (BNEF)
4. 2019 World Air Quality Report - Region & City PM 2.5 Ranking by IQAir
5. The Economic Times, updated on May 05, 2019
infrastructure and viable business models for setting up charging infrastructure will play a major role in large scale deployment of EVs.

Development of electric mobility ecosystem in India may follow a different growth trajectory as compared to developed or economically varied global EV markets. In India, the transition is expected to be driven by private two-wheelers and public three-wheelers that dominate the shared mobility space. This also makes the battery swapping model significant for India as it reduces upfront EV cost and increases commercial run time of the e-vehicle (which is often worked in multiple daily shifts).

While EV penetration will not have any major impact on electricity generation and transmission infrastructure, the distribution network will require investments – for enhanced technical planning and upgradation of network. The additional electricity demand likely to arise from EV charging could range between 2% to 4% of total demand by 2030, which is not significant. However, uncontrolled EV charging could cause disruption in the electricity distribution network, through increase in peak demand, overloading, phase imbalance, power quality issues and power losses. Though such impacts are expected to be localized and concentrated mainly in the urban areas, DISCOMs would need to upgrade their technical planning skills and tools and use digital technologies to monitor the network. Investments for procurement of planning tools, training and network upgradation would be necessary.

While uncontrolled EV charging could lead to an increase in peak demand at distribution level, smart charging is a boon for distribution network operators. Smart EV chargers, with suitable communication and control protocols, can help manage the disruption of distribution network and even improve power quality by supporting voltage and reactive power control of distribution networks. DISCOMs may also utilize smart charging of EVs to support their Demand Side Management (DSM) programs. DISCOMs may therefore be mandated to establish a simplified and fast-track approval process for smart EV chargers. The process for EV charger approvals could become part of “Ease of Doing Business” matrix for DISCOMs.

Given the evolving nature of EV deployment, the state regulators are still in the process of developing an understanding of issues. Regulatory mechanisms to review network augmentation plans, approve investments and provide tariff and other incentives to encourage EV deployment need to be formulated.

Central and state governments can leverage electric mobility to increase the share of renewable energy in the power grid and to reduce carbon intensity of energy and transport sector. Government investment in distribution grid planning and upgradation to support deployment of EVs can integrate more distributed energy resources into the network. Through appropriate demand response program and Time of Day (ToD) tariffs, EV charging loads could be shifted to off-peak and high RE generation periods.

Coordinated approach between electricity, transport and urban planning departments is necessary to undertake city level integrated mobility planning. City level electricity network planning and timely upgradation of electricity infrastructure in potentially high EV-demand locations will help in accelerating EV adoption while avoiding network disruption. This will require significant coordination between multiple state departments (energy, transport and land), city municipalities, fleet operators and other relevant entities. Network planning will require robust technical capabilities and data regarding EV growth forecast, charging pattern forecast (broken down to vehicle segments), demographic assessment, transport flow assessment, to name a few. Currently, there is a lack of institutional capacity to undertake such assessments.

Central and state governments should accelerate charging infrastructure
deployment by taking a technology agnostic approach and encourage private sector investments. Globally, the lack of access to convenient and affordable charging infrastructure is seen as a top barrier towards EV adoption. Realizing this, the Government of India has allocated INR 1,000 crore (US$ 137 million6) towards charging infrastructure deployment under the FAME-II scheme. The government may also devise mechanisms for fiscal incentives under FAME-II scheme to flow towards private sector charge-point operators to drive innovation, rapid proliferation and cost reduction in the EV charging space.

2W and 3W segments contribute to 50% of the total subsidy outlay and 96% of the total number of vehicles targeted under FAME-II scheme7. Faster adoption in these segments will lead to overall success of the FAME-II scheme. The benefits of FAME-II subsidy and Goods and Services Tax (GST) reduction needs to be extended towards battery swapping infrastructure also. This will enable faster adoption of EVs in the 2W and 3W segments. Further, the relative lack of EVs on Indian roads creates a lack of confidence among potential consumers. This can be alleviated through access to cheaper commercial financing or in the short-term increasing the subsidy quantum per EV while keeping the total subsidy outlay under FAME-II scheme constant. The additional incentive will make the EV option much more compelling and the following demand will create confidence in other potential consumers, leading to overall achievement of the objectives of FAME-II scheme.

State governments should review the overall ecosystem of bus service delivery and bring in efficiencies in e-Bus procurement. The poor financial health of State Transport Undertakings (STUs) increases the payment risk for e-Bus operators and investors. It is recommended that overall ecosystem of bus service delivery including funding, procurement, information technical services (ITS) and gross cost contracts (GCC) must be reviewed to make them less risky and less onerous to private sector e-Bus contractors.

State governments should aggregate e-Bus procurement across cities to achieve procurement efficiency, better prices, quick deployment and development of robust service network by OEM. Currently, e-Bus procurement initiatives happen at city-level which leads to fragmentation and smaller size contract sizes. Further, the technical and managerial capacity at the city government level is low. This causes delays in e-Bus procurement, leading to eventual delay in deployment and utilization of FAME-II funds. Aggregation of demand and consolidated procurement can lead to better prices and OEM commitment. Drawing long-term e-Bus procurement contracts will also go a long way in providing demand clarity to OEMs and help in achieving scale and overall development of the e-Bus ecosystem.

State governments may create long-term, timebound phasing out targets to encourage EV transition among large taxi fleets and logistics fleets. EVs are currently economically viable compared to ICE vehicles in certain transport applications (like 4W taxis in Tier-1 cities and fleet use of 2W, 3W). Due to comparatively heavier usage (in terms of kilometers), taxi fleets and urban logistics fleets also result in much higher carbon emissions. Hence, it is recommended that central and state governments work with the taxi and urban logistics industry to develop long-term transition roadmaps and phase-wise transition targets.

Innovative EV financing coupled with intensive use of EVs will be a precursor for large-scale EV deployment. Cost-conscious Indian consumers are skeptical to buy EVs due to high upfront cost, therefore EV financing through innovative business and ownership models are necessary to reduce the upfront cost of EVs. High utilization applications of EVs, such as in fleets, achieve total cost of ownership (TCO) parity with ICE vehicles quickly. TCO parity

6 US$ 1 = INR 73
7 Scheme for Faster Adoption and Manufacturing of Electric Vehicles in India Phase II (FAME India Phase II), available on www.fame2.heavyindustry.gov.in
is seen to be achieved with an average daily utilization of around 90-110 kms for 2W; 100-120 kms for 3W and 220-240 km for 4W.

- **Central government should increase quantum and timeliness of access to micro-credit for e-2W and e-3W under the MUDRA scheme.** The initiative of the central government to support micro-credit for e-2W and e-3W through the MUDRA scheme is appreciable. However, there are still certain issues in the quantum and timeliness of credit received, especially since many recipients have poor credit history and banks are often hesitant to extend micro-credit under the MUDRA scheme. To accelerate e-2W and e-3W adoption, the central government may supplement current initiatives with low-cost, long-tenor financing from development financial institutions (DFIs). Risk reduction mechanisms such as portfolio-level guarantees by DFIs, vehicles warranties and buyback guarantee by OEMs will help in creating confidence among lenders to provides loans for EVs.

- **Central government may encourage EV uptake through increasing quantum of incentive per vehicle (while keeping the total subsidy outlay constant) and by providing support for the retrofitting of existing vehicles.** Government may encourage the organized EV retrofitting market and increase organizational capacity of certification institutes for safety considerations.

- **The central government may create a long-term roadmap for transition of automotive industry towards EVs and design skilling and re-skilling programs to create employment opportunities.** The central government may work with the automotive industry and create a long-term industry transition roadmap for each vehicle segment. The roadmap must also include disincentives (emission penalties, scrappage incentives) for operating old ICE vehicles in order to encourage people to buy EVs. Further, the advent of EVs which have less than 1/100th the number of components compared to ICE vehicles could cause job losses in auto-component sector. The government should proactively initiate skilling and re-skilling programs for workers in the industry.

- **Central government may support private sector mineral sourcing and investments in mines globally through government-to-government (G2G) facilitation rather than undertaking public investments.** The demand for batteries is expected to grow rapidly with increased adoption of electric vehicles (EVs). Recycling and reuse of EV batteries is imperative to ensure a sustainable evolution towards electric mobility. The continuously evolving battery technology poses stranded-asset risk to public investments in mines globally. Further, a reliable supply chain of key minerals may attract companies to establish battery manufacturing units in India to cater to the rising demand from EVs. Using its bilateral relations with mineral-rich countries, Government may facilitate the private sector to enter into partnerships/joint ventures with global mining companies to ensure continuous supply of various strategic\(^8\) and rare earth\(^9\) minerals essential for manufacturing of batteries.

- **Central government may encourage the battery manufacturing industry through provision of long-term roadmap, incentives, R&D support and demand creation initiatives.** Lack of adequate domestic battery manufacturing could result in import dependence. However, the current lack of demand visibility in downstream applications such as EVs and stationary storage do not provide enough confidence to the private sector to setup battery manufacturing in India. Hence, it is recommended that the government may provide a clear long-term roadmap for automotive and power industry to create demand. Given the importance of automotive sector for the Indian economy, the government may provide direct and indirect tax benefits to the battery manufacturing industry. This

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\(^8\) Strategic minerals are tin, cobalt, lithium, beryllium, germanium, gallium, indium, tantalum, niobium, selenium and bismuth

\(^9\) Rare earth elements are 17 elements which have extremely less economically exploitable mineral ore deposits; neodymium and samarium are used in permanent magnets of motors
may be coupled with R&D support to create new battery technologies suitable for Indian climatic conditions.

- **The central government should promote battery recycling through mandates on used-battery collection and incentive support.** With many EV batteries reaching end-of-life, battery reuse and recycling will become a significant area of concern. Second life EV batteries could be used in applications such as behind the meter, uninterrupted power supply in residential and other buildings, and micro-grid applications. While experience indicates that such use of battery is likely to develop as an unorganized market, regulations could be framed to require battery manufacturers and sellers to collect used batteries and maintain a database of all the batteries sold and collected. Further impetus to this area may be provided through innovation-challenge grants for improved battery design facilitating easy dismantling and recycling of batteries.

- **Central and state governments should move towards implementation-focused assessments through government-industry-academia collaboration on electric mobility.** Further research is required in various areas such as creation of mobility transition roadmaps, implementation plans, assessment frameworks, financing models and provide implementation support to multiple stakeholders for accelerating EV adoption in India.

Several policies and schemes such as National Mission on Transformative Mobility and Battery Storage, the Phased Manufacturing Plan, Faster Adoption and Manufacturing of Electric Vehicle Scheme II, state-level policies and various fiscal incentives are already introduced by India for faster EV adoption. However, despite efforts by the central and state governments to spur electric mobility uptake and domestic manufacturing, various market and implementation challenges exist currently in this transition. The following section gives a brief on the identified key issues and the suitable recommendations to accelerate EV adoption in India.
The following eight chapters of the report, each dedicated to the one value chain segment of the EV value chain, provide details on strategic importance, current scenario, challenges, recommendations and further required studies. A summary of those recommendations against each value chain segment is provided below.

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<tr>
<th>No.</th>
<th>Issue</th>
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<tbody>
<tr>
<td></td>
<td><strong>Power Supply and Grid Infrastructure</strong></td>
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<tr>
<td>1</td>
<td>Lack of adequate grid capacity at distribution transformer level for installation of charging infrastructure and lack of coordination among state departments to undertake city planning and grid impact assessments</td>
<td>Undertake grid augmentation in high potential areas through better coordination among departments in state-level and city-level governments</td>
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<td></td>
<td>State governments, state energy departments, DISCOMs, state urban departments</td>
<td>Short term</td>
</tr>
<tr>
<td>2</td>
<td>Lack of capacity among DISCOMs to undertake EV forecasts, demographic assessments, transport flow assessments and other studies to effectively plan grid infrastructure upgradation for EVs</td>
<td>Build technical capacity among SERCs and DISCOMs in cooperation with transport departments to plan, execute and regulate investments for EV-related grid infrastructure</td>
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<td>3</td>
<td>Lack of mandate on communication protocols for smart charging</td>
<td>Develop guidelines to mandate installation of smart chargers with suitable communication protocols</td>
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<tr>
<td>4</td>
<td>Lack of dynamic, comprehensive ToD/ToU programs to shift EV charging demand to off-peak hours and enable RE integration</td>
<td>Facilitate load shifting by introducing ToD/ToU tariff mechanism</td>
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<tr>
<td>5</td>
<td>Financial health of DISCOMs remains weak and limits their ability to invest in network upgrades to accommodate EV charging</td>
<td>Allow cost recovery of capital and operational costs incurred by DISCOMs for grid augmentation due to EV charging through ARR filings</td>
</tr>
<tr>
<td>6</td>
<td>Lack of freely available information regarding availability of grid capacities for installation of charging infrastructure by charge point operators and fleet operators</td>
<td>DISCOMs should publish a map of distribution assets along with available capacities in the public domain</td>
</tr>
<tr>
<td>7</td>
<td>Lack of clarity on EV tariffs and associated charges across states</td>
<td>Introduce time-bound waiver of fixed/demand charges and other surcharges on EV tariff</td>
</tr>
<tr>
<td>8</td>
<td>Lack of supporting adequate policy and regulatory support to encourage use of renewable energy for EV charging</td>
<td>Undertake policy and regulatory interventions to encourage use of renewable energy for EV charging including: a) reduction of open access threshold for procurement of RE; and b) mandate DISCOMs to set-off all EV charging demand in a certain year through RE purchase additional to existing RPO obligation</td>
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### Charging Infrastructure Deployment

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<th>Issue</th>
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<th>Stakeholder(s)</th>
<th>Timeline</th>
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<tbody>
<tr>
<td>1</td>
<td>Lack of FAME-II subsidy support for charging infrastructure flowing to the private sector companies</td>
<td>Devise mechanisms for fiscal incentives under DHI’s FAME-II subsidy to flow towards private sector charge-point operators to drive innovation, rapid proliferation and cost reduction through efficient deployment in natural spaces such as homes, office, shopping places, gas stations</td>
<td>DHI, MoP</td>
<td>Short term</td>
</tr>
<tr>
<td>2</td>
<td>Lack of enough scale and density of chargers in potentially high EV-demand cities which leads to lack of consumer confidence in public EV charging infrastructure</td>
<td>Charging infrastructure installation should be focused on top EV-demand cities in the early stages of the market. The expansion to other cities should be done based on holistic assessments to understand the type of public charging infrastructure required</td>
<td>DHI</td>
<td>Short medium term</td>
</tr>
<tr>
<td>3</td>
<td>Lack of subsidy support for battery swapping model (esp. in e-2W, e-3W segments)</td>
<td>In line with battery swapping getting included under MoP guidelines, provide subsidy support for battery swapping model in the FAME-II scheme</td>
<td>DHI, MoF</td>
<td>Short medium term</td>
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<tr>
<td>4</td>
<td>High GST for swappable batteries sold separate from vehicles (including spare batteries) and battery swapping services</td>
<td>Reduce GST on swappable batteries, charging service and battery swapping service from 18% to 5% in line with GST rates for EVs, EV chargers and factory-fitted batteries in EVs</td>
<td>MoF</td>
<td>Short term</td>
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<td>No.</td>
<td>Issue</td>
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<td>Stakeholder(s)</td>
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<tr>
<td>5</td>
<td>Lengthy and inefficient approval process followed by DISCOMs for EV chargers; lack of institutional accountability for timely approval of EV chargers and installation of associated infrastructure</td>
<td>Establish a simplified and fast-track approval process for EV chargers and rate DISCOMs on the process for getting EV charger approvals as part of ease of doing business matrix for DISCOMs</td>
<td>CERC, SERCs, DISCOMs</td>
<td>Short medium term</td>
</tr>
<tr>
<td>6</td>
<td>High cost of enhancing LT level grid infrastructure for EV chargers (at homes, workplaces, commercial and public spaces)</td>
<td>Encourage DISCOMs to incur grid infrastructure upgradation cost and provide “plug and play” connections to charge point operators (CPOs)</td>
<td>SERCs, MoHUA</td>
<td>Short term</td>
</tr>
<tr>
<td>7</td>
<td>Inability of potential EV users to set-up EV charging in multi-unit dwellings (MUDs)</td>
<td>Mandate Residential Welfare Associations (RWAs) under MUD’s purview to allocate parking spaces and allow separate metering connections for EV users</td>
<td>MoHUA, SERCs, DISCOMs</td>
<td>Short term</td>
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**EV Financing**

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<th>No.</th>
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<th>Stakeholder(s)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Inadequate payment security for investors and lenders and onerous requirements on performance security for e-Bus contracts under gross cross contract (GCC) model</td>
<td>Review the GCC contracts and balance the risks between contractor and employer. A detailed World Bank Study is ongoing on this topic</td>
<td>MoRTH, state transport departments, city municipalities</td>
<td>Short medium term</td>
</tr>
<tr>
<td>2</td>
<td>Fragmented e-Bus procurement initiatives among cities leading to cost inefficiency in public bus procurement; Lack of long-term demand clarity for e-Bus OEMs leading to small scale production and high unit costs</td>
<td>Standardize financial conditions and specifications in procurement contracts; aggregate procurement at state level and draw out long term procurement plan staggered over years</td>
<td>MoRTH, state transport departments, city municipalities</td>
<td>Short medium term</td>
</tr>
<tr>
<td>3</td>
<td>Lack of quick and collateral-free micro-credit for e-3W and e-2W</td>
<td>Support micro-credit access for e-2W and e-3W to micro-finance institutions through MUDRA scheme</td>
<td>MoF, DHI</td>
<td>Short medium term</td>
</tr>
<tr>
<td>4</td>
<td>High perceived risk by banks and hesitance in providing loans for e-2W, e-3W; provision of loan at high interest rates and short repayment periods due to high risk perception</td>
<td>Supplement lower-cost, longer-tenor DFI financing to support micro-credit access for e-2W, e-3W and work closely with OEMs to explore additional risk reduction models such as extended warranties, buy-back offers and residual value guarantees to increase confidence among financiers about EVs</td>
<td>PSBs, NBFCs, micro finance institutions</td>
<td>Short medium term</td>
</tr>
</tbody>
</table>

10 Micro Units Development and Refinance Agency Ltd. (MUDRA) is an NBFC supporting development of micro enterprise sector in the country. MUDRA provides refinance support to Banks/MFIs/NBFCs for lending to micro units having loan requirement up to 10 lakhs. MUDRA provides refinance support to micro business under the Scheme of Pradhan Mantri MUDRA Yojana.
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<tbody>
<tr>
<td></td>
<td><strong>EV Deployment</strong></td>
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<tr>
<td>1</td>
<td>High upfront cost of EVs</td>
<td>Increase the quantum of FAME subsidy per EV, rather than targeting more EVs with lesser subsidy with a focus of most sustainable vehicle segments. Commercial financing should also be explored to reduce the cost parity with ICE counterparts and accelerate adoption</td>
<td>DHI</td>
<td>Short term</td>
</tr>
<tr>
<td>2</td>
<td>Lack of high-quality EVs in India and poor consumer perception regarding performance and range of EVs</td>
<td>Allow import of up to 25,000 EVs per OEM at zero or reduced customs duty based on existing investments made by the OEMs operating in India</td>
<td>DHI, MoF</td>
<td>Short term</td>
</tr>
<tr>
<td>3</td>
<td>Lack of incentives for retrofitting and inadequate certification infrastructure to tackle upcoming retrofitting demand</td>
<td>Develop regulations to encourage the organized EV retrofitting market and increase organizational capacity to ramp-up the certification infrastructure for safety considerations</td>
<td>DHI, ARAI</td>
<td>Medium term</td>
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<tr>
<td>4</td>
<td>Absence of disincentives/mandates for large fleet operators (which are responsible for major portion of vehicular pollution) to transition towards EVs</td>
<td>Mandate fleet transition trajectories for certain “obligated entities” such as large fleet operators for certain vehicle segments over fixed timelines</td>
<td>MoRTH, state road transport governments, city municipalities</td>
<td>Medium long term</td>
</tr>
<tr>
<td>5</td>
<td>Lack of any preferential incentive for replacing old ICE vehicles with EVs rather than another ICE vehicle</td>
<td>Provide higher incentives for replacement of old vehicles with EVs compared to ICE vehicles under the planned Vehicle Scrappage Policy</td>
<td>MoRTH, DHI</td>
<td>Medium term</td>
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<td></td>
<td><strong>EV Manufacturing</strong></td>
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<tr>
<td>1</td>
<td>Lack of clear long-term roadmap for automotive industry’s transition to electric vehicles</td>
<td>Create a long-term industry transition roadmap with strict enforcement of intermediate targets</td>
<td>DHI</td>
<td>Short medium term</td>
</tr>
<tr>
<td>2</td>
<td>Economic over dependence on auto-components sector</td>
<td>Develop a clear, technology-agnostic transition roadmap for auto-component industry with a focus on innovation; design skilling programs and re-skilling programs to tackle the lack of EV specific skills and job losses respectively</td>
<td>DHI, NSDC, Ministry of Skills Development and Entrepreneurship</td>
<td>Short medium term</td>
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<td><strong>Mining and Mineral Sourcing</strong></td>
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<tr>
<td>1</td>
<td>Non-availability of battery minerals in India Continuous evolving battery technology goal post which poses stranded-asset risk to public investments in mines globally</td>
<td>Support private sector mineral sourcing and investments in mines globally through government to government (G2G) facilitation rather than undertaking public investments</td>
<td>DHI, MoM</td>
<td>Medium term</td>
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<tr>
<td>1</td>
<td><strong>Battery Manufacturing</strong>&lt;br&gt;Lack of long term industry roadmap and policy commitment for domestic battery manufacturing and downstream applications&lt;br&gt;High dependency on imported oil which increases India’s current account deficit (CAD)</td>
<td>Provide long term policy clarity and firm target commitments in downstream applications such as electric vehicles and battery storage power systems in a technology agnostic manner</td>
<td>DHI, NITI Aayog, MoP</td>
<td>Short long term</td>
</tr>
<tr>
<td>2</td>
<td>Lack of long-term support for demand creation in downstream applications such as EVs and battery storage power systems</td>
<td>Provide long term demand creation incentives and favorable regulatory support for the electric vehicles and power sector</td>
<td>DHI, MoP</td>
<td>Medium long term</td>
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<tr>
<td>3</td>
<td>Lack of cost competitiveness of Indian battery manufacturing compared to other global hubs (esp. China)</td>
<td>Provide direct tax benefits (corporate tax and MAT reduction) for specific time period to attract battery manufacturers to India</td>
<td>DHI, MoF, NITI Aayog</td>
<td>Short medium term</td>
</tr>
<tr>
<td>4</td>
<td>Risk perception among battery OEMs regarding multiple clearances required and availability of adequate trunk infrastructure</td>
<td>Support battery OEMs in setting up battery manufacturing facilities through provision of trunk infrastructure and single window clearance</td>
<td>DHI, NITI Aayog, State Governments</td>
<td>Short medium term</td>
</tr>
<tr>
<td>5</td>
<td>Global battery manufacturers have already made investment commitments in other countries</td>
<td>Implement a stable customs duty regime on battery imports in consultation with automotive OEMs and battery OEMs</td>
<td>DHI, MoF, NITI Aayog</td>
<td>Short medium term</td>
</tr>
<tr>
<td>6</td>
<td>Inadequate battery localization (for Indian conditions) and testing infrastructure for the same</td>
<td>Increase investment in battery R&amp;D and testing infrastructure to test current and new battery technologies for local conditions</td>
<td>DHI</td>
<td>Short term</td>
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<tr>
<td>7</td>
<td>Inadequate testing infrastructure and consumer concerns around promised vs. real world battery performance</td>
<td>Increase investment in testing infrastructure and ensure strict testing standards to alleviate consumer concerns around battery performance and safety</td>
<td>DHI, ARAI</td>
<td>Short medium term</td>
</tr>
<tr>
<td>1</td>
<td><strong>Battery Recycling and Second Life</strong>&lt;br&gt;Absence of specific regulatory framework on collection and recycling of lithium ion batteries from automotive applications</td>
<td>Impose extended producer responsibility (EPR) norms on battery manufacturers and mandate battery sellers to maintain a database of all the batteries sold and collected</td>
<td>MoEFCC, DHI</td>
<td>Short term</td>
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<tr>
<td>2</td>
<td>Insufficient recovery rate and purity of battery minerals during various recycling procedures</td>
<td>Provide innovation-challenge grants to encourage development of innovative designs for battery packaging</td>
<td>DHI</td>
<td>Short medium term</td>
</tr>
<tr>
<td>3</td>
<td>Current unattractive business case for establishing battery recycling units</td>
<td>Provide fiscal and non-fiscal benefits for companies setting up urban mining companies</td>
<td>MoEFCC, DHI, MoF</td>
<td>Medium term</td>
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<tr>
<td>4</td>
<td>Lack of demand for recycled batteries in applications where they can meet the desired performance requirements</td>
<td>Encourage use of recycled batteries in grid-connected energy storage projects and telecom towers</td>
<td>MoP, TRAI</td>
<td>Medium long term</td>
</tr>
<tr>
<td>5</td>
<td>Lack of awareness among consumers and battery intermediaries on benefits of battery second life and battery recycling</td>
<td>Implement an information, communication and education program on battery recycling and second life targeted at end consumers</td>
<td>MoEFCC, DHI</td>
<td>Medium long term</td>
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</table>
Around 14% of the global greenhouse gas emissions is attributed to the transport sector and nearly 72% of transport sector emissions are accounted for by road-based transport. Therefore, if the transition to EVs is made in a way to reduce aggregate emissions, it presents a substantial emission-reduction potential for countries, also enhancing their declared contributions to the Paris Agreement. Road-based transport represents around 40% of the global oil demand. Countries dependent on imported oil, such as India and China, view electric mobility transition as a potential opportunity towards gaining energy independence.

1. Growth Forecast for EVs in India

According to Society of Indian Automobile Manufacturers (SIAM), nearly 21.5 million\textsuperscript{11} internal combustion engine (ICE) vehicles were sold in fiscal year 2019-20 in India. As per Society of Manufacturers of Electric Vehicles (SMEV), around 0.15 million electric vehicles (EVs) were sold in FY20, which excluded the sale of e-rickshaws\textsuperscript{12}. With no official data, owing to the largely unorganized sector of e-rickshaws, it is estimated that around 90,000 units could have been sold in FY20. Of the total number of vehicles sold, the majority were two-wheelers, accounting for nearly 80% of ICE vehicle sales and 97.5% of EV sales. Based on total ICE sales and EV sales, it is clear that annual EV sales as percentage of total vehicle sales is currently below 1% in India.

The Global EV Outlook 2020\textsuperscript{13} estimated that India could achieve 30% EV sales penetration around 2030 as a consequence of existing policies and it could reach 55% if aggressive measures are implemented to achieve the goal of limiting the global temperature rise to below 1.7-1.8°C. A report by NITI Aayog and Rocky Mountain Institute (RMI)\textsuperscript{14} estimated EV sales

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11 Society of Indian Automobile Manufacturers (SIAM)
12 Bloomberg Quint
13 Global EV Outlook 2020
14 India’s Electric Mobility Transformation – NITI Aayog & Rocky Mountain Institute
penetration trend based on the effect of FAME-II scheme, other electric mobility supporting policies in India and stakeholder consultations with industry experts. Figure 1 depicts the EV sales penetration projected from 2020 to 2030, it is projected that by 2030 in India, EV sales penetration will be 80% for 2 and 3-wheelers, 70% for commercial cars, 40% for buses and 30% for private cars. A total of approximately 80 million EVs are expected to be sold in 2030, of that 70% are 2-wheelers and 3-wheelers, rest are cars and buses.

In the FAME-II scheme, out of the total fund of US$ 1.3 billion, nearly 35% is allocated for e-Buses and 25% for electric 3-wheelers which are aimed at public transportation. Therefore, transition of public transportation towards e-mobility is one of the top priorities for the central government.

2. Growth Forecast for EV Charging Infrastructure in India

By the end of 2019, there were 1,827 publicly accessible EV chargers in India, of which only 5% were fast chargers. The growth of publicly accessible slow and fast chargers in India is depicted in the figure given below.

It can be observed that the number of fast chargers is minimal as compared to the number of slow chargers. To increase the availability of public chargers, the Ministry of Heavy Industries sanctioned 2,636 charging stations across 62 cities in India under the FAME-II scheme in January 2020. Out of the 2,636 charging stations, 1,633 would be fast chargers

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15 India’s Electric Mobility Transformation – NITI Aayog & Rocky Mountain Institute
16 Department of Heavy Industries
17 Global EV Outlook 2020
18 Global EV Outlook 2020
19 Ministry of Heavy Industries & Public Enterprises
charging stations and remaining 1,003 would be slow charging stations.

The Government of India aims to promote EV adoption by providing public charging infrastructure every 3 kms within cities and at every 25 km on national highways; and facilitating destination charging across multi-storied buildings and commercial centers. Considering only the minimum requirements laid down by MoP\textsuperscript{20} regarding density/distance between two public charging stations (PCS), the estimated number\textsuperscript{21} of PCS for roll-out of EV public charging infrastructure in India is depicted in the figure given below.

Presently, many electric car or electric 2-wheeler owners charge their EVs at home but according to research, 60-70\% of Indian vehicle owners do not have a dedicated parking space at home\textsuperscript{24}. With lack of dedicated parking spaces for vehicles, public charging will be more prevalent in future in India, as compared to home-charging.

3. Growth forecast for batteries in India

The evolution of electric mobility has spurred an increase in the demand for batteries which will lead to large-scale manufacturing and cost reduction of batteries. Research indicates that energy density of batteries will increase from 200-250 Wh/kg in 2018 to 400-500 Wh/kg in 2025 while the price will fall from US$ 176/kWh in 2018 to anywhere between US$ 100/kWh and US$ 75/kWh in 2025\textsuperscript{25}. The increasing energy densities and falling battery costs will lead to EVs reaching price parity between 2025 and 2029, depending on the vehicle segment\textsuperscript{26}.

According to a FICCI and RMI report\textsuperscript{27}, to meet the demands of a 100\% EV market by 2030, India would require at least 800 GWh of batteries per year. The domestic market for EV batteries in India is estimated to be US$ 300 billion between 2017 and 2030.

4. Growth Forecast for Electricity Consumption from Electric Mobility

Various studies have different estimates of the electricity demand from EV charging based on varying growth scenarios. A study by Brookings India estimated that the electricity demand could vary from 37 TWh under 33\% penetration of EV sales in 2030 to 97 TWh under 100\% penetration

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\textsuperscript{20} Ministry of Power
\textsuperscript{21} EY Analysis – Assumptions for Phase – 1: 9 Mega cities and 12 corridors; Phase – 2: 12 state capitals and 35 state highways connecting major cities; Phase – 3: remaining Indian urban land area and under construction highways/expressways. Considered 1 PCS per 3x3 grid in cities and 1 PCS at every 25 km on both sides of highways. Each PCS could have one or more EV chargers as specified in the MoP guidelines. The data on area of cites and population considered from 2011 census.

\textsuperscript{22} EY Analysis

\textsuperscript{23} EY Analysis - As per Ministry of Power guidelines on public charging stations (cumulative of every Charging Infrastructure technology as per MoP guidelines and standards) and national priority for rollout of EV Public Charging Infrastructure.

\textsuperscript{24} Stakeholder Consultation
\textsuperscript{25} BloombergNEF Report
\textsuperscript{26} BloombergNEF
\textsuperscript{27} Enabling the Transition to Electric Mobility in India – FICCI & RMI
of EV sales in 2030\textsuperscript{28}. The electricity demand was estimated based on estimated EV stock, annual vehicular kilometers (VKMs) per vehicle in 2030 and performance of EVs (km/kWh)\textsuperscript{29}.

**FIGURE 4: Vehicular Category-wise Electricity Demand by EVs in 2030 in India\textsuperscript{30}**

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<thead>
<tr>
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<th>2030 (UB)</th>
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<td>Buses</td>
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It is observed that the highest electricity demand is from e-Buses and they also have the least performance efficiency (km/kWh). Buses and cars constitute more than 50% of the demand followed by 3-wheelers, 2-wheelers and taxis.

In 2030, according to Global EV Outlook 2020\textsuperscript{31}, in India, the electricity demand from EVs is expected to be approximately 33 TWh under the STEPS\textsuperscript{32} scenario and nearly 83 TWh under SDS\textsuperscript{33} scenario.

**IMPACT OF ELECTRIC MOBILITY ON THE POWER SECTOR**

The impending increase in EV penetration will inevitably cause a rise in electricity demand if there is no significant fall in demand from other sectors. The integration of EV charging infrastructure with the grid creates both challenges and opportunities for the power sector.

Table 1 gives an overview of the key impacts of EVs on the three stages of electrical power supply to the consumers.

Each of the impacts on the power sector are explained in detail in the following sections.

1. Impact of Electric Mobility on Power Generation and Transmission

Being a growing economy, India is witnessing increasing electricity consumption in all the economic sectors. With the rise of e-mobility, the electricity consumption on account of EVs will rise but is expected to be minor when compared to overall power demand from other sectors.

The Global EV Outlook 2020\textsuperscript{34} estimated that the share of electricity consumption attributable to EVs in India by 2030 is 2% under the STEPS and 3% under SDS scenarios\textsuperscript{35}. In another study by LBNL, the range of annual BEV energy consumption\textsuperscript{36} in 2030 is 62–103 TWh and the peak load is 19–39 GW\textsuperscript{37}. This energy demand is projected to constitute

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\textsuperscript{28} Electrifying Mobility in India – Brookings India

\textsuperscript{29} The analysis has been carried out for intra-state kilometres travelled by passenger vehicles. EV penetration was calculated based on NEMMP 2020 targets and the author’s calculations. Scenarios defined: UB – Upper bound (Ambitious scenario), LB – Lower Bound (Modest scenario). FY 2014-15 has been considered as the base year. Active vehicles per 1000 persons (2030): 2W – 212; 4W – 63; Buses – 3; 3W – 17. Annual intra-city VKMs/vehicles estimated (2030): Cars – 4,908; Taxis – 12,093; Buses – 9040; 2W – 4,073; 3W – 11,175

\textsuperscript{30} Electrifying Mobility in India – Brookings India

\textsuperscript{31} Global EV Outlook 2020 – The electricity demand was from EVs was evaluated using the Mobility Model (IEA 2020)

\textsuperscript{32} State Policies scenario (STEPS) - Illustrates the likely consequences of existing and announced policy measures. Estimated EV share of vehicle sales in 2030: 2/3Ws – 44%; LDVs – 6%; Buses – 7%; Trucks – 1%

\textsuperscript{33} Sustainable Development Scenario (SDS) - Based on limiting the global temperature rise to below 1.7-1.8 °C with a 66% probability to reach net zero emissions by 2070. Estimated EV share of vehicle sales in 2030: 2/3Ws – 67%; LDVs – 26%; Buses – 24%; Trucks – 2%

\textsuperscript{34} Global EV Outlook 2020

\textsuperscript{35} Electricity demand from EVs was evaluated with the Mobility model (IEA, 2020); total final electricity consumption from (IEA, 2020) and IEA (forthcoming)

\textsuperscript{36} Techno-Economic Assessment of Deep Electrification of Passenger Vehicles in India - Ernest Orlando Lawrence Berkeley National Laboratory

\textsuperscript{37} Electrifying Mobility in India – Brookings India

\textsuperscript{32} The electricity demand from EVs was evaluated using the Mobility Model (IEA, 2020)

\textsuperscript{33} State Policies scenario (STEPS) - Illustrates the likely consequences of existing and announced policy measures. Estimated EV share of vehicle sales in 2030: 2/3Ws – 44%; LDVs – 6%; Buses – 7%; Trucks – 1%

\textsuperscript{34} Global EV Outlook 2020

\textsuperscript{35} Electricity demand from EVs was evaluated with the Mobility model (IEA, 2020); total final electricity consumption from (IEA, 2020) and IEA (forthcoming)

\textsuperscript{36} Techno-Economic Assessment of Deep Electrification of Passenger Vehicles in India - Ernest Orlando Lawrence Berkeley National Laboratory

\textsuperscript{37} Electrifying Mobility in India – Brookings India

\textsuperscript{32} The electricity demand from EVs was evaluated using the Mobility Model (IEA, 2020)

\textsuperscript{33} State Policies scenario (STEPS) - Illustrates the likely consequences of existing and announced policy measures. Estimated EV share of vehicle sales in 2030: 2/3Ws – 44%; LDVs – 6%; Buses – 7%; Trucks – 1%
less than 4% of the aggregate country-wide demand projected in 2030. If growth rates remain consistent with these projections, it can be concluded that at an aggregate level, no major additional investments will be required in generation capacity to cater to energy demand from EVs. On the other hand, planned EV charging could help in optimum utilization of existing generation assets.

EVs can reduce lifetime CO₂ emissions compared to fossil-fuel based vehicles by an average of 29% to 79% depending on the emissions intensity of the grid. As per a European study, even for an EV driven in Poland (coal-dominant grid) with a battery manufactured in China (coal-dominant grid), the lifetime emissions are 22% lower than diesel cars and 28% lesser than petrol cars. The increase in renewable energy generation and EV adoption offers India a compelling opportunity to decarbonize the power sector and transport sector, together.

India has committed to ambitious renewable energy targets of 175 GW by 2022 and 500 GW by 2030. To effectively utilize the planned renewable energy assets and to further meet its Nationally Determined Contribution (NDC) targets under the Paris Climate Agreement, India will have to encourage the use of electricity from renewable energy for EV charging. EVs are flexible loads and therefore their charging time could be coordinated with RE generation for effective utilization of RE power. Through attractive time of day tariffs, EV charging could be shifted to night-time when the wind power generation is high or during daytime when the solar power generation is high.

The impact of EVs on the transmission sector is proportional to its impact on the generation sector since the sizing of transmission network is usually based on the planned generation capacity. Since the additional energy demand due to EVs is less than 4%, which does not necessitate a significant increase in power generation. No major impact is expected on the transmission sector due to EV growth.

### 2. Impact of EVs on Power Distribution

The EV charging stations are connected to the grid at the distribution level and this presents both opportunities and challenges to the distribution sector. However, in the absence of effective planning and grid-management techniques, the

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38 European Federation for Transportation and Environment
39 MNRE
challenges could outweigh the opportunities for the power distribution utilities. As discussed in the previous section, although the increase in additional energy demand due to EVs is only around 4% at the national level, cities in our country are going to witness disproportionate increase in peak demand at DISCOM level.

To analyze the impact of EV penetration at DISCOM level, a study was undertaken by Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)\(^40\) for BSES Yamuna Power Limited (BYPL). The projected peak demand\(^41\) for 2030 is 2,943 MW with a CAGR of 6% as per historical growth, without considering EVs. The additional energy requirement with EV penetration for 2030 is 1,517 MW, an increase of 13.8% in the energy consumption from 2019-20. Considering BYPL’s current load factor of 0.48, the peak demand contribution of EVs is 361 MW, which translates to 12.3% increase in peak demand in the year 2030, from 2019-20, on account of EV charging. This study also estimated the additional Aggregate Revenue Requirement (ARR) for 2030 is of 12.3% owing to investment in grid augmentation for inclusion of EVs.

A white paper released by United States Agency for International Development (USAID) in partnership with Ministry of Power (MoP)\(^42\), distribution network analysis was undertaken for BSES Rajdhani Power Limited (BRPL) in Delhi. The impact of network loading on select feeders and distribution transformers (DTs) was analyzed for various levels of EV penetration scenarios\(^43\) for the next 10 years. The results of the simulation showed that there were at least 30 overloading\(^44\) instances observed for any DT each year and except on DT all the other DTs reached their overloading capacity before 2030.

With suitable EV tariff, both the consumers and the DISCOMs would benefit from EV penetration. Presently, there are 22 states and union territories (UTs)\(^45\) which have announced EV tariffs and in most cases, the EV tariff have a flat energy rate. It was also observed that in most of the cases the EV tariffs were higher than residential tariffs and lower than commercial tariffs. In order to boost EV adoption, seven states\(^46\) have announced that there will be no demand charge. In the National Tariff Policy 2016, it has been specified that the electricity tariff must progressively reflect the cost of supply and therefore the tariffs should be within ±20% of the average cost of supply (ACoS)\(^47\). Figure 5 illustrates the state-wise comparison between EV charging energy charges and ACoS.\(^48\)

![Comparison of state-wise EV Charging Energy Charge with ACoS](image)

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\(^{40}\) Impact Assessment of Large-Scale Integration of Electric Vehicle Charging Infrastructure in the Electricity Distribution System – GIZ and PRDC

\(^{41}\) For this study, three existing feeders in Delhi were shortlisted on the basis of technical parameters such as presence of EV charging stations, solar rooftop penetration, loading of the feeder and other critical parameters. The conclusions drawn from the simulation studies of the three feeders are used to extrapolate the outcomes at DISCOM level for 2030.

\(^{42}\) Electric Vehicle Charging Infrastructure and Impacts on Distribution Network – USAID

\(^{43}\) Key Assumptions: Net EV load on each DT in the base year of simulation (2019) is 165 kW (corresponding to 50 E-Rickshaws); Target of 30% EV penetration by 2030; CAGR of EV load - 30%; cumulative load growth (EV and consumer) – 5%; spare capacity of each DT is difference of 70% of rated capacity and actual loading of the DT

\(^{44}\) Overloading instance: Situation whenever the loading of any DT crosses 70% of the rated DT capacity

\(^{45}\) Alliance for an Energy Efficient Economy

\(^{46}\) Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Punjab, Telangana and Uttar Pradesh

\(^{47}\) Ministry of Power

\(^{48}\) A New Entrant to India’s Electricity Consumer-basket EV: Impact on Utility Cost of Supply and the Need for a New Approach for Tariff-Setting – Shakti & AEEE
It can be observed from the figure that the deviation of EV energy charges from ACoS varies from -44% in Delhi to 16% in Odisha. It is evident that majority of the state energy regulatory commissions (SERCs) have announced EV tariff which are lesser than the ACoS, in order to promote EV adoption.

Smart charging of EVs present an increase in the volume of controllable load which can support demand side management (DSM) programs by DISCOMs. In the future, smart EV chargers, with suitable communication and control protocols, could also support voltage and reactive power control. The USAID study\(^\text{49}\) also mentions that with the presence of suitable market structures, EVs can provide demand response/ancillary services which would benefit the utilities/aggregators and the EV owners.

The increase in peak demand adversely affects the distribution network leads to a range of issues such as overloading, system imbalances, power quality issues and power losses which are discussed below.

### 3. Technical Challenges in Power Distribution

The key requirements for integration of charging infrastructure with the grid are communication, grid stability, load management and data security. The key challenges faced in this regard are briefly explained as given below:

1. **Overloading of distribution transformer**

When an EV is plugged in to a charger and it charges at maximum power, there is an additional load on the distribution transformer (DT) and the corresponding feeder. Low voltage feeders and distribution transformers are most sensitive to overloading from EV clusters as these components do not benefit from spatial diversity.

2. **Phase imbalance**

Charging multiple EVs with single-phase chargers at the same grid connection point on the same phase, may lead to a phase imbalance. Three-phase EV chargers do not contribute to phase imbalances.

3. **Increase in peak load**

As discussed above in the GIZ study, the increase in peak demand could be around 12.3% for a DISCOM in Delhi. This peak handling is a major concern for the power utility particularly in case of parallel charging.

4. **Power system losses**

The variable component of power system losses increases with EV charging, due to increased load requirements. The period of peak load is significant, as variable losses are proportional to the square of current. This non-linear relationship means that the losses due to high market EV adoption rates could become an important issue for power network operators.

5. **Issues in power quality**

Harmonic studies were undertaken as a part of the GIZ study\(^\text{51}\) to study the impact of EVs on power quality. EV battery chargers use power electronic devices to convert AC to DC power. This conversion

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49 Electric Vehicle Charging Infrastructure and Impacts on Distribution Network – USAID

50 Impact Assessment of Large-Scale Integration of Electric Vehicle Charging Infrastructure in the Electricity Distribution System – GIZ and PRDC

51 Impact Assessment of Large-Scale Integration of Electric Vehicle Charging Infrastructure in the Electricity Distribution System – GIZ and PRDC
process can cause voltage and current harmonic distortion. During the charging period, the EV charge controller moves through different charging phases and during this the Total Harmonic Distortion (THD) of the current drawn by EV will change as a function of time. When EVs frequently connect and disconnect from high power DC chargers, it will generate more harmonics and can lead to serious power quality issues.

6. Reactive power issues

As the energy stored in the battery is in the form of DC, conversion must take place from AC to DC through the AC-DC converter. These converters have power factor limits and lower the power factor, higher will be the reactive power flow. Reactive power flows in the line and it burdens the grid by raising the total current of the system. The increased current translates into higher heat losses and affects the lifespan of the assets.

7. Lack of protocols for communication and control

The CEA has proposed Open Charge Point Protocol (OCPP) to be used as communication protocol between electric vehicle supply equipment (EVSE) and central monitoring system (CMS) in the utility. OCPP protocol does not help the CMS to actively control EV charging based on the grid conditions. Presently in India, there are no standards or communication protocols specified for active control of EV charging.

8. Complicated demand forecasting due to variable demand

EV charging depends on several factors such as EV battery capacity, battery SOC, departure time, charger’s capacity, charger availability and driver’s preferences. With so many dependent factors, it is complicated to predict the future load growth for EVs.

9. Issues with power supply at the consumer’s end

Uncontrolled and uncoordinated EV charging could lead to voltage drop, voltage flicker and power outage due to false tripping of relays on the consumer’s end. In the GIZ study\(^{52}\), it was observed that when the EVs are connected closest to the substation, EV penetration of up to 42% could be accommodated without any voltage limit violations. When EVs are connected at households farthest from the substations, only 28% of EV penetration could be accommodated without violating the voltage limit at the consumer’s end.

The penetration of EVs will have both technical and commercial impacts on the power sector. Suitable policy and regulatory interventions are necessary to mitigate the issues arising from integration of EVs with the grid. Incentives aligned with what is suitable to the grid will have a big impact on the future load growth. This report sheds light on all the segments involved in the development of the electric mobility market in India, in the framework and structure as explained in the following section.

FRAMEWORK AND STRUCTURE OF THE REPORT

Considering the scope, lens and objectives of the current study, this report explores in detail the impact of future EV adoption on the power sector in India. Subsequently, the report examines the wider electric mobility ecosystem and divides it into eight segments involved with the development of electric mobility market in India. The prerequisite for this EV evolution is power supply and grid infrastructure which would lay the foundation for deployment of charging infrastructure. EV financing would help in overcoming the hurdle of high upfront cost for EVs.

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\(^{52}\) Impact Assessment of Large-Scale Integration of Electric Vehicle Charging Infrastructure in the Electricity Distribution System – GIZ and PRDC
deployment which would lead to demand for EV manufacturing in India. The manufacturing industry would attract investment in mineral sourcing which would then facilitate battery manufacturing. With a large number of EV batteries reaching their end-of-life, battery resuse and recycling would gain importance. Further, second life applications of batteries could then serve in grid upgradation and stability. Therefore, the order of the eight chapters is structured to understand this unique cyclical evolution of the electric mobility market in India, which is depicted in the illustration given in Figure 6.

The report explores each segment (in each chevron) in detail across the six sub-sections (A-F) as explained below the illustration.

A. **Strategic importance**: Strategic importance for India or sector. Analyzes issues such as economic impact, emission reduction, affordability, energy security and more.

B. **Current scenario**: Current government policies, schemes and regulations, proposed government interventions and existing market scenario.

C. **Key market challenges**: Challenges arising due to structural factors of a sector such as fixed and variable costs, affordability, demand, supply, technology maturity, etc.

D. **Key issues in implementation**: Challenges in implementation of government policies, schemes, or initiatives or private sector initiatives.

E. **Recommendations**: Policy recommendations to the Government of India to address the identified market and implementation challenges.

F. **Further analysis and studies**: Topics identified during the study which were not covered due to scope boundaries and require further research or analysis.

This framework and structure would provide detailed insights to the readers on the development of electric mobility market in India, beginning with the first chapter on power supply and grid infrastructure.
1.1 Strategic Importance

As charging infrastructure is critical for uptake of EVs, similarly, availability of adequate grid infrastructure is critical for deployment of charging infrastructure. Globally, there have been concerns around the ability of city-level power distribution grids to accommodate (often large and unpredictable) loads, peak power surge, voltage and frequency fluctuations, asset degradation and more, from EV charging. Interviews with EV charging industry reveal that availability of grid-capacity at ideal locations is among the top barriers towards successful charging infrastructure deployment. Hence, it becomes important for DISCOMs to undertake grid studies and reinforcement activities. Globally, some progressive utilities are proactively undertaking such initiatives and regulatory commissions are also enabling them through appropriate tariff pass-through mechanisms. Further, innovative approaches such as smart charging, V2G, ToU pricing and others are being leveraged to enable stable grid operations and also to leverage renewable energy for EV charging. Leveraging these approaches for grid management can yield certain benefits such as:

- Avoidance of increase in T&D losses
- Peak load management, improved QoS and reliability
- Reduction in cost of creation of grid energy storage infrastructure
- Renewable energy integration

1.2 Current Scenario

In India, the more progressive and enterprising utilities have begun taking on initiatives to prepare their grids and infrastructure to EV charging:

- BESCOM is developing an app for EV users to locate chargers and charging tariffs (half-hourly or hourly).
- MSEDCL is planning to set up an EV Charging Infrastructure Operations Centre to monitor installation, charging activity, health of local grid and infrastructure and more.
- BYPL, with GIZ’s support, conducted a detailed grid impact study to assess current grid readiness and future requirements for charging in Delhi.

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53 Focus of all the policies is on manufacturing, DISCOM planning and other initiatives have not been dealt with in the policies.
54 BESCOM
55 MSEDCL
56 Bids were invited in September 2019. Even though the tender was scrapped, MSEDCL is currently working internally to develop the centre.
57 BYPL
State Governments have introduced special EV charging tariffs, which are lower than commercial and even lower than residential tariffs in some states.

### 1.3 Key Market Challenges

1. Lack of assessments to analyse the EV adoption trends and associated grid impacts

The process of grid upgradation is performed in response to demand and development in the DISCOM’s region rather than being based on anticipation or forecasts. Therefore, in a business-as-usual scenario, grid upgradation will be slow, due to low initial demand of chargers, and will not be able to keep pace with charger deployments once the demand rises.

While several states are promoting use of electric vehicles, only a few DISCOMs have undertaken studies to assess impacts of EV charging on the electricity network.

2. Financial health of DISCOMs remains weak and limits their ability to invest in network upgrades to accommodate EV charging

Barring a few private sector-led utilities most state-owned utilities (DISCOMs) remain in poor financial health. The DISCOMs cumulatively incurred losses worth INR 28,369 crores in FY19 and their combined debt is estimated at INR 2.28 lakh crores in FY19. This limits their ability to invest in network upgrades to accommodate EV charging.

### 1.4 Key Issues in Implementation

1. Lack of support from DISCOMs to charge-point operators in provision of LT level infrastructure

As per the Electricity Act and prevailing grid codes, LT (low voltage) level upgrades (distribution transformers) need to be undertaken by the

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58 Respective State SERC Tariff Orders (Refer to Annexure 4)

59 News Articles

60 News Articles
concerned utilities/DISCOMs, and the cost can be recovered through demand charges to the users. However, due to their poor financial condition, sometimes DISCOMs are either unwilling to incur expenditure in distribution transformers or delay such expenditures by several months or insist that the charge point operators (CPOs) make the needed investments in order to get electricity connection\textsuperscript{61}. This significantly hurts the profitability of CPOs and the investor sentiment in the EV charging market.

For example, though stakeholder consultations, it was revealed that in certain major cities, the CPOs were directed by the DISCOMs to themselves incur distribution transformer related infrastructure costs; even though as per prevailing norms this kind of LT-level infrastructure cost should be borne by the DISCOM itself. Such additional infrastructure cost equals the cost of the EV charger itself (15-20 kW DC charger) and effectively doubles the capex incurred, thus severely affecting the financial viability of the EV charging business.

2. Lack of institutional funding mechanism for undertaking grid impact studies and pilots related to ToU pricing, V2G, etc.

Currently there is no provision under the FAME-II to allocate funds to DISCOMs to undertake studies and pilots that will facilitate charging infrastructure and associated-grid investments. Due to regulatory, technological and demand uncertainty, getting such funding secured in tariff orders through SERCs is also a major challenge for DISCOMs.

3. Lack of Smart Grid infrastructure in the current grid system to support EV charging activities and retain grid health

Smart Grid Infrastructure can enable ToD pricing, remote monitoring of chargers, assess grid health through back-end centers and more; such enablers are currently missing in most grid systems, making it all the more difficult in preparing for intermittent loads from EV charging. Also, the DISCOMs lack capacity to undertake grid-modelling assessments, impact assessments and network planning on account of EV charging.

4. Lack of mandate for communication protocols for smart charging

A grid simulation study jointly conducted by Shakti Foundation and TERI shows that uncontrolled and uncoordinated charging may lead to overloading of the distribution system\textsuperscript{62}. The MoP guidelines and the CEA regulations\textsuperscript{63} only specify the safety and standards to be followed for the front-end connection between the EV and EVSE. However, there are no standards or protocols mandated for backend communication between the EV charger and the distribution system operator. This communication will be vital to maintain grid safety.

5. Lack of regulatory mechanism for DISCOMs to recover investments in charging infrastructure

Presently, with lack of demand for charging infrastructure and the consequent lack of revenue, investments in grid infrastructure augmentation are difficult to be borne by utilities and charge point operators (CPOs). Based on studies and examination led by the Bureau of Energy Efficiency (MoP) on the investment required for setting up public charging infrastructure, it was observed that of the total investment about 40-50\% was needed for grid augmentation vis-à-vis the transformer and the cabling\textsuperscript{64}. This effectively doubles the cost of setting up charging infrastructure and renders the business model unviable.

To overcome this situation, DISCOMs must be required to upgrade or set up the necessary grid infrastructure.

However, currently the DISCOMs are not allowed to socialize the grid augmentation cost for EV charging\textsuperscript{65}. One of the barriers towards socializing

\textsuperscript{61} Stakeholder consultation

\textsuperscript{62} Electric Vehicles: Perspective of DISCOMs And Stakeholders - Shakti Sustainable Energy Foundation & TERI

\textsuperscript{63} Central Electricity Authority

\textsuperscript{64} EY’s analysis with BEE

\textsuperscript{65} Stakeholder Consultation
these costs is the relatively low utilization forecast (<40%-50%) over the next 3-4 years, due to low demand in early stages of the market. With such low utilization, it will be difficult to justify the socialization of the such expenses. Also, low utilization of such grid infrastructure would increase the level of technical losses which it will have to make up for from other revenue sources.66

6. Varying quantum of grid capacity available for charging infrastructure due to varying weather conditions

Availability (or unavailability) of grid capacity for EV charging operations is not a constant feature of the urban grid throughout the year. It depends on the time of the year or the season. For example, from stakeholder consultations it was revealed that for more than two-third duration of the year, the grid in New Delhi is underloaded (spare capacity is available), while for the rest of the year, the grid is loaded to nearly its rated capacity (no spare capacity available). These variations are caused due to varying weather conditions; for instance, hot summer months witness nearly full loading of the grid due to heavy demand for air conditioning.

7. Lack of clarity on variable EV tariffs and associated charges across states

In total, 22 states including Union territories in India have notified a special EV tariff. Out of the 22, there are 15 states and UTs which have announced demand charges for EV charging whereas the other seven states have announced no demand charges to boost EV adoption67. As of April 2020, only two regulatory commissions have announced ToD tariff for EV consumers. A comparison of EV tariff with other category tariffs for 10 states is depicted in the figure given below.

While special EV charging tariffs are on an average ~35% lower compared to commercial tariff rates, residential tariffs are still ~13% lower than EV charging tariff in most of the states. There is no uniformity regarding categorization of EV charging. Depending on the state, EV is currently categorised as non-residential, commercial, non-industrial or bulk supply. There is also lack of clarity on whether taxes, non-tariff surcharges and Power Purchase Adjustment Charges (PPAC) are applicable over and above the special EV tariff.

**FIGURE 8: Comparison of tariffs from different Indian states**68

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<tr>
<th>State</th>
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66 Stakeholder Consultation

67 Dissecting India’s Electricity Tariff Landscape for EV – AEEE report

68 Respective tariff orders of the states
1.5 Recommendations

1. Undertake grid augmentation in high potential areas through better coordination among state departments

- The DISCOMs could invest in grid augmentation to speed up the process of installing charging stations. This requires a coordinated approach among transport, energy and urban planning departments to undertake location-specific planning for deployment of EV chargers.

- Ministry of Power (MoP) could consider providing funds to DISCOMs under the Integrated Power Development Scheme (IPDS) to properly plan charging infrastructure across the cities.

- State Government should nominate competent authorities across relevant state departments to enable timely coordination and results. Suitable studies undertaken as part of “smart cities” planning under AMRUT scheme could be leveraged for grid planning.

2. Build technical capacity among SERCs and DISCOMs to plan, execute and regulate investments for EV-related grid infrastructure

- CERC and relevant ministries under GOI could undertake a comprehensive technical assistance grants to develop EV charging infrastructure

US Department of Energy’s Clean Cities Programme offers technical assistance grants to cities to develop EV charging infrastructure plans. Termed as “Clean Cities Community Readiness and Planning for Plug-In Electric Vehicles and Charging Infrastructure” award and totalling US$ 8.5 million, it has helped 50+ cities across 24 states to develop “PEV Readiness Plan” in 2011. The detailed plans included crucial aspects such as – Demand forecast, Location assessment, permit process streamlining, grid infrastructure plan, etc.

Select Content on Power Grid and Electric Utility Policy and Planning Available in Readiness Plans

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<td>Time of use incentives and smart grid</td>
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</tbody>
</table>

Further to this, EV charging infrastructure investments by DISCOMs in the USA rose to US$ 1.5 billion in the first quarter of 2020 alone and a majority of this approved funding was for grid augmentation to facilitate deployment of EV chargers rather than investing in the itself.

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69 US Department of Energy  
70 Electrify Heartland  
71 Maui EVA  
72 Plug-in Ready Michigan  
73 Texas Triangle  
74 New York  
75 Getting to 20 Million EVs by 2030 - The Brattle Group
capacity building programme for SERCs. This programme will enable SERCs to:

a. Increase awareness of EV adoption trends (demand growth, infrastructure requirements, etc.)

b. Supporting DISCOMs requesting for additional investments in EV-related grid reinforcements to promote EV demand and ensure grid safety

c. Allow necessary studies and pilots required to be undertaken

State Governments could undertake a comprehensive technical capacity building programme for DISCOMs. This programme will enable DISCOMs to:

a. Increase awareness of EV adoption trends (demand growth, infrastructure requirements, etc.)

b. Prepare the tariff order filings from DISCOMs requesting for additional investments in EV-related grid infrastructure

c. Undertake necessary studies and pilots required to be undertaken for grid impact assessment, ToU pricing, RE integration of EV charging and other necessary measures

3. Develop guidelines to mandate installation of smart chargers with suitable communication protocols

There is a requirement for seamless communication between the EV, EVSE and grid for controlled and coordinated charging. Smart chargers would help in deferring expensive grid augmentation costs by managing the EV load effectively and will prevent overloading the grid.

Mandatory ICT protocols and standards must be in place for continuous communication between EV, EVSE and the grid. With suitable ICT protocols such as ISO 15118, OCPP, OCPI, OSCP and Open ADR, interoperability of EVs and chargepoints can be ensured. Adoption of these protocols will assist in billing, handling registration, EV smart charging, providing chargepoint information, operating chargepoint, reservation, roaming and managing the grid. In future, smart chargers would also facilitate V2G and provide ancillary services to the grid76.

4. Facilitate load shifting by introducing ToD/ToU tariff mechanism

Utilities/SERCs could design special tariff programs such as ToD and ToU tariff for EV charging, with the objective of shifting demand to off-peak hours by offering discount to consumers who charge EV during off-peak hours. Depending on the availability of the grid, utilities can create incentives to promote EV charging at times that would benefit the grid (load balancing, RE integration, etc.). In future, real-time electricity pricing tariff could be introduced for EV charging with dynamic tariff signals. Major US utilities such as SCE, SDG&E, PG&E have been offering special EV charging tariffs77.

5. Allow cost recovery of capital and operational costs incurred by DISCOMs for grid augmentation due to EV charging infrastructure installation

As discussed earlier, the investment in grid augmentation for setting up a charging station is close to 40%–50% of the total investment. This doubles the cost of charging infrastructure and the service offered to the consumers.

A joint study between Shakti and TERI estimates that if the full investment is socialised to all the consumers, the impact on tariff will be of INR 0.0040/kWh, whereas it will be of INR 0.1970/kWh when it is charged only to EV users78. Since the environmental benefits of e-mobility are societal, it could be justified to socialize the cost of investment in EV infrastructure to all consumers. SERCs could allow the cost to be passed through to the consumers through the ARR, subject to certain thresholds of infrastructure utilization established through detailed project reports undertaken at that time.

76 Forum of Regulators  
77 BNEF: U.S. Utilities Offer Multiple Electric Car Charging Rates  
78 Electric Vehicles: Perspective of DISCOMs and Stakeholders - Shakti Sustainable Energy Foundation & TERI
6. DISCOMs should publish a map of distribution assets along with available capacities in the public domain

It is recommended that DISCOMs should collect and share granular information regarding distribution assets at the city level (including available capacities) with the fleet operators and charge point companies so that the latter can plan optimal deployment of charging infrastructure across locations. This initiative will also help tackle the issue of under-utilization of distribution assets.

7. Introduce time-bound waiver of fixed/demand charges and other surcharges on EV tariff

SERCs should categorize EV charging as a special category in their tariff schedule. To promote EV adoption in the initial years, SERCs should waive off the fixed/demand charges and other surcharges over and above the specified EV tariff. Although, demand charge is used by DISCOMs to compensate for the surge in EV power demand, it could be waived off for initial 2–3 years to enable charging service as a viable business opportunity. The EV tariff must be structured after considering the aspects such as uneven load requirement and bidirectional power flow which would enable EVs to be leveraged as distributed energy sources (DERs) using V2G technology. Presently, seven states\(^{80}\) namely Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Punjab, Telangana, and Uttar Pradesh have announced no demand charges under EV tariff.

8. Undertake policy and regulatory interventions to encourage use of renewable energy for EV charging

The environmental benefits of leveraging renewable energy for EV charging are well established (Section D). Based on stakeholder consultations, two important recommendations are made to achieve the same:

a. SERCs should reduce the open access threshold for procurement of renewable energy by CPOs. This should be combined with a provision for CPOs to aggregate electricity demand from their chargers at the city-level/DISCOM-level to be eligible for open access RE procurement even through fragmented demand at charging stations.

For example, a CPO having 10 charging stations in New Delhi with a load of 100-150 kW each should be eligible to aggregate a demand more than 1 MW aggregated demand and thus become eligible to cross the threshold demand level for RE procurement through open access.

b. SERCs could create a provision for DISCOMs which will require the latter to set-off all the EV charging demand in a certain year with RE procurement. This RE procurement would be in addition to their existing RPO fulfilment requirement. In this scenario, all the EV charging demand could be deemed as served by renewable energy.

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\(^{79}\) Forum of Regulators

\(^{80}\) Dissecting India’s Electricity Tariff Landscape for EV – AEEE report
This initiative will provide DISCOMs with the flexibility to manage the grid in a manner that is conducive technically and in line with their current grid operations. This will also minimize the EV-charging specific grid requirements such RE forecasting, RE scheduling, RE banking and other complexities that arise from the intermittency of RE sources.

1.6 Further Analyses and Studies Recommended

The Government could consider undertaking further work on the following aspects:

- Undertake detailed studies to understand software capabilities and digital tools employed by utilities globally (such as by Enel X and EDF in Europe) to support charging activities and grid management.

- Develop a model framework for undertaking grid planning and grid impact assessments; these frameworks can then be used for deployment at state and city level.

- Undertake grid impact assessment and necessary grid upgradation in all major cities and towns where EV charging infrastructure is expected to be deployed in the next 2-3 years.

- Undertake detailed assessment of skills and capabilities required to be built within SERCs, State Energy Departments and DISCOMs for effective planning and creation of an EV-ready grid.

- Undertake detailed assessment of policy and regulatory interventions required to encourage use of renewable energy for EV charging.
CHAPTER 2
Charging Infrastructure Deployment

2.1 Strategic Importance

EV charging is an indispensable activity for operating EVs. Major consumer surveys reveal that a lack of accessible charging infrastructure is one of the top barriers to EV adoption, along with the high capital cost (in comparison with ICE vehicles) and range anxiety. Consequently, deployment of a reliable, accessible, available and affordable charging network in the country has a considerable strategic importance.

From Figure 9, it is clear that developing e-mobility markets consider availability of charging stations as the top enabler for EV adoption. Even more mature e-mobility markets consider it as the third highest enabler for EV adoption.

Additionally, key factors across charging segments and technology reveal the strategic importance of charging to OEMs, operators and vehicle owners in the e-mobility space. This has been captured below:

**FIGURE 9:** Percentage share of EV customers indicating charging infrastructure as top enabler

<table>
<thead>
<tr>
<th>Survey position of chargers as an enabler</th>
<th>Italy</th>
<th>Korea</th>
<th>India</th>
<th>USA</th>
<th>Germany</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing e-mobility markets consider chargers the top enabler for adoption</td>
<td>44%</td>
<td>34%</td>
<td>25%</td>
<td>22%</td>
<td>20%</td>
<td>18%</td>
</tr>
<tr>
<td>Established e-mobility markets consider chargers the 3rd highest enabler for adoption</td>
<td>1st</td>
<td>1st</td>
<td>1st</td>
<td>3rd</td>
<td>3rd</td>
<td>3rd</td>
</tr>
</tbody>
</table>

- Suitable locations keeping user convenience in mind will lead to higher utilization
- China has close to 6,000,000 public chargers (predominantly GB/T) – mostly set up by the state and provincial authorities; a lot of those chargers suffer from severe under-utilization; this could be due to states installing chargers at available locations rather than suitable and convenient ones for users
- Tesla’s Supercharger network (Tesla’s proprietary standard) has been ascribed as leading factor for its record sales
- Volkswagen, another major global automaker is following suit by installing 2,800 chargers (CCS standard) across 17 of the largest US cities by 2019 and invest US$ 2 billion in charging infrastructure

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81 Deloitte Consumer Survey 2018
82 China’s public chargers are only used for 15% of the time on average
83 Tesla Superchargers
## Importance of public charging to influence purchase decision

- Chargers and access to fast charging is rated as top criteria when buying EV – Survey of EV owners in USA, 2017[^84]. Lack of public charging ranked as third major reason for not buying an EV – Survey of potential EV buyers in the USA, 2016
- 60-70% of Indian vehicle owners do not have dedicated parking space[^85], thus making public charging an important segment in India

## Importance of home charging

- According to industry experts, 93% of EV charging by personal users, in the 2W and 4W segment, happens at home in India[^86]. These chargers are mostly slow chargers[^87]
- There is a need to focus on home charging of 2Ws and 4Ws for urban users (assumed to be the early adopters of EVs), especially the ones living in multi-storied residential areas

## Renewed focus on battery swapping

- Given the economic and demographic scenario of India, the e-2Ws and e-3Ws will continue to constitute as a large segment of vehicles in India
- There is a need to support battery swapping model which is a proven technology for commercial 2Ws/3Ws[^88] and gives several advantages to the EV users such as reduced downtime (for charging) and reduced upfront purchase cost

## Digital interventions to improve utilization of charging infrastructure and battery swapping stations

- The accessibility and visibility of charging and battery swapping stations, can be improved through digital technologies which can enable extensive mapping of demand areas, analysis of consumer patterns, monitoring of vehicle and charge usage, etc.
- There is a need to promote such digital interventions to improve the operational efficiency of the charging and battery swapping stations, hence improving their utilization besides contributing to consumer satisfaction

From the above figure, it is clear that developing e-mobility markets consider availability of charging stations as the top enabler for EV adoption. Even more mature e-mobility markets consider it as the third highest enabler for EV adoption.

### 2.2 Current Scenario

The Government of India has taken various initiatives to accelerate investments in charging infrastructure. The key initiatives are mentioned below.

- Delicensing of EV charging business and opening it to private sector companies in April 2018.
- Formulation of guidelines and standards for EV charging. No particular charging standard was specified and the selection of the charging standard was left open to the discretion of the charging infrastructure operator in December 2018.
- Bureau of Energy Efficiency (BEE) designated as the Central Nodal Agency (CNA) for charging infrastructure in February 2019.
- Formulation of guidelines by the Ministry of Housing and Urban Affairs (MoHUA) towards allotting 20% parking space in residential and commercial building for EVs. It is a non-binding guideline to the local municipalities to implement and monitor allocation of parking spaces in February 2019.
- Provisioning of INR 1,000 crore for charging infrastructure as part of GoI’s flagship FAME-II scheme for electric mobility sector in March 2019.
- Invitation of proposals for installation of charging infrastructure across 80+ cities by DHI for subsidy disbursement under FAME-II scheme in August 2019.

[^84]: China’s public chargers
[^85]: Industry interviews
[^86]: Ather Energy
[^87]: Home charging here considers charging of lithium-ion based 2Ws and 4Ws. It also considers charging of lead-acid batteries in earlier variants of electric 2/3Ws which were majorly taking place at home and new charging models of lithium-ion based electric 2 and 3 wheelers used for commercial purposes (where the driver takes the battery home to charge).
[^88]: Sun Mobility’s partnership with Smart-E (3W); Ola mobility’s swapping operations in ride-hailing (2/3Ws)
Formulation of revised guidelines and standards on EV charging in October 2019.
Sanctioning 2,636 EV charging stations under FAME-II scheme in January 2020.
Ministry of Road Transport and Highways (MoRTH) has directed all the states and Union Territories to allow sale and registration of electric vehicles (EVs) without batteries, to encourage battery swapping.

A timeline of initiatives that have been undertaken by the government for policy and regulatory interventions as well as implementation support in FY 2018-19 and FY 2019-20 have been shown in Figure 10 and 11.

Besides government initiatives, a number of private sector companies have emerged in the last two years in the charging infrastructure domain, with the likes of Exicom, Delta and Tritium as charger OEMs; and Fortum, Magenta Power, Tata Power, Voltic EV charging and many others as CPOs. Different business models are being pursued by each company governed by their investing capability, technology competence, strength of partnerships and risk-taking propensity. Since the market is at early stages of development, no

FIGURE 10: Policy and regulatory interventions as well as implementation support by GoI in FY 2018-19

FIGURE 11: Policy and regulatory interventions as well as implementation support by GoI in FY 2019-20

89 Ministry of Road Transport and Highways (MoRTH)
private charge point operators had a public network of more than 100 chargers as of January 2020. A typical charging infrastructure operator business model can be represented by the following ownership table:

**TABLE 2: CPO Ownership models**

<table>
<thead>
<tr>
<th></th>
<th>CPO owns chargers</th>
<th>CPO does not own chargers</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPO owns land</td>
<td>Tesla provides charging through its fully owned ultrafast charging network</td>
<td>-</td>
</tr>
<tr>
<td>CPO does not own land</td>
<td>Fortum partners with petrol pumps, car dealerships etc. who provide land</td>
<td>ChargePoint (USA) provides charging operation and mapping services to public charger owners</td>
</tr>
</tbody>
</table>

CPOs usually price their charging services as INR/kWh or INR/time. There is no regulatory cap on the tariff that can be charged to the end customer. However, in case of public charging stations set up utilizing government subsidy under the FAME scheme, the end tariff (or service charge as referred by the MoP) will be regulated by the State Nodal Agency.

**2.3 Key Market Challenges**

1. **Lack of profitability in charging infrastructure business for players in the early stages of the ecosystem**

Charging infrastructure, inherently as a business, lacks profitability and a business case in the early stages of the market – this is due to low utilization of assets (low demand) and high cost of trunk infrastructure (chargers, wiring, transformers, land and more). The current FAME-II scheme for subsidy disbursement on deployment of charging infrastructure, provides subsidy on the capital cost of the chargers and not the trunk infrastructure. There have been scenarios in which the trunk infrastructure costs almost similar to the capital cost of the chargers, if it includes deployment of a separate transformer and the associated infrastructure.

This capital cost of deployment of chargers and the trunk infrastructure, along with the lower utilization of the chargers, lead to the lower profitability for the early stage service providers. Even mature markets, such as USA and Europe, charge point operators are setting up wide charging networks, whereas the current utilization still doesn’t secure profits.

2. **Lack of affordable access to convenient and feasible charging sites for charge-point operators and other players**

The feasibility of a charging station is based on three pillars:

- **Accessible locations**, for ease of approach for the consumers along with presence of such chargers in the vicinity of residential and commercial complexes such as malls, restaurants, supermarkets and offices.

- **Infrastructure availability**, i.e., locations backed by power and road infrastructure for operations lending to the reliability of the chargers and

- **Appropriate charging technology**, i.e., specifications of the chargers should be determined based on demand assessments. For example, locations having large number of e4W owners, should have a higher density of chargers relevant to e4W (CCS or CHAdeMO or Bharat Standard chargers depending on type of cars prevalent in the area), whereas a location having more e2W and e3W owners, should have a higher density of slow chargers (relative to the e4W chargers which will be of higher power rating and unusable for e2Ws and e3Ws). Table 3 refers to vehicle segments and charging technologies suitable for them.

90 Based on consultations with experts in the UK
### TABLE 3: Types of EV chargers for different EV segments\(^{91}\)

<table>
<thead>
<tr>
<th>No.</th>
<th>Electric vehicle segments</th>
<th>Slow chargers</th>
<th>Fast chargers</th>
<th>Connectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Two-wheeler(^{92}): On-board charger of 2.5 kW to 3 kW</td>
<td>15 A socket or smart charger</td>
<td>Bharat DC 001, Battery swapping</td>
<td>-</td>
</tr>
<tr>
<td>2.</td>
<td>Three-wheeler(^{93}): On-board charger of 2.5 kW to 3 kW</td>
<td>15 A socket or smart charger – Bharat AC 001</td>
<td>Battery swapping</td>
<td>-</td>
</tr>
<tr>
<td>3.</td>
<td>Cars</td>
<td>Mahindra e2o: On-board charger of 2.5 kW to 3 kW</td>
<td>Bharat DC 001</td>
<td>GB/T</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Nissan Leaf, Mitsubishi, Kia (Japanese)</td>
<td>AC Level 1 and DC Level 2</td>
<td>CHAdeMO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BMW, GM, VW, Ford, Audi, Porsche</td>
<td>AC Level 2</td>
<td>CCS1 and CCS2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tesla</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4.</td>
<td>Buses(^{94})</td>
<td>AC Level 2</td>
<td>DC Level 2 or battery swapping</td>
<td>GB/T</td>
</tr>
</tbody>
</table>

3. Lack of consumer awareness initiatives for information exchange among the population on the advantages of EVs and the use of charging infrastructure

The myth and knowledge gaps surrounding EVs and charging infrastructure such as charging time, range anxiety, safety hazards due to EV chargers, hinder its adoption. The lack of nation-wide, state-wide or manufacturer-initiated campaigns and roadshows to promote EVs and to impart knowledge around EV chargers, leads to the lack of adoption by the potential vehicle buyers.

### 2.4 Key Issues in Implementation

1. Lack of FAME-II subsidy support for charging infrastructure flowing to the private sector companies

In the first tranche of FAME-II funds towards charging infrastructure, 2,636 charging stations have been sanctioned by DHI in January 2020. In this process, only PSUs and government agencies have been selected for provision of subsidies. Also, where the PSUs and government agencies could submit proposals directly to DHI, the private organizations were required to send their proposals through the urban local body (ULB). This creates a non-level playing field in a market that is open to private sector organizations as well.

Besides, PSUs are able to secure locations, which are primarily in the ownership of state agencies, on the basis of MOU whereas Private sector struggles to get those locations from state agency even at suitable payment. This creates a huge non level playing field.

2. Lack of sufficient scale and density of chargers in potentially high EV-demand cities due to broader, country-wide, deployment scope of government’s FAME-II scheme

Currently, the government funds for charging infrastructure development are being used to set up infrastructure in 62 cities. This will provide, on average, only 40 chargers per city. It has been observed that lack of adequacy and density of chargers leads to lack of consumer confidence in public charging infrastructure. To boost customer

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\(^{91}\) ISGF - Electric Vehicle Charging Stations Business Models for India

\(^{92}\) PluginIndia

\(^{93}\) PluginIndia

\(^{94}\) AEEE and Shakti Sustainable Energy Foundation - Charging India’s Bus Transport
confidence in charging stations, a dense charging network is required, especially in homes, offices, shopping outlets and existing parking.

3. High GST for swappable batteries sold separate from vehicles (including spare batteries) and battery swapping services

Currently the GST applicable on EVs and EVSE (charging equipment) is 5%. The GST for factory-fitted batteries in EVs is also 5%. However, the GST on swappable batteries is high, at 18%. In addition, the GST on EV charging and battery swapping service is 18%. This is counter-productive since it disproportionately affects the auto-drivers, delivery personnel and other people at the lower end of the income segment. Also, given that the business of charging infrastructure operators and battery swap operators is unviable in the early stages of the market, it becomes important that the taxes applicable on the end consumers be reduced to the minimum possible, to facilitate adoption in users.

4. High cost of enhancing LT-level grid infrastructure for EV chargers (at homes, workplaces, commercial & public spaces)

Currently, cost associated with the enhancement of LT-level grid infrastructure, if required, for EV chargers is required to be incurred partially (50%) or in full by the user. This cost can be high and can deter investments in EV charging, especially for fast chargers for 4 wheelers.

5. Inability of potential EV users to set-up EV charging in multi-unit dwellings (MUDs)

A challenge in home charging segment is difficulty in obtaining permits by RWAs (resident welfare associations) for EV charging in multi-storied buildings. Such hindrances are often unlawful, based on unsubstantiated concerns and often a result of lack of awareness. Also, in housing societies, the parking lot belongs to the RWA and therefore there is a need for legal clarity about who will own the charging infrastructure in the parking lot. In addition, due to lack of awareness at DISCOM level, procedure for grant of supply for EV charging is ambiguous in several geographies.

Considering the current state of affairs of real estate developers, investment in charging infrastructure in new multistoried buildings is perceived to have regulatory risk due to variance in interpretation of the Supply Code. Also, on average the connected load in an ordinary household is around 6 kW, while the rating of the EV charging can be from 3W up to 7 kW. This increase in load (infrastructure upgradation) might require permission for additional load or a new connection from the DISCOM along with installation of a separate meter. This process is often long and accompanied with lack of adequate awareness among ground level staff/officials.

6. Lack of alignment in charging infrastructure subsidy and vehicle subsidy program

A major portion of FAME-II scheme subsidies are allocated towards 2W and 3W segments. As a percentage of the total FAME-II subsidies, 2W segment accounts for 20% and 3W segment accounts for 25%. On the other hand, 4W segment accounts only for 5.5% of the total FAME-II subsidy fund.

Under FAME-II, the subsidies are aimed at public transport, e-2W and e-3W, but it must be noted that these vehicles do not have fast charging capacity (“maximum of 0.2 C or 0.3 C charging rate) which is a major concern. Slow charging of e-2W and e-3W, at the most require 15 A socket.

However, in terms of charging infrastructure, more than 80%95 of the fund allocation is towards chargers suited only for 4W segment (high powered chargers not suitable for 2W and 3W). Therefore, there is a mismatch between FAME-II demand subsidies to EVs and charging infrastructure96.

95 Stakeholder Consultation
96 Stakeholder Consultation
7. Lack of subsidy support for battery swapping model (esp. in e2W, e3W segments)

The FAME-II scheme of DHI does not include subsidy support to battery swapping. Further, the MoP guidelines on charging infrastructure neither includes reference to battery swapping nor includes it as a possible mode of charging in the definition of charging infrastructure. Hence, battery swapping operators cannot avail EV tariffs (since the DISCOMs have to comply with MoP guidelines to offer it).

In addition, relatively low awareness at RTO level offices impedes registration of battery swappable vehicles since there are no updates in the Motor Vehicle Rules and regulations regarding registration of the same.

8. Lengthy and inefficient approval process followed by DISCOMs for EV chargers; lack of institutional accountability for timely approval of EV chargers and installation of associated infrastructure

Due to lack of awareness at DISCOM level, procedure for grant of supply for EV charging is ambiguous. CPOs are setting up charging stations in multiple cities and many states have announced special EV tariff but implementing the EV tariff on ground has been a constraint due to operational problems. There needs to be process simplification for availing EV tariff.

In the developed countries (the USA, Norway, the UK, etc.), it is seen that 80%-90% of EV charging (4W segment) happens at people’s homes (home charging). The proportion of EV home charging in India is similarly high (>90%) since most of the early-generation EV buyers hail from financially well-off section of the society (owing to affordability constraints for 4W EVs). Recognizing this dynamic, many countries (UK, Germany, France, etc.) have included home charging segment in their charging infrastructure subsidy programs.

However, in India, since the government’s focus through the FAME-II scheme is only towards commercial and public transport vehicles (taxis in 4W segment), home charging has not been included. This hinders the growth of EV adoption among personal EV buyers.

9. Absence of a national level portal for aggregating location of charging stations for ease of consumers

A key market challenge is that independent charging networks are being developed which display chargers installed and owned by respective charging companies. In the absence of a National Service Provider (NSP), there is no common platform to get access to all the chargers or share information regarding them across all charging networks. Eventually, this might result in a situation which requires EV users to sign up for multiple apps and multiple subscriptions to be able to access chargers by different companies in different locations and cities.

10. Lack of regulatory interventions to organize the e-3W charging market

Though DISCOMs and regulators are witnessing challenges due to illegal charging of e-3W that is contributing to AT&C losses, minimal effort is being taken to organize the market. e-3W is a segment that has been mushrooming across cities in India with good penetration in Tier II and Tier III cities due to lower cost of acquisition and operations. As a result of lack of awareness and inadequate organized charging provisions the e-3W drivers have little to no option but to charge wherever they find a point to charge. The current FAME-II scheme has no provision for creation of charging stations/hubs specifically for e-3Ws.

11. Lack of collaboration among the stakeholders for developing a sustainable charging infrastructure ecosystem

The Ministry of Power’s charging infrastructure guidelines and standards have nominated various
State Nodal Agencies (SNAs) for the development of charging infrastructure ecosystem in the respective states.

With reference to the allocation of FAME-II subsidy allocation towards deployment of charging infrastructure, 2,636 charging stations have been sanctioned by the Department of Heavy Industries (DHI) in January 2020. Where the PSUs and government agencies could submit proposals directly to DHI, the private organizations were required to send their proposals through the ULB, even in the presence of SNAs.

As the process lacked proper communication channels, many private players faced a challenge in forwarding their proposals through ULBs or their proposals stood to be rejected. The lack of collaboration among the stakeholders, such as ULBs, DISCOMs, charging infrastructure manufacturers and operators, would hinder development of a sustainable ecosystem in the country.

In addition, battery swapping, a proven and commercially viable mode of charging batteries for 2W and 3W segments is not included under the ambit of charging infrastructure fund. This has been one of the contributors towards inadequate infrastructure for e-2W and e-3W and thus lower than expected demand for them.

12. Lack of alignment between charging demand and government sponsored charging infrastructure deployment

A challenge observed globally (especially in China) with PSUs installing charging infrastructure relates to the non-optimal location of chargers. Global research reveals that people prefer chargers to be in places where they would naturally spend time rather having to go out of their way and waiting just for charging their vehicle. This implies that the EV owners prefer chargers in malls, restaurants, etc. instead of waiting for one to two hours at charging stations in public parking lots, gas stations or other inconvenient locations.

Due to the tender-driven, low cost approach of PSUs, the resulting charging infrastructure might be installed at places which are cheaper to install (government offices, municipal parking lots, petrol stations, etc.) but are inconveniently located and will suffer from severe underutilization of the chargers (and hence, valuable public funds). Another risk could arise from the selected government PSUs not being able to sign bilateral/contracts with commercial entities (malls, restaurants, office spaces, etc.) due to the highly customized and fragmented approach (rents, revenue-sharing model, etc.) required for each kind of location. Also, due the dynamic nature of EV charging technology and continuously evolving standards, PSUs may be at a risk of investing public funds in the wrong charging technology, unless they work in close collaboration with the automotive OEMs.

Lastly, the service-oriented and technology-intensive nature of the EV charging business (mobile applications, memberships cards, customized rates, etc.) might require significant capabilities at the end of municipal corporations, which may not be in a strong position to deliver such digital-enabled services.

2.5 Recommendations

1. Devise mechanisms for fiscal incentives under DHI’s FAME-II subsidy to flow towards private sector charge-point operators to drive innovation, rapid proliferation and cost reduction in the EV charging space

The Department of Heavy Industries (DHI) could provide equal opportunity and same qualification procedures to private sector charging companies in future rounds for awarding subsidies under FAME-II scheme. This will ensure a level playing field ensuring private sector investment. Further mechanisms should be conceptualized to support private sector participation in EV charging to drive innovation, cost reduction and alternate business models.
2. Charging infrastructure installation should be focused on top EV-demand cities in the early stages of the market; expansion to other cities only when top cities have achieved a certain density and saturation level of public EV charging infrastructure.

Currently, the government funds for charging infrastructure development are being used to set up infrastructure in 62 cities. This will provide, on average, 40 chargers per city.

To boost customer confidence in charging stations, a dense charging network is required. Hence, it is recommended that the program should focus on 10 cities with high demand potential for electric mobility. On average, it will enable the setting up of a dense network of ~240 chargers per city and drive customer confidence. Further, holistic demographic as well as demand assessments need to be done to assess the type of chargers that need to be deployed for 2 wheeler, 3 wheeler and 4 wheeler at locations such as home, office, shopping outlet and existing parking.

3. In line with battery swapping getting included under MoP guidelines, provide subsidy support for battery swapping model in the FAME-II scheme.

DHI should include battery swapping under the ambit of FAME-II. This will provide strong impetus to e-2W and e-3W while also reducing costs and increasing incomes for auto-drives, delivery personnel and other economically burdened sections of the society.

In order to make minimal policy and regulatory changes, the swappable battery could be provided along with the vehicle and the subsidy could be provided to the OEM just like it is currently being done for vehicles with factory-fitted batteries. The OEM could pass on the subsidy to the battery swap operator, which would in turn reduce the price of swapping service and ultimately pass the benefit onto the end consumer. As an alternative (for the long term), the subsidy could be directly provided to the battery swapping operator and the battery utilization could be monitored through relevant telematics data.

4. Reduce GST on swappable batteries, charging service and battery swapping service from 18% to 5% in line with GST rates for EVs, EV chargers and factory-fitted batteries in EVs.

The government can also look at other services such as GST on ride-hailing, rides in Ola and Uber (at 5%), as precedence to dissolve such misalignment in the applicable GST for swappable batteries, charging infrastructure service and battery swapping service.

5. Establish a simplified and fast-track approval process for EV chargers. Also rate the DISCOMs on their process for providing EV charger approvals as part of the ease of doing business matrix for DISCOMs.

Due to lack of awareness at DISCOM level, procedure for grant of supply for EV charging is ambiguous. It is recommended that the Forum of Regulators develop a standard framework procedure for the DISCOMs to follow. Further, the FAME-II funds for awareness creation should be utilized to create full awareness at levels within DISCOMs to ensure quick approvals and support for EV chargers.

Also, the approval process guidelines and the results achieved should be included in the “Ease of Doing Business” matrix for the DISCOMs. This will encourage the DISCOMs to adopt and constantly improve their processes.

6. Encourage DISCOMs to incur grid infrastructure upgradation cost and provide “plug and play” connections to charge point operators (CPOs).

The Ministry of Power’s charging infrastructure guidelines and standards have nominated various State Nodal Agencies (SNAs) for the development of

99 Stakeholder Consultation
charging infrastructure ecosystem in the respective states. Each state government should utilize the institutions authorized for development of charging infrastructure ecosystem in their respective states.

The SNAs should be empowered by the state government and be made responsible for necessary coordination and implementation activities. Simultaneously, SNAs can play a vital role of collaborating with stakeholders such as ULBs, DISCOMs, CPOs, swapping operators and others to create “plug and play” infrastructure for EV charging.

For instance, project preparation and execution towards deployment of charging infrastructure at strategically important locations can consider collaboration amongst:

- ULBs for identification of key land parcels for parking and charging.
- SNAs to coordinate among the ULBs, DISCOMs and the charge point operators to facilitate and accelerate the process of deployment, through initiatives such as single window clearance for approvals and clearances for charging station deployment.
- Transport experts/fleet operators (like Ola, Uber, etc.) for identification of high demand areas across the city.
- DISCOMs for identification of augmentation of the distribution infrastructure in identified demand areas.
- State energy department for provision of necessary funds and approvals required for infrastructure augmentation by DISCOMs.
- Charge point operators for identifying and deploying charger technologies viable for identified locations.

CASE PRECEDENT

Successful project preparation and coordination by SREDAs

State renewable energy development agencies/corporations (like NREDCAP, RERA, etc.) have been successful in the project preparation, coordination and implementation activities for solar parks and other solar deployment initiatives in their respective states.

7. Mandate Residential Welfare Associations (RWAs) under MUD’s purview to allocate parking spaces and allow separate metering connections for EV users

State governments could make it unlawful for RWAs to withhold approvals for home charger installation (in multi-storied buildings); appropriate regulations and consumer protection measures should be in place to ensure streamlined installation process of home chargers for EV owners.

100 EY Analysis. Technology Providers are essentially the Charge-point operators, battery swapping operators, which SNAs (DISCOMs in most cases) should enlist in finally deploying charging infrastructure at the city- and state-level.

101 NREDCAP
New buildings could be designed to mandatorily have power source for EV charging infrastructure in the parking space. States governments and SERCs could mandate DISCOMs to process charging infrastructure related permits and approvals in a timely manner.

2.6 Further Analysis and Studies

The government can undertake further work on the following aspects:

- Consumer behavior studies and demographic studies to gauge new trends in terms of time spent on roads, parking areas, weekend activities, preferred charging spots, acceptable charging wait-times and more.
- Consultation study with international experts on best practices for enabling home charging especially for multistoried residential owners.
- Techno-commercial impact study of integrating renewable energy and energy storage systems with charging stations (and battery swapping stations).
- Consultation study with international experts on best practices for developing V2G (vehicle to grid)/V2H (vehicle to home) technologies, as well as other charging technologies such as inductive charging and portable charging.
- Study to understand the economic impact due to reduction of GST/taxes on the services charged to EV users for EV charging by the Charging infrastructure operators.
- Study for development of financial instrument to promote deployment of EV charging infrastructure and battery swapping.

102 V2H technology is essentially V2G technology; here only the location of connection is defined.
CHAPTER 3

EV Financing

3.1 Strategic Importance

EVs cost anywhere between 1.5 to 2 times more when compared to their ICE equivalents across 2W, 3W, 4W and bus segments. Even though most vehicle segments with EV variants now achieve TCO parity at typical daily utilization\(^{103}\) (kms/day) as seen in various applications, the higher upfront cost remains a significant barrier for consumer adoption. The higher capital cost also implies that the financing burden (in the form EMIs) is unsustainable considering the same, short tenor loans available for cheaper ICE vehicles. This necessitates the existence of flexible and favorable financing options for EVs specially in the public transportation sector (E-buses, 3Ws, 4Ws).

Besides this, balancing of certain contractual obligations (like payment security) are also important to make investment in electric bus-based public transport segment more attractive to investors and private bus operators. Lastly, it is important to explore mechanisms to provide micro-credit to potential e-2W and e-3W drivers since they may not be able to afford the upfront cost and may not have credit history. Yet they would benefit significantly from the reduced operating expense, increased daily income and significantly better health outcome.

3.2 Current Scenario

In India, financing of electric vehicles has made some progress. In segments where favorable financing is unavailable, authorities have turned to DFIs and global funds to support their electric enterprises:

- Only three to four financial institutions are currently extending loans to e-Bus operators, according to market experts.
- Tamil Nadu Government signed an INR 1,580 crore financial assistance program with the German development bank KfW for 500 e-Buses and BS-VI emission compliant buses\(^{104}\).
- Few start-ups such as RevFin and Three Wheels United are innovating micro-financing in e-2W, e-3W and e-4Ws through psychometric loan analyses and long-term credit facilities to support thousands of auto, rickshaw drivers, delivery personnel and more\(^{105}\).

3.3 Key Market Challenges

1. High upfront cost of electric vehicles

The cost of electric vehicles is 1.5 to 2 times more when compared to an ICE equivalent. The higher upfront cost is a big deterrent to potential buyers.

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103 TCO thresholds calculated - 2W: 90-110 kms/day; 3W: 100-120 kms/day; 4W: 220-240 kms/day; Buses: 180-220 kms/day
104 Tamil Nadu and KfW
105 RevFin
2. Credit risk faced by financial institutions while lending higher amounts to EV buyers

Banks are faced with a larger credit risk while offering loan for an EV as compared to an ICE vehicle to the same buyer (with same credit profile). This is because of the high upfront cost of electric vehicles. Small fleet operator or the personal buyer may find it difficult to buy such cars due to financing challenges\textsuperscript{106}.

3. High perceived risks by financial institutions for extending EV loans and high interest rates

Due to a lack of long operational history and uncertainty in residual values of EVs, banks are hesitant to extend credit to potential EV buyers. This situation is aggravated in the case of e-2W and e-3W buyers who may not have a credit history. Consequently, the volume of credit offered is low.

In cases where credit is offered, the terms are worse compared to those offered on ICE vehicles. Industry consultations reveal that the loan quantum for EV loans in major banks is low (70% of vehicle cost compared to 90% for ICE vehicles), interest rates are high (14%-26% compared to 10%-16% for ICE vehicles) and the repayment period is low (a year-and-a-half to two years compared to four to five years for ICE vehicles).

4. Lack of flexible, long-term financing options for EV buyers

Most commercial banks (such as SBI\textsuperscript{107}, HDFC\textsuperscript{108} and others\textsuperscript{109}) provide vehicle loans for personal segment (2W, 4W) and commercial segment (4W taxis, buses, trucks) buyers with a maximum repayment period of typically five years.

The higher capital expenditure (capex) for EVs cannot be serviced with these financial products. EVs should be eligible for flexible, long-term financing of 6-12 years depending on vehicle utilization, to make their deployment commercially viable. For example, studies done by India Innovation Lab for Green Finance reveal that the additional capex of an e-Bus compared to a similar diesel bus would be recovered after six to nine years of operations depending upon the daily usage (kms run).

5. Poor/Unavailable credit history of e-Bus operators leading to additional financial and operational risk for auto OEMs

In India, GCC model\textsuperscript{110} for operations of buses is fairly recent and the operationalities are being explored amongst the stakeholders. Until now, the dominant model has been for STUs (state transport undertakings) to own, operate and maintain the buses themselves. Hence, there are few operators with significant presence and financial history. This makes it difficult for e-Bus operators to participate in the e-Bus tenders and avail finance from banks to purchase e-Buses.

As a result, large OEMs (bus manufacturers) must step in and provide additional guarantees on behalf of bus operators, thus increasing their balance sheet liabilities. In many cases, they are also required to be a part of the tripartite agreement between the bank, the e-Bus operators and themselves, thus increasing the financial and operational risk for them.

6. Significant counter-party risk for operators running e-Buses under GCC model

According to a MORTH’s annual report 2018-19, the 55 STUs in India reported a combined loss of INR 14,213 crore in the FY 16-17. This exposes the e-Bus operators bidding for contracts under GCC model to significant counter-party risks.

\textsuperscript{106} Economic Times
\textsuperscript{107} SBI
\textsuperscript{108} HDFC
\textsuperscript{109} Bank Bazaar

\textsuperscript{110} Under the Gross Cost Contract Model, the OEM provides the electric bus as a service to the transport authority or customer. The OEM charges an INR/km fees from the customer for operating and maintaining the electric bus.
3.4 Key Issues in Implementation

1. Inadequate payment security for investors and lenders and onerous requirements on performance security for e-Bus contracts under gross cross contract (GCC) model

According to market experts, FAME-II subsidy has the potential to facilitate GCC operations close to INR 30/km as seen in the case of BYD Goldstone in Bangalore; instead, contracts are being awarded at INR 70/km and INR 51/km since operators are required to secure high performance securities (close to 10% of project cost – as observed in e-Bus tenders in Jaipur and Mumbai) as part of the contracts. This inflates the upfront cost for the OEMs who are not able to fully benefit from the subsidy.

2. Operational uncertainties for E-bus operators

E-bus operators must finance heavy upfront costs emerging from procurement of e-Buses and setting up of a charging infrastructure in the bus depot. Considering how e-Bus operators have little experience in operating electric buses at a large-scale, uncertainties such as overcrowding, air-conditioning, climate and terrain might thwart the operator’s ability to make good on agreed conditions with the STU and would also translate into a loss of revenue.

3. Fragmented e-Bus procurement initiatives among cities

Currently, e-Bus procurement is being led by the various state and city-level transport undertakings separately. This leads to cost inefficiency in public procurement. Also, a lack of technical and managerial capacity at the city government level for e-Bus procurement leading to delay in deployment and utilization of FAME-II funds.

4. Lack of quick and collateral-free micro-credit for e-3W and e-2W

Most e-vehicles in India are e-rickshaws and are driven by people from relatively poor sections of the society, with 80% of earning between US$ 200 to US$ 400 per month\textsuperscript{111}. According to various estimates, there are close to 1.5 million e-rickshaws running in India\textsuperscript{112}. Industry leaders and entrepreneurs believe that this number could be much higher (up to five times more) if financing was available to the drivers who typically hail from tier-3 and tier-4 towns and do not have credit history or CIBIL scores to make them eligible for loans by commercial banks\textsuperscript{113}. They also lack any collateral to be applicable for loans.

To move towards inclusive financing, in the absence of credit history of borrowers, various innovative solutions are required for loan appraisal beside strong micro-finance programs. Some start-ups such as RevFin, SMV Green Solutions and others are deploying a combination of measures such as psychometric analysis, biometric verification and vehicle monitoring to appraise loan applications by e-rickshaw drivers in the absence of credit history.

3.5 Recommendations

1. Review the GCC contracts and balance the risks between contractor and employer

Reviewing current GCC contracts, we recommend the state transport departments and STUs to consider the following recommended actions:

- Reducing “Performance Security” in GCC contracts for operators, to avail full benefits of the FAME-II subsidy; STUs may consider reducing payment security to 5% for e-Bus contracts in the short-term (three to five years)\textsuperscript{114}:
  - GCC contracts, as observed in e-Bus tenders awarded in Kolkata, Bengaluru and Ahmedabad usually include a 10% payment security for the operator to the authority/STU.
  - To allay concerns of STUs, in light of reduced performance security in e-Bus contracts, (1) market participation should be encouraged amongst more operators

\textsuperscript{111} Shakti Foundation
\textsuperscript{112} Shakti Foundation
\textsuperscript{113} Inc 42
\textsuperscript{114} Stakeholder Consultation
and, (2) capacity building of STUs can be considered, so that STUs can step in when operators fail to perform.

- In addition, the bank guarantees should be maintained on a depreciating basis. For example, in a contract for 10 years, the bank guarantee could decrease by 10% every year.
- Predictability in EV power tariffs for the duration of the GCC contract should be provided; currently there is no clarity around the exact tariff which will be applicable throughout the contract duration.
- Also, GCC contracts for both operations with fast chargers and battery swapping could be considered. The contracts may remain technology agnostic or could have scope for either technologies (in the current case: charging and swapping). Further, there could be more flexibility in the business model followed under e-Bus contracts by allowing participation of bus fleet aggregators, leasing companies and more.

2. Standardize financial conditions and specifications in procurement contracts; aggregate procurement at state level and draw out long term procurement plan staggered over years

To ensure procurement efficiency, STUs should standardize specifications and financial conditions in procurement contracts. The demand can be further aggregated at the state-level rather than the city-level to increase the scale and drive down costs.

Further, long term procurement plans should be drawn out by STUs with commitment made for staggered procurement across the period (six to eight years). This kind of certainty will enable the e-Bus OEMs to strike supply agreements, financing agreements, increase scale and in-turn drive down costs for the STUs. The flexibility of the business model in e-Bus tenders could be increased by allowing participation of bus fleet aggregator/leasing companies.

3. Support micro-credit access for e-2W and e-3W to micro-finance institutions through MUDRA scheme

In the current scenario of the MUDRA scheme, individuals can avail micro-financing for 2Ws and 3Ws. But according to secondary research and industry consultations, drivers seeking micro-financing for their vehicles face delays in application approval, required to offer collateral and in many cases, not offered loans at all. Also, there is considerable lack of interest among banks to offer EV loans under the MUDRA scheme. It is hence recommended that the on-ground implementation of micro-credit program for e-2W and e-3W under MUDRA scheme should be closely monitored and adequate support should be provided to banks for offering collateral free and have expedited loan approvals to potential buyers.

115 RUMSL
116 SUTP India
117 Micro4 Units Development and Refinance Agency Ltd. [MUDRA] is an NBFC supporting development of micro enterprise sector in the country. MUDRA provides refinance support to Banks/MFIs/NBFCs for lending to micro units having loan requirement up to 10 lakhs. MUDRA provides refinance support to micro business under the Scheme of Pradhan Mantri MUDRA Yojana
118 Pradhan Mantri Mudra Yojana
4. Supplement lower-cost, longer-tenor DFI financing to support micro-credit access for e-2W, e-3W; and work closely with OEMs to explore additional risk reduction models such as extended warranties, buy-back offers and residual value guarantees to increase confidence among financiers about EVs

To increase interest among banks and to reduce lending risks, long term DFI financing could be leveraged to provide portfolio-backed guarantees, risk-pooling and other risk reduction mechanisms. In addition, models could be explored by banks, other lending institutions and DFIs whereby vehicle OEMs, service providers also contribute to de-risking through extended warranties, buy-back offers and residual value guarantees, etc.

3.6 Further Analysis and Studies Recommended

The government could undertake further work on the following aspects:

- Financial products for EVs to provide flexible loan terms and long-term repayment tenor for EV buyers.
- Feasibility study for developing an electric mobility fund through the application of cess on sale of petrol and diesel; conduct cost-benefit analysis and assess the economic impact on exchequer.

- Study with e-Bus operators and STUs to understand the technological, operational risks in running e-Buses and the challenges in getting access to finance at affordable rates and with convenient terms.
- Economic feasibility studies for creation of a partial-risk sharing fund/partial-risk guarantee fund at state government-level or PSB-level alongside DFIs.
- Pilots to study the benefits of a battery leasing model in e-Buses and the conditions requisite for smooth functioning of financial institutions backing such an operating model with other players such as e-Bus operators, auto-OEMs and STUs.
- Methods to increase the disbursement of micro-credit loans to 2 and 3-wheeler drivers through MUDRA scheme; assess if re-appropriation of funds is required under the scheme to provide additional focus for EVs.
- Study to understand global micro-credit programs for consumers with no credit history or bank accounts; learnings could be synthesized for an electric-3W program to allow low cost financing options for drivers with poor/unavailable credit history.
4.1 Strategic Importance

Globally, conventional mobility is associated with high carbon emissions and fossil fuel consumption. As a growing market, India’s national fleet of 2W, 3W, 4W, bus and other commercial vehicles are expected to grow rapidly between now and 2030. If the impending addition of vehicles in India is done through EVs rather than ICE, significant carbon emissions and oil import dependence can be reduced.

Considering current market growth rate and conditions, vehicle fleets could grow in the following manner by 2030.

In addition, leading cab aggregators are already clocking high number of kilometers annually and taking a severe toll on the environment; in 2019, alone, a leading Indian cab aggregator clocked:

- 1.2 billion kms on 3Ws
- 366 million kms on intercity 4W services
- 166 million kms on 2Ws
- 6 billion kms across all vehicle segments on offer

In a business-as-usual scenario, the potential emissions would reach to more than 600 million tonnes of CO₂ per year by 2030 from motorized transport alone, according to NITI Aayog and RMI’s report.

Apart from environmental benefits, EV’s low operational costs would mean higher disposable income for driver-cum-owners in 2W, 3W, 4W and LCV fleets. While these benefits today can only be realized at subsidized upfront costs, the right technology fit and technological know-how, technology innovation and falling costs from EV deployment promise to yield significant benefits in future.

4.2 Current Scenario

The Indian EV ecosystem has witnessed growing adoption of EVs in ICE vehicle fleets. This has either been in the form of public transportation such as electric buses and electric rickshaws, or, commercial

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**TABLE 4: Market growth in terms of annual sales**

<table>
<thead>
<tr>
<th>Vehicle segment</th>
<th>Annual sales (2018-19)</th>
<th>Annual sales (2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-wheelers</td>
<td>21 million</td>
<td>46 million</td>
</tr>
<tr>
<td>3-wheelers</td>
<td>0.7 million</td>
<td>1.6 million</td>
</tr>
<tr>
<td>4-wheelers</td>
<td>3.3 million</td>
<td>6.5 million</td>
</tr>
<tr>
<td>Small CVs</td>
<td>0.5 million</td>
<td>1.4 million</td>
</tr>
<tr>
<td>Buses</td>
<td>0.08 million</td>
<td>0.22 million</td>
</tr>
</tbody>
</table>

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119 SIAM (Society of Indian Automotive Manufacturers
120 CAGR used for projection is the CAGR between 2015-19; the value for different segments are: 7% (2W), 8% (3W), 6% (4W), 10% (SCV); and 10% (Bus)
121 NITI Aayog and Rocky Mountain Institute
fleets in employee transport, logistics and ride-hailing sector (across 2W, 3W, 4W and buses). Some of the steps taken toward adoption in both spheres of public transport and commercial fleets are as follows:

- Deploying EVs in public transportation:
  - Through FAME-I, GCC contracts were awarded in Hyderabad, Ahmedabad, Mumbai, Jaipur, Bengaluru (both 9 and 12 meters) and outright purchase bids were also awarded in Indore, Lucknow, Kolkata, Jammu, Guwahati (mostly 9 m buses)\(^{122}\).
  - Pune’s PMPML, in 2019, deployed 133 e-Buses. This was done in partnership with e-Bus OEM Olectra Greentech (and BYD), who owns, operates and maintains the e-Buses\(^{123}\).

- NITI Aayog in early 2019, introduced the Model Concession Agreement for Electric Bus Fleets in Cities. The tool was envisioned to support STU targets and project bankability for private operators who will own and operate the buses\(^{124}\).

- By 2019, India already had electric rickshaws numbering close to 2 million. This number continues to grow due to low upfront cost of lead acid batteries and low running cost; as per the industry, newer electric rickshaws are li-ion based\(^{125}\).

\(^{122}\) LBNL and UITP

\(^{123}\) Pune e-Bus experiment

\(^{124}\) NITI Aayog’s Model Concession Agreement

\(^{125}\) Stakeholder Consultation

### TABLE 5: GCC contracts across India in FAME-I

<table>
<thead>
<tr>
<th>City</th>
<th>Agency</th>
<th>Contract type</th>
<th>Supplier</th>
<th>Cost (INR/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bengaluru</td>
<td>Bengaluru Metro Transportation Corp</td>
<td>GCC (12 m AC)</td>
<td>Goldstone-BYD</td>
<td>37.35</td>
</tr>
<tr>
<td>Mumbai</td>
<td>BEST Undertakings</td>
<td>GCC (9 m AC)</td>
<td>Goldstone-BYD</td>
<td>57</td>
</tr>
<tr>
<td>Hyderabad</td>
<td>Telangana State Road Transport Corp</td>
<td>GCC (9 m AC)</td>
<td>Goldstone-BYD</td>
<td>36</td>
</tr>
<tr>
<td>Ahmedabad</td>
<td>Ahmedabad Janmarg Limited</td>
<td>GCC (9 m AC)</td>
<td>Ashok Leyland Limited</td>
<td>48</td>
</tr>
<tr>
<td>Jaipur</td>
<td>Jaipur City Transport Services Ltd</td>
<td>GCC (9 m AC)</td>
<td>Tata Motors Limited</td>
<td>70</td>
</tr>
</tbody>
</table>

### TABLE 6: Outright purchase contracts across India in FAME-I

<table>
<thead>
<tr>
<th>City</th>
<th>Agency</th>
<th>Contract type</th>
<th>Supplier</th>
<th>Cost (INR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indore</td>
<td>Atal Indore City Transport Services</td>
<td>OP (9 m)</td>
<td>Tata Motors Limited</td>
<td>85,00,000</td>
</tr>
<tr>
<td>Lucknow</td>
<td>Lucknow City Transport Services Ltd</td>
<td>OP (9 m)</td>
<td>Tata Motors Limited</td>
<td>85,00,000</td>
</tr>
<tr>
<td>Kolkata</td>
<td>West Bengal Transport Corp Limited</td>
<td>OP (9 m)</td>
<td>Tata Motors Limited</td>
<td>77,00,000</td>
</tr>
<tr>
<td>Kolkata</td>
<td>West Bengal Transport Corp Limited</td>
<td>OP (12 m)</td>
<td>Tata Motors Limited</td>
<td>88,00,000</td>
</tr>
<tr>
<td>Jammu</td>
<td>Jammu and Kashmir State Road Corp</td>
<td>OP (9 m)</td>
<td>Tata Motors Limited</td>
<td>99,00,000</td>
</tr>
<tr>
<td>Guwahati</td>
<td>Assam State Transport Corps</td>
<td>OP (9 m)</td>
<td>Tata Motors Limited</td>
<td>99,00,000</td>
</tr>
</tbody>
</table>
Deploying EVs in commercial fleets (employee transport, ride-hailing, logistics)

- EEE taxis (~200), Blu Smart (~1000) and Lithium-cabs (~1200) are leading all-electric Indian upstarts providing ride-hailing and employee transport services.
- Ola, after its Nagpur pilot is focusing on 2Ws and 3Ws (and battery swapping); and Uber, which has partnered with Blu Smart and EEE taxis and is also exploring the 2W/3W space for deployment.
- Amazon (10,000 EVs by 2025) and Flipkart (40% of last-mile fleet by 2020) both have committed to short-/medium-term EV targets for their logistic fleets and associated vendors.
- Big Basket – Euler logistics, GATI – IKEA, Hero- electric – Swiggy and other partnerships have made progress with EV deployment for grocery, furniture, food and other deliveries.
- Smart-E – Sun Mobility have partnered in the 3W ride hailing segment, deploying Smart-E’s fleet since April 2018 when phase 1 began with 500 EVs.

In the face of certain regulatory impediments, other business models and deployment categories such as micro-mobility have sprung up, which rely on the Government’s Rent-a-Motorcycle-Scheme. Some of these start-ups are Bounce, ONN Bikes and Drivezy.

- Measuring the ability of top use-cases to accommodate EVs for operations
  Current EV models, their performance and cost, yield certain TCO parity thresholds for various vehicle segments. Use-cases are measured$^{126}$ for their ability to run the vehicles (daily utilization in kms/day) and hence their ability to accommodate current EV options (with limited range, smaller batteries and more):

- Assessing the addressable market for EV transition by 2030 across vehicle segments
  Considering this, businesses are slowly moving to capitalize on market opportunities across vehicle segments; based on annual new sales in 2030 and an EV penetration per vehicle segment, we estimate the addressable markets as follows$^{127}$:

  By 2030, segments such as 2Ws and 4Ws will form an addressable market of ~US$ 25 billion and ~US$ 20 billion, respectively, this would include both personal and commercial vehicles. Other segments such as SCVs could have three times increase in the addressable market for players; bus sales include both for 127 SIAM; Segment CAGR between 2015-19 has been taken as: 7% (2W), 8% (3W), 6% (4W), 10% (SCV); and 10% (Bus); Average ticket size (cost) assumed for most popular vehicle option in the segment; for example, for 4W segment, the highest selling vehicle is Maruti Suzuki’s Swift DeZire (~INR 7,00,000); EV penetration of new sales in 2030 are assumed to be: 80% (2W,3W); 30% (4W, SCV); 40% (Buses); US$ to INR rate assumed to be INR 75.75, as on 07 April 2020; Ashok Leyland and Tata Motors sales data, The Climate Finance Lab

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$^{126}$ EY Analysis on top e-mobility use-cases

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**FIGURE 13: TCO parity with ICE for varying use-cases and vehicle segments**

<table>
<thead>
<tr>
<th>Use case</th>
<th>ETS</th>
<th>Ride-hailing</th>
<th>Deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parity with ICE</td>
<td>Use case utilization</td>
<td>Daily utilization in kms/day</td>
<td></td>
</tr>
</tbody>
</table>

**FIGURE 14: Addressable market growth for vehicle categories by 2030**

<table>
<thead>
<tr>
<th>Vehicle segments</th>
<th>Annual New Sales (in Mn)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2W</td>
<td>21</td>
</tr>
<tr>
<td>3W</td>
<td>21</td>
</tr>
<tr>
<td>4W</td>
<td>31</td>
</tr>
<tr>
<td>LCV</td>
<td>14</td>
</tr>
<tr>
<td>Bus</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Current New Sales (2020) vs. Annual New Sales (2030)

Addressable market - USD Bn
private and STU applications and to capture this market, private players will have to adopt E-buses as well.

- Assessing ability of EVs to reduce lifetime CO₂ emissions

The strategic importance for EV deployment is more toward preventing carbon emissions than benefiting from low operational costs (which is not being currently realized in most cases).

There are increasing concerns in the more established markets (of Europe and the USA), where EVs are being charged on the existing grid mix (renewable vs. other sources), that EVs may not play a vital role in reducing carbon emissions as envisioned before.

However, research reveals that EVs can reduce lifetime CO₂ emissions by an average of 29% to 79% depending on the emissions intensity of the grid. Even for an EV driven in Poland (coal-dominant grid) with a battery manufactured in China (coal-dominant grid), the lifetime emissions are 22% lower than diesel cars and 28% lesser than petrol cars. This is depicted in Figure 15.

Globally and in India, the awareness of EVs and their potential societal benefits is increasing. The current Covid-19 situation seems to have accelerated this process and increased the awareness further. For example, in a survey of 200 UK consumers in April, Venso Automotive Solutions, a fleet management company, found that an additional 45% of respondents were considering buying an EV after seeing how clear the air can be. In conjunction with the 17% consumers who had already decided to buy an EV, this means that 62% of UK consumers in this particular survey are willing to go electric. While further research is certainly required on this subject, it can be inferred that despite the adverse short-term impacts on EV-related auto sales and supply chains, the long-term effects on EV adoption could be more favorable.

4.3 Key Market Challenges

1. High upfront cost of EVs which acts as a barrier to adoption

Most business models for top use-cases such as ride-hailing, employee transport and deliveries have individuals or small vendors owning the vehicles. Given the high upfront cost and the associated infrastructure required to operate EVs, individual drivers are usually unwilling to own/operate them.

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128 European Federation for Transportation and Environment
2. Lack of high-quality EVs in India and poor consumer perception regarding performance of EVs

Keeping with budget constraints, in an extremely price-sensitive market, newly fabricated EVs are known to have lower volumetric and payload capacities than required for their logistics applications. This leads to reliability issues for fleet operators, additional EVs (more EVs than corresponding ICE vehicles) must be procured and maintained to carry out operations smoothly.

3. High downtime for EV drivers across vehicle segments

The table below describes the downtime a driver faces with fast and slow charging of their vehicle. The fact that the time spent charging could otherwise be spent earning revenue, has become a major impediment to EV adoption.

### TABLE 7: Understanding the upfront cost disparity between EV and ICE per vehicle segment

<table>
<thead>
<tr>
<th>Vehicle segment</th>
<th>ICE cost (INR lacs)</th>
<th>EV cost (INR lacs)</th>
<th>Disparity (EV/ICE %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-wheelers</td>
<td>0.5</td>
<td>1.2</td>
<td>240%</td>
</tr>
<tr>
<td>3-wheelers</td>
<td>1.5</td>
<td>2.5</td>
<td>167%</td>
</tr>
<tr>
<td>4-wheelers</td>
<td>7</td>
<td>15&lt;sup&gt;29&lt;/sup&gt;</td>
<td>215%</td>
</tr>
<tr>
<td>Buses</td>
<td>50</td>
<td>150</td>
<td>300%</td>
</tr>
<tr>
<td>LCVs&lt;sup&gt;^^&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: *The companies for cost of vehicles include models of Ather/Okinawa, Kinetic Green, Mahindra and BYD/Ashok Leyland for 2W, 3W, 4W and buses respectively

<sup>29</sup> 4W models such as Mahindra E-Verito and Tata Tigor have been considered as they are predominantly being used by commercial fleets; EV options such as Hyundai Kia and Tata e-Nexon have also been considered in such applications

### TABLE 8: Average charging time across various vehicle segments available in India

<table>
<thead>
<tr>
<th>Vehicle segment</th>
<th>Battery* (kWh)</th>
<th>Usual range* (km)</th>
<th>Fast charging** (hours)</th>
<th>Slow charging** (hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 wheelers</td>
<td>3-5</td>
<td>60-100</td>
<td>0.5</td>
<td>3-6</td>
</tr>
<tr>
<td>3 wheelers</td>
<td>3-5</td>
<td>40-80</td>
<td>0.5</td>
<td>3-6</td>
</tr>
<tr>
<td>4-wheelers</td>
<td>15-25</td>
<td>120-160</td>
<td>0.5-2</td>
<td>6-7</td>
</tr>
<tr>
<td>Buses</td>
<td>180-300</td>
<td>180-220</td>
<td>4-6</td>
<td>-</td>
</tr>
<tr>
<td>LCVs&lt;sup&gt;^^&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: *The companies for range and battery size assumptions include currently available EV models in India of Ather/Okinawa, Kinetic Green, Mahindra and BYD/Ashok Leyland for 2W, 3W, 4W and buses respectively

** The charging standard assumption for fast charging includes Type 2 AC fast, DC001 Bharat standard, CHAdeMO and CCS. For slow charging, the charging standard assumption is AC001 Bharat standard; Fast charging in 2Ws only considered for Ather Energy

<sup>^^</sup> LCVs have no electric vehicle options in market hence data on LCV operations is not available

### 4.4 Key Issues in Implementation

1. Policy and regulatory impediments for deployment of electric vehicles

While India has issued multiple policy pieces to support EV adoption in fleets, both at national and state-level, regulatory impediments to avail those benefits remain. Few of the regulatory obstacles are:

- RTO registrations and licenses need to be secured on a city-by-city basis, depending on base of operations. When coupled with inadequate understanding of EVs at the RTO level, this often implies separate liaising with several RTO offices across cities for fleet operators, thus causing delays in launching EV-based operations.
- Inadequate pace of requisite ARAI certifications of battery swappable EVs and retrofitting kits.
- Onerous tender eligibility criterion for private charge point operators to set up public chargers.

2. Lack of long-term policy targets for fleet adoption in ride-hailing and logistics

There are no long-term policy targets set by the government to support EV adoption; mandates are not present in terms of:

- Clean miles driven by fleets for timelines such as 2025, 2030, 2035 and beyond.
Rebates and credits program for fleets aiming to achieve mandates.

Regulations to mobilization demand in tier 1, 2 and 3 cities.

Government can take inspiration from its CNG transition mandates for city buses and taxis.

3. Lack of incentives for retrofitting and inadequate certification infrastructure to tackle upcoming retrofitting demand

Retrofitting has the potential to reduce cost to the driver in both fixed battery and battery swapping models. However, players in the segment, usually smaller and regional, need support for the expensive testing infrastructure. There should also be an incentive mechanism to encourage retrofitting.

4. Absence of disincentives/mandates for large fleet operators (which are responsible for major portion of vehicular pollution) to transition towards EVs

Various large fleet operators such as leading cab aggregators are already clocking high number of kilometers (billions) annually which is taking a severe toll on the environment. However, there are no mandates/disincentives/incentives to ensure their transition towards EVs.

5. Lack of any preferential incentive for replacing old ICE vehicles with EVs rather than another ICE vehicle

France has recently introduced “conversion prime”, an additional premium subsidy applicable to buyers who decommission/scrap their old ICE vehicle for replacement with an EV. Providing this additional incentive ensures higher environmental benefits by the removal of an ICE vehicle from the transport system.

4.5 Recommendations

Recommendations suggested below mainly target vehicle segments: 4Ws, LCVs and 3Ws.

1. Increase the quantum of FAME subsidy per EV, rather than targeting more EVs with lesser subsidy, with a focus of most sustainable vehicle segments, to reduce the cost parity with ICE counterparts and accelerate adoption

FAME-II is targeting an appreciable number of EVs to be subsidized: 1 million e-2Ws, 500,000 e-3Ws, 55,000 e-4Ws and 7,090 e-Buses. If the number of EVs targeted under the scheme were to reduce while keeping the overall subsidy outlay constant, the government could subsidize EVs to a further extent on per-vehicle basis (more than 20% of capex, as per FAME-II currently). This may provide additional incentive to end-users and fleets to rapidly purchase EVs, as more and more use-cases will become viable and could benefit from lower cost of operations130. Another benefit would be the awareness created among consumers by witnessing a large number of EVs on road. This accelerated demand will also increase the learning curve of EV manufacturers and help them reduce costs through the increased scale of operations.

2. Allow import of certain number of EVs per OEM at zero or reduced customs duty based on existing investments made by the OEMs in India

The government could allow for annual imports of certain number of EVs (lets say 25,000) per OEMs at zero or reduced customs duty in the short- to medium-term. This would reduce the upfront of cost of such EVs. More importantly, the high-performance imported EVs would raise the profile of EVs in consumer psyche and create a confidence in EV technology among potential buyers. In the interest of retaining and encouraging manufacturing investments, this duty waiver could be designed on the basis of existing investments made by OEMs operating in India.

130 Stakeholder consultation
3. Develop regulations to encourage the organized EV retrofitting market and increase organizational capacity to ramp-up the certification infrastructure for safety considerations

Retrofitting has the potential to reduce cost to the driver in both fixed battery and battery swapping models. The Department of Heavy Industries is recommended the following actions to facilitate the growth of retrofitting market:

- Expediting certification of retrofitting kits through ARAI for wider recognition of retrofitting as an e-mobility solution for driver-cum-owners; while ARAI is engaged in certification of retrofitting kits, the testing facilities at ARAI may need to provide some support to small retrofitting players to undertake the often-expensive testing infrastructure.
- Developing a separate subsidy scheme or accommodate retrofitting of 3Ws/4Ws/LCVs in FAME-II scheme (2020-22).

4. Institute fleet transition trajectories for certain “obligated entities” such as large fleet operators for certain vehicle segments over fixed timelines

- MoRTH, State Transport Departments and DHI could set realistic mandates to define transition trajectories for bigger fleets such as Uber and Ola. The mandates could be in the form of:
  - **Defined metric for transition for fleets**: Percentage zero-emission miles driven for 2022, 2025, 2030 and beyond for each vehicle class and segment (2/3/4Ws, LCVs and more)
  - **Defined benefits and rebates**: (1) for fleet operators and OEMs to support them in meeting mandated deadlines; (2) for individual drivers to replace their old ICE vehicles for EVs
  - **Defined scope of the policy**: Policy could be for taxis, light-commercial vehicles, medium/heavy commercial vehicles; the government can also define cities for first, second and third wave of transition (Tier 1 cities for example can begin in the short- to medium-term)

- Dedicated funds could be set up for facilitating achievement of EV transition targets (facilitate procurement of EVs and chargers). Such dedicated funds can be set up through multiple avenues:
  - **GST charge on rides**: Government can place 4-wheeler rides in a higher GST bracket (from 5% to 12%) to accrue funds for a clean mile mandate scheme to support fleets converting their vehicles to EVs.

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**CASE PRECEDENT**

**Clean-mile mandates for light and heavy commercial fleets**

**California Air Resource Board’s (CARB)**

The mandating body may consider California Air Resource Board’s (CARB) regulations on reducing greenhouse gas emissions from light-commercial, light-private and heavy commercial vehicles. CARB specifically included the following:

- US$ 200 million for the Clean Vehicle Rebate Project (CVRP), including increased rebates for low-income consumers. (CVRP promotes clean-vehicle adoption by offering rebates for the purchase or lease of new, eligible zero-emission vehicles, including electric, plug-in hybrid electric and fuel cell vehicles.)
- US$ 75 million for transportation equity projects, including the Enhanced Fleet Modernization Plus-Up/Clean Cars 4 All Program (incentives for lower-income drivers to scrap and replace older, high-polluting cars with zero-emission cars), Clean Mobility Options, Agricultural Worker Vanpools and the new Clean Mobility in Schools Project
- US$ 180 million for Clean Truck and Bus Vouchers (HVIP and Low NOx Engine Incentives) and the Zero- and Near-Zero Emission Freight Facilities Project.

The government can also look at trajectories set for CNG conversion in the past and benefits offered in the form of gas subsidy to support OEMs, vendors and consumers in the transition.

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131 California Air Resource Board
Additional environmental tax on vehicle based on their pollution characteristics.

- **Surcharge/Contribution per ride:** Alternatively, the private fleet companies could be encouraged to set up such funds towards meeting their transition. For example, Ride-hailing and taxi companies can add a surcharge on their 3W/4W rides to support drivers to switch to EVs. For illustration purpose, a surcharge of INR 5/ride in Ola or Uber (which combined do more than 1 billion rides a year in India) could yield an INR 500 crore fund for procuring EVs and chargers. Alternatively, a surcharge can be included on an INR/km basis to yield a similarly sized fund.

5. Provide higher incentives for replacement of old vehicles with EVs compared to ICE vehicles under the planned Vehicle Scrappage Policy

The government could provide higher incentives to fleet operators and personal users replacing their old ICE vehicles with EVs, as part of MoRTH’s vehicle scrappage guidelines and policy. The government could look at global cases such as that of France, where “conversion primes” are added as additional premium to EV buyers who decommission their ICE vehicles. Also, a scrappage policy for EVs would force the industry to decide the residual value of EVs, which could encourage financiers to provide finance for EVs.

### 4.6 Further Analysis and Studies Recommended

Recommendations suggested below mainly target vehicle segments: 4Ws, LCVs and 3Ws.

- Study to understand the scope for retrofitting and its potential to support Government and Industry targets for electrification; the study can shed more light on the size of the subsidy scheme, demand figures and technology solutions.
- Study to assess the increase in testing capacity required at institutes such as ARAI and ICAT to undertake the increased volume of homologation tests and other procedures on account of different vehicle and battery combinations that will emerge from wide spread of the adoption battery swapping model.
- Study to assess risk sharing (warranties, guarantees, etc.) between OEMs, battery swap operators, fleet operators and consumers in the battery swapping model.
- Studies to understand creation of different types of EV transition roadmaps; global case-studies such as UK’s Road to Zero transition roadmap (2040) and California’s roadmap for commercial fleets can be looked at to devise an EV transition strategy and targets with regional and time constraints.
- Techno-commercial assessment to amend the vehicles scrappage policy to allow EVs to run beyond 15 years since they emit no emissions irrespective of their age.

CASE PRECEDENT

**Creating a fund by levying surcharge**

Creating a fund by levying surcharge

Uber London unveiled a “Clean Air Plan initiative” to go all electric in London by 2025 by raising GBP 200 million. This fund will be created through charging GBP 0.15/mile as a surcharge on regular rides. Uber expects 20,000 drivers to upgrade to EVs by end of 2021 by utilizing the collections from this fund.

132 Uber Clean Air Program
133 Stakeholder Consultation
134 California Air Resource Board
5.1 Strategic Importance

EV manufacturing giants such as China, US and Germany have launched national-level plans for promoting domestic EV manufacturing to achieve export-competitive manufacturing competence and to serve domestic and global demand for EVs.

Setting-up a domestic EV manufacturing ecosystem could be of strategic importance to India as well to retain automobile industry’s high economic contribution.

Approximately 18% of all vehicles manufactured in India are exported. Considering the industry’s high contribution to India’s economy, the global transition from ICE vehicles to electric vehicles and dependence on exports, the industry could be at risk of reducing employment opportunities and GDP contribution, therefore, setting-up local EV manufacturing and supporting supply chains could be of strategic importance to India.

5.2 Current Scenario

- India currently has 29 OEMs registered with the DHI, Government of India which manufacture electric 2Ws, 3Ws, 4Ws and buses eligible for government subsidy under FAME–II.
- The electric 4W segment has limited options with just five models from Hyundai, Tata Motors, Mahindra and MG Motors. More models from these manufacturers and Maruti Suzuki are expected to be launched in India in the period 2020-22.
- The electric 3W segment, however, has numerous models varying in manufacturer type (large OEMs to medium-sized enterprises), performance, batteries (lead acid or lithium ion), etc. There are a large number of players.

<table>
<thead>
<tr>
<th>Country/Region</th>
<th>EV manufacturing policy</th>
</tr>
</thead>
</table>
| China\(^{135}\) | • Enforcing EV manufacturing mandates on large OEMs to increase vehicle supply  
  • Other national-level and province-level R&D support |
| US\(^{136}\)    | • Enforcing EV manufacturing mandates on large OEMs to increase vehicle supply |
| Germany\(^{137}\) | • Providing upfront federal subsidies in the form of direct cash of up to US$ ~10,000 |

### Table 9: EV manufacturing policies

135 Centre for Strategic and International Studies  
136 US Department of Energy  
137 Fleet Europe

\(^{138}\) The Indian automotive industry is currently reeling from a dip in sales in FY 2020, which have plunged by 18% as compared to sales in FY 2019  
\(^{139}\) Department of Heavy Industries, Government of India

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**CHAPTER 5: EV Manufacturing**
in the unorganized sector as well and the total e-3W fleet in India has always been a contentious subject. The unorganized sector is mostly involved in producing low-cost electric rickshaws which utilize lead acid batteries and do not require Government registration due to low speed and smaller batteries. Hence, no definitive statistics are available of the total number of rickshaws on the road.

- The electric 2W segment has the most manufacturers and models available. Both lead acid and lithium ion battery-powered 2Ws are available. Both established OEMs such as Hero Electric, Bajaj etc. and new entrants such as Okinawa, Ather, etc. are present in the market.

- The electric bus segment has seen some activity due to procurement of electric buses by states and city transport authorities. OEMs such as Tata Motors, Ashok Leyland, Goldstone-BYD, etc. are present.

- The Government of India, considering the strategic importance of domestic EV manufacturing, has introduced the following initiatives to transition the Indian auto manufacturing such as:

  - **Phased Manufacturing Program (PMP):** The PMP, introduced by the DHI, Government of India in 2019, lays out the government’s plan to stimulate domestic manufacturing and assembly of EVs and EV components in India by inverting the Basic Customs Duty (BCD) across EVs and EV components. As per PMP, the Government of India has increased the BCD on completely built units (CBUs) to 50%, while keeping it low for completely knocked down units (15%) and various key EV components (waived) such as regenerative brakes and control units.

  - **FAME-II:** Localization requirements: To promote local EV manufacturing, the DHI, Government of India has also mandated a minimum percentage localization criterion for EVs applying for subsidy under FAME-II. The current localization criterion stands at 40% and 50% of total vehicle cost for buses and other vehicles respectively (2W, 3W and 4W).

- Apart from the initiatives by the Government of India, several State Governments have introduced their EV policies which provide fiscal incentives for promotion of EVs and domestic EV manufacturing.

### TABLE 10: State EV Policy Highlights

<table>
<thead>
<tr>
<th>No.</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
</table>
| 1   | Andhra Pradesh            | - Separate tariff included (INR 6.95/kWh) for EV charging  
- Goal of 1 million EVs and 0.1 million slow and fast EV charging stations by 2024  
- Plans to stop registration of petrol and diesel cars by 2024 in the upcoming capital city of Amaravati  
- All government vehicles, including corporations, boards and government ambulances to be electric by 2024 |
| 2   | Bihar                     | - 15% subsidy on base price for first 1,00,000 EVs  
- Incentive of Rs. 10,000 to e-rickshaw using lithium ion battery  
- Manual paddle rickshaw to be upgraded/converted to electric by 2022  
- Exemption from registration fees and road tax  
- Top-up subsidy of Rs. 8,000 if user is below poverty line or SC/ST category  
- 25% capital subsidy for first 250 public charging stations  
- Common charging points in residential areas, societies, bus depots, public parking areas, railway stations and fuel pumps  
- Fast charging stations at every 50 kms on national/state highways |
<table>
<thead>
<tr>
<th>No.</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
</table>
| 3   | Chandigarh    | Government vehicles to be converted to all electric by 2025  
All electric 3-wheeler auto, corporate vehicles, cabs and school buses by 2030  
Subsidy of Rs. 20,000 for first 3,000 buyers of electric 2- and 3-wheelers  
First 1,000 EV buyer to get 1-year insurance for free  
Group purchase incentive of Rs. 30,000/vehicle  
30% EVs parking slots in new parking spaces  
Subsidy of 30% on installation of home charging stations  
15% subsidy for setting up public charging stations  
Dedicated EV charging lane in every sector of the city  
Incentivize battery recycling by providing Rs. 2,000/passenger vehicle and Rs. 20,000/ e-bus to battery recycling facility operator |
| 4   | Delhi         | Incentive of Rs. 5,000/kWh of battery capacity/vehicle, maximum up to Rs. 30,000/vehicle  
Delivery service providers to convert 50% of their 2-wheeler fleet to electric by 2023 and 100% by 2025  
All new home/workplace to have 20% electric vehicle holding capacity (with required infrastructure)  
100% grant for purchase of charging equipment for first 30,000 charging points  
100% of net SGST accrued to Government shall be provided as reimbursement to the energy operators  
Charging station within 3 km travel from anywhere in Delhi |
| 5   | Gujarat       | 100,000 electric vehicles to be deployed during policy period across all categories with maximum share coming from electric 2-wheelers and 3-wheelers  
Research & Development centre for EV industry  
State Level Investment facilitation Centre for facilitating manufacturing units |
| 6   | Karnataka     | Separate tariff (INR 4.85/kWh) for EV charging  
100% of three and four wheelers moving goods to transition to electric by 2030  
Attract investments of INR 31,000 crores (US$ 4.2 billion$^{140}$)  
Incentives for first 100 fast chargers |
| 7   | Maharashtra   | Target to increase number of EV registrations to 0.5 million  
Incentives and provisions for EV buyers of private/public passenger vehicles for five years  
Attract investments of INR 25,000 crores (US$ 3.4 billion$^{141}$) for manufacturing |
| 8   | Madhya Pradesh| 1% motor vehicle tax for first 15,000 EVs/total EV 2-wheelers in 5 years, whichever less  
Registration fees exemption for 22,500 EV 2-wheelers or total EV 2-wheelers in 5 years  
1% motor vehicle tax for first 5,000 e-rickshaw/total e-rickshaws in 5 years, whichever less  
Exemption of vehicle registration fees for 7,500 shared e-rickshaw/total e-rickshaws in 5 years, whichever less  
100% waiver in parking charges at all Urban Local Body run parking stations for 5 years  
1% motor vehicle tax for first 5,000 EV auto rickshaw/total EV auto rickshaw in 5 years, whichever less  
Exemption of vehicle registration fees for 7,500 EV auto rickshaw/total EV auto rickshaw in 5 years  
1% motor vehicle tax for first 2,000 EV 3-wheeler goods carrier/total EV 3-wheeler goods carrier in 5 years  
Exemption of vehicle registration fees for 3,000 goods carrier/total EV goods carrier in 5 years, whichever less |

$^{140}$ Exchange rate as of September 2020  
$^{141}$ Exchange rate as of September 2020
<table>
<thead>
<tr>
<th>No.</th>
<th>State</th>
<th>Description</th>
</tr>
</thead>
</table>
|     |             | • 1% motor vehicle tax for first 6,000 EV cars/total EV cars in 5 years, whichever less  
|     |             |  • Exemption of vehicle registration fees for 9,000 EV cars/total EV cars in 5 years, whichever less  
|     |             |  • 1% motor vehicle tax for first 1,500 EV buses/total EV buses in 5 years, whichever less  
|     |             |  • Exemption of vehicle registration fees for 2,250 EV buses/total EV buses in 5 years, whichever less  
|     |             |  • Small Charging stations: 25% subsidy for first 300 stations (up to Rs. 1,50,000)  
|     |             |  • Medium Charging stations: 25% subsidy for first 100 stations (up to Rs. 2,00,000)  
|     |             |  • Large charging stations: 25% subsidy for first 100 stations (up to Rs. 10,00,000) 
|     |             |  • Charging station at every 50 kms on highways  
|     | Punjab      | • 25% share of electric 2-wheeler in new sales over the policy period  
|     |             |  • 25% share of electric 3-wheeler (auto) in new sales in target cities over policy period  
|     |             |  • 100% waiver on permit fee and motor vehicle tax during policy period for 3-wheeler goods carrier and 3-wheeler auto  
|     |             |  • 25% share of electric 4-wheeler in new sales over the policy period  
|     |             |  • 100% electric fleet in government departments and 100% waiver on motor vehicle tax for corporate fleets  
|     |             |  • 25% of bus fleet under Transport department to be electric  
|     |             |  • 25% capital subsidy for first 1,000 charging points  
|     |             |  • Punjab E Mobility Centre of Excellence for skill development, R&D, collaboration  
|     | Tamil Nadu  | • Attract INR 50,000 crore (US$ 6.8 billion142) in investments and create 0.15 million jobs in the electric mobility segment  
|     |             |  • Special incentives to the EV and component manufacturers creating employment opportunity for at least 50 people  
|     |             |  • 100% refund of State GST (SGST) for EVs made and sold in Tamil Nadu until 2030  
|     |             |  • Capital subsidy of 15% and 20% for investments in EV manufacturing and battery production, respectively till 2025  
|     |             |  • 15% subsidy on the cost of land for EV or parts production project in the state’s industrial parks. For projects started in southern districts, the investors will get 50% subsidies until 2022  
|     | Telangana   | • State Transport Corporation has set a target of 100% electric buses by 2030 for intra-city, intercity and interstate transport  
|     |             |  • Government vehicles (owned and contractual) to switch to all electric by 2025, in phased manner. Permits for private operators with EV fleet operations  
|     | Uttar Pradesh | • 1,000 EV buses for public transportation by 2030  
|     |             |  • Green routes in major cities for 70% EV public transportation  
|     |             |  • All government vehicles to be electric and 50% EV in private transportation in major cities by 2024  
|     |             |  • Encourage adoption of EV for goods transport in major cities  
|     |             |  • 100% waiver on vehicle registration fees across all vehicle category during policy period and 100% road tax exemption for electric 2-wheelers and 75% for other EVs for first 1,00,000 buyers  
|     |             |  • Promote adoption of EV in goods transportation with an aim to achieve 50% EV in goods transportation in major cities by 2024 and all cities by 2030  
|     |             |  • 25% capital subsidy for first 100 charging stations  
|     |             |  • 20% subsidy to institutes providing training on EV and battery repair, maintenance  
| 10  | Uttarakhand | • 1,000 EV buses for public transportation by 2030  
|     |             |  • Green routes in major cities for 70% EV public transportation  
|     |             |  • All government vehicles to be electric and 50% EV in private transportation in major cities by 2024  
|     |             |  • Encourage adoption of EV for goods transport in major cities  
|     |             |  • 100% waiver on vehicle registration fees across all vehicle category during policy period and 100% road tax exemption for electric 2-wheelers and 75% for other EVs for first 1,00,000 buyers  
|     |             |  • Promote adoption of EV in goods transportation with an aim to achieve 50% EV in goods transportation in major cities by 2024 and all cities by 2030  
|     |             |  • 25% capital subsidy for first 100 charging stations  
|     |             |  • 20% subsidy to institutes providing training on EV and battery repair, maintenance  

142 Exchange rate as of September 2020
5.3 Key Market Challenges

1. Dependence on imports for EV battery cells due to lack of a robust domestic supply chain

Most Indian EV OEMs have not been able to completely localize their manufacturing value chains and are hence dependent on imports, particularly from China, for batteries (packs and cells) and certain other components. This dependence leaves the Indian EV manufacturing industry vulnerable to supply shortages. While some large OEMs are able to work with their suppliers and achieve full localization (except battery cells), the sector-wide localization is yet to be achieved and will require significant investments in R&D, innovation and testing infrastructure. Also, due to lack of scale in the initial stage, the investment required for testing will be huge in the initial years and will be required to be amortized over the next few years\(^\text{143}\).

2. Reduced focus of auto OEMs on EVs due to government’s push for BSVI fuel norms

The GoI had mandated Auto OEMs in February 2016 to transition to BSVI fuel with stricter emission norms, effective April 2020. This timeline was four years shorter than the earlier prescribed timeline of April 2024 in the then prevailing Auto Fuel Policy 2025 and involved skipping the BSV norms altogether\(^\text{144}\). Such a short transition timeline was unprecedented (three to four years in India vs. typically 7-10 years in Europe)\(^\text{145}\) and required an investment in the range of INR 60,000–70,000 crores (US$ 8.2–9.6 billion) by the auto OEMs. Compliance with the BSVI norms required investing in the technology and significant changes in procurement and manufacturing processes which may have led reduced focus by auto OEMs on EVs.

3. Economic overdependence on auto-components sector

The auto-components sector contributed to US$ 57 billion annual turnover, 4% of India’s exports and 5 million jobs in FY19\(^\text{146}\). Potential revenue loss and job loss in auto-component’s sector may be high since EVs use about 1/100th the number of components compared to an ICE counterpart.

5.4 Key Issues in Implementation

1. Lack of clear long-term roadmap for automotive industry’s transition to electric vehicles

Currently, no clear targets and timelines exist for the auto manufacturing industry in India to gradually transition from ICE manufacturing to EV manufacturing. No clear incentives exist for the auto manufacturing industry to make the transition. Global auto manufacturing hubs such as China and the USA, have an incentive/disincentive mechanism for OEMs to transition to EV manufacturing. Such mechanisms coupled with demand-side subsidies have resulted in an increase in available products/models, competition amongst local OEMs and as a result, higher uptake of EVs in these countries.

5.5 Recommendations

1. Create a long-term industry transition roadmap with strict enforcement of intermediate targets

Manufacturing mandates along a tradable credits program are one of the most effective ways to increase EV adoption in a country\(^\text{147}\). China and several states in the USA (including California) have successfully leveraged a form of ZEV mandates to drive automotive OEMs towards increasing the numbers of available EV models.

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143 Stakeholder Consultation
144 News Articles
145 DNA India
146 ACMA
147 Centre for American Progress (CAP)
The Government of India (Department of Heavy Industries) could work together with the SIAM, SMEV and other industry bodies to develop an EV manufacturing transition roadmap mandating major Indian OEMs to gradually transition a portion of their manufacturing capacity to EV manufacturing in the medium- to long-term. The roadmap could clearly mention the eligibility criteria for the OEMs (minimum vehicles manufactured per year), the minimum number of EVs to be manufactured by the OEM (based on percentage of ICE vehicles manufactured), the credits earned by manufacturers per EV manufactured and timeline for transition. The credits generated can be made tradeable to disincentivize major OEMs which do not transition.

Introducing such a mandate could:

- Provide clarity to the manufacturers on government’s long-term priorities
- Accelerate the manufacturing transition
- Increase the number of available models
- Increase cost-competitive models in the market

Countries with high levels of auto manufacturing such as the US and China have implemented such mandates.

2. Develop a clear, technology-agnostic transition roadmap for auto-component industry; design skilling programs and re-skilling programs to tackle the lack of EV-specific skills and job losses respectively

Considering the high potential job losses and revenue losses associated with EV transition, a transition roadmap for the auto-component industry along with skilling and re-skilling programs should be prepared.

5.6 Further Analysis and Studies Recommended

The government could undertake further work on the following aspects:

- Collaborate with SIAM, SMEV and other industry bodies to assess the sector-wide impact (transition propensity, impact on revenues, profitability, employment, etc.) and timelines of a possible manufacturing transition mandate.
- Collaborate with SIAM, SMEV and other industry bodies to identify emerging technologies in the electric mobility space requiring incentives and promotion by the Government of India.
- Assess the challenges in technology development and innovation in EV & battery sectors in India in collaboration with SIAM, SMEV and Auto OEMs.
6.1 Strategic Importance

The rise in global EV adoption is resulting in the rising demand of various strategic\textsuperscript{150} and rare earth\textsuperscript{151} minerals essential for manufacturing of EVs and lithium ion batteries. It is estimated that by 2050,

Battery performance is highly dependent on the battery chemistry and this in turn is driven by material composition\textsuperscript{153}. EVs are expected to account for about 85% of lithium demand and 65% of cobalt demand in 2025 from 50% and 52% respectively in 2017\textsuperscript{154}.

Although, lithium and cobalt are crucial for battery manufacturing, only 14% of the cost of battery pack accounts for mining, sourcing and processing. Figure 18 shows the manufacturing cost breakup of lithium-ion battery.

Across the globe there are examples of countries which have emerged as battery manufacturing hubs even without having reserves of these critical elements. Figure 19 shows the availability of critical elements in various countries. We can observe that Brazil and Australia have abundant reserves but neither country is a hub for battery manufacturing. On the other hand, Japan and South Korea have poor or no reserves of these minerals, yet they have

\textsuperscript{150} Strategic minerals are tin, cobalt, lithium, beryllium, germanium, gallium, indium, tantalum, niobium, selenium and bismuth

\textsuperscript{151} Rare earth elements are 17 elements which have extremely less economically exploitable mineral ore deposits; neodymium and samarium are used in permanent magnets of motors

\textsuperscript{152} World Bank report on Climate-Smart Mining: Minerals for Climate Action

\textsuperscript{153} MERCK - Lithium-Ion Battery Performance: Dependence on Material Synthesis and Post-Treatment Methods

\textsuperscript{154} EY Report: Produce or Procure?
emerged as battery manufacturing giants through robust technology innovations, global supply chains and long-term sourcing contracts.

It is widely observed that global battery manufacturers generally work with a global network of raw mineral suppliers, processed mineral suppliers and component suppliers. This facilitates customizing the components to their specific requirements and helps in moving the suppliers in lockstep with the frequent innovations in battery technology. Therefore, it is crucial for India to develop an ecosystem for battery manufacturing, technology development and facilitating sourcing of raw materials through the global supply chain.

6.2 Current Scenario

Apart from the estimated lithium reserves of around 14,000 tonnes in Mandya district of Karnataka\textsuperscript{156}, discovered by researchers at Atomic Minerals

\textsuperscript{155} BNEF

\textsuperscript{156} The Economic Times
Directorate, there is no information about any other lithium reserves in India. As per the last update of the National Mineral Inventory in April 2015, there is no production of cobalt in the country and the entire demand is met through imports. As on 1st April 2020, there were 45 million tonnes which have been classified as remaining resources, implying that it is not economically viable for mining. It is estimated that there are 188.86 million tonnes of nickel ore in India, but it is entirely placed under the remaining resources category. Although the entire demand is met through imports, nickel is also recovered as a by-product during refining of copper.

It is noteworthy that India has rich bauxite mineral base and it is one of the largest producers of aluminum in the world and the overall installed capacity is 41 lakh tonnes in 2017-18. There is a total of 1.51 billion tonnes of copper reserves in India and the production of copper ore was 3.68 million tonnes in 2017-18.

157 EY Analysis, USGS
158 National Mineral Inventory
159 Indian Minerals Yearbook 2018
160 Indian Minerals Yearbook 2018
A total of 194.89 million tonnes of graphite reserves are present across the country with production of 33,558 tonnes\(^{161}\) in 2017-18. Although, India has rich mineral resources, it does not have enough reserves of critical elements. The current scenario of sourcing critical elements is heavily dependent on imports which indicates that there is a global supply chain in place to cater to the demand for critical elements.

The Government of India launched Khanij Bidesh India Limited (KABIL) to identify, invest and acquire global reserves to meet India’s future demand of the critical minerals such as lithium, nickel, cobalt, etc. The Khanij Bidesh India Ltd. (KABIL) is a joint venture company set up by a consortium of three Central Public Sector Enterprises, namely: National Aluminium Company Ltd. (NALCO), Hindustan Copper Ltd. (HCL) and Mineral Exploration Company Ltd. (MECL)\(^{162}\). The KABIL team visited mines in Argentina, Bolivia and Chile in February 2019 and now the follow-up activities are underway although there has not been any breakthrough yet in terms of strategic agreements with these countries for mineral procurement. However, India and Australia have recently signed an MOU for supplying critical minerals to India including lithium, cobalt, zircon, antimony, tantalum and other rare earths\(^{163}\).

A few private companies in India have announced plans to set-up lithium ion battery manufacturing plants in India. TDSG is the India’s first lithium-ion battery manufacturing plant in Gujarat which is being set up joint venture between Suzuki Motor Corporation (50% equity stake), TOSHIBA Corporation (40%) and DENSO Corporation (10%) to manufacture and supply lithium-ion battery to Maruti Suzuki and Suzuki Motor in Gujarat\(^{164}\). Tata Chemicals has acquired land in Dholera, Gujarat\(^{165}\) to set up the lithium-ion cell manufacturing plant. As of January 2019, Bharat Heavy Electricals Limited (BHEL) and Libcooin were in a dialogue to build a 1 GWh lithium ion battery plant in India. MoHIPE recently quoted plans of scaling the plant’s capacity to 30 GWh in due course\(^{166}\). Libcooin is a consortium comprising Magnis Energy, Duggal Family Trust and Charge CCCV(C4V) and has plans to build large lithium-ion battery giga-factories globally. With the rise in battery manufacturing plants in India, there is a need to have a robust and reliable supply of raw materials through global supply chains.

6.3 Key Market Challenges

1. Lack of adequate demand for lithium batteries to justify the huge investments required for domestic manufacturing

India currently has a small demand from EVs for lithium ion batteries. To put it into perspective, in FY19, the sales of e-4W in India was 3,600 units only against global EV sales of ~2 million in 2019\(^{167}\). The overall demand lithium ion battery from EVs was below 2 GWh in FY19\(^{168}\) against the global EV-based lithium ion battery demand of 160 GWh\(^{169}\). Such a small quantum of demand and lack of clarity on future demand has kept the battery OEMs away from making investments in battery manufacturing, especially in cell manufacturing, in India.

2. Unavailability of battery minerals in India

Due to lack of data on potential lithium reserves in India, there is a lack of confidence in investors to invest on lithium exploration in the country. Since there are no lithium battery cell manufacturing companies in India, there is no demand for domestic raw lithium. Therefore, the government has not yet invested in exploration of the potential of lithium reserves in India. This is a vicious cycle where the investors would not come forward without knowing the potential and the government might not invest in expensive exploration exercise if there is no demand from the market for raw lithium. The stakeholders from battery storage industry have also voiced opinion that India has not explored whether there are adequate

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\(^{161}\) Indian Minerals Yearbook 2018  
\(^{162}\) Ministry of Mines  
\(^{163}\) Minister for Resources, Water and Northern Australia  
\(^{164}\) TDSG  
\(^{165}\) Live mint  
\(^{166}\) Saur Energy  
\(^{167}\) Global EV Outlook 2019  
\(^{168}\) EY analysis  
\(^{169}\) BNEF
reserves of lithium and therefore they are not aware of its potential in the country.

3. Geographical concentration of global reserves

As of 2018, nearly 41% of the global lithium production was in Australia and Chile produced 33%.

Close to 80% of global lithium production is concentrated in the three South American countries and Australia170.

Also, 51% (3,600,000 MT) of the world's total cobalt reserves are located in the Democratic Republic of Congo while contributing to 72% of global cobalt production, as of February 2020.

4. Concentrated ownership of mines and processing plants of key mineral reserves globally

Apart from uneven distribution of mineral reserves, supply is also constrained by several factors such as technical challenges (in geology and extraction), politics, laws, environmental regulations, land restrictions, economics and infrastructure. These factors also result in concentration of critical minerals in only a few regions. China accounts for nearly one-third of the global demand for lithium given that it manufactures the largest number of batteries in the world. The dominance of China over cobalt and lithium production is depicted in Figure 22.

China has emerged as a leading manufacturer of EVs and batteries and therefore controls significant portion of global lithium supply and a higher share of the refined cobalt market than any other nation. Globally, it also holds 75% electrolyte market, 75% anode materials market, 62% cathode materials market and 45% of the separators market171.

5. Continuously evolving battery technology goal post poses stranded-asset risk to public investments in mines globally

It must be noted that lead acid battery is the oldest rechargeable battery with a history of 150 years and has retained its market share over years due to its cost-effectiveness and low self-discharge of 40% per

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170 Resource Capital Report

171 Clean Technica
The evolution of lead acid batteries has not been as rapid or as volatile as lithium ion batteries. Over the past 25 years, Li-ion batteries have improved and patents in this field have increased almost threefold from 2010. In 2015 alone, nearly 4,800 patents were filed for the research activity undertaken in li-ion technologies.

Owing to such rapid pace of innovations, there is a significant risk in investing, owning and operating mines related to key battery minerals. Battery chemistries and their compositions are continuously changing. Tesla, for example, reduced the cobalt content in its battery by 88% from 2010 to 2018 to tackle the challenges of unstable supply and volatile prices.

### 6.4 Key Issues in Implementation

1. **Lack of policy and regulatory support for private sector investment**

   The involvement of private sector in mining sector depends on the availability of baseline geoscientific data, public access to the data, ease of doing business and return on investment. There are no fiscal incentives provided to the private sector companies that engage in exploration activities.

   In addition, the government’s key scheme for supporting EV adoption (FAME-II scheme) has a timeline of support of only three years (FY19-FY22), with no visibility on possible extension of support. Such short timeframe for the subsidy support towards EV adoption adds further uncertainty to investors making large battery manufacturing investments with long payback periods.

2. **Lack of government initiatives for public private partnerships**

   There is no restriction on private sector companies to undertake explorational activities, but they are not given any mineral concessions other than those through auction. Further, there are no fiscal incentives provided or government partnerships offered to the private companies which could in turn reduce the risk on investment for expensive explorational activities.
6.5 Recommendations

1. Support private sector mineral sourcing and investments in mines globally through government to government (G2G) facilitation rather than undertaking public investments

New lithium mines are being discovered across the globe, for instance, reserves amounting to 60% of global reserves, as on 2018, are estimated to be discovered in Australia, the USA, Canada and Mexico by 2027. Also, significant advancements are being made in lithium extraction technologies. As an example, Albemarle, the largest global lithium miner, is expected to increase lithium extraction efficiency by 56%. With such developments, the industry believes that there are sufficient lithium reserves on the earth’s crust to power EVs globally.

Furthermore, an integrated global supply chain has emerged for lithium and other battery minerals whereby major battery manufacturers and global mining companies are entering into long-term lithium supply agreements now (for 7-10 years) compared to short-term agreements (for two to three years) almost four years ago. These developments combined with relatively low contribution of minerals in final product price (<15%), have meant that concerns of battery manufacturing OEMs around mineral sourcing are low.

In line with this, the Government of India should take an overview of whether the global demand for batteries can be met with present global reserves. Support from the government in the form of bilateral trade agreements would help the domestic manufacturers to access minerals from foreign countries. The key actions recommended are:

- Evaluate entry into long-term preferential trade agreements with countries rich in reserves to facilitate procurement of minerals for battery manufacturers and EV manufacturers establishing manufacturing units in India.
- Ensure procurement of minerals through responsible sourcing network (devoid of child labor and human rights abuse) and from mines which employ sustainable mining techniques.

6.6 Further Analysis and Studies Recommended

The government could undertake further work on the following aspects:

- Assess the bottlenecks in mining sector for the stakeholders and undertake measures to expedite the completion of National Aero-Geophysical Mapping Project, National Geochemical Mapping (NGCM), National Geophysical Mapping (NGPM) programs. It is also essential to prepare the Obvious Geological Potential (OGP) maps on priority for critical minerals.
- Capacity building programs with national and international research organizations for north-south and south-south knowledge exchange on global best practices in exploration and sustainable mining of critical minerals.
- Economic feasibility analysis to study the impact of reduction in import duty of raw materials on the exchequer.
- Identify the amendments or new additions required in trade-agreements with mineral-rich countries to secure supply for current and future battery manufacturers in India.

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177 BNEF
178 BNEF
179 Industry consultation
180 BNEF
181 Industry consultation
182 Ministry of Mines
183 National Mineral Exploration Policy – Base paper for discussion
7.1 Strategic Importance

Globally, countries such as China, the US and Germany have launched national-level plans promoting domestic battery manufacturing\(^\text{184}\) to achieve export-competitive manufacturing competence and serve domestic and global demand for EV batteries.

Setting-up a domestic battery manufacturing ecosystem could be of strategic importance to India as well to:

- **Maintain automobile industry’s high economic contribution**
  
  The automobile industry contributes to more than 7% of India’s GDP and roughly 49% of its manufacturing GDP\(^\text{188}\). It also employs 30 million people directly or indirectly\(^\text{189}\). Considering the industry’s high contribution to India’s economy, the global transition from ICE vehicles to electric vehicles, batteries’ high value share (30-50%) in an EV and India’s lack of domestic battery manufacturing, it should be of strategic importance for India to set up local battery manufacturing. The auto OEMs would also prefer to have battery manufacturing close to the EV manufacturing units (approximately within 100 km radius)\(^\text{190}\).

- **Reduce risk of import dependence on batteries**
  
  One of the key drivers for Government of India to promote EV uptake is India’s high dependence on imported oil. India currently

<table>
<thead>
<tr>
<th>Country</th>
<th>Battery manufacturing incentives</th>
</tr>
</thead>
</table>
| China\(^\text{185}\) | \- Increasing entry barriers for foreign manufacturers by subsidizing vehicles powered by batteries manufactured in China  
\- Creating demand through EV subsidies and a vast state-funded charging infrastructure network  
\- Other national-level and province-level R&D support |
| US\(^\text{186}\) | \- Direct funding (grant and debt) or tax benefits to companies across the battery manufacturing value chain |
| Germany\(^\text{187}\) | \- Direct funding (grant) to multiple vehicle OEM – battery manufacturing consortiums based on technical competence |

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184 Scope includes component manufacturing, cell manufacturing and pack assembling (including battery management system). Only vehicle and power sector applications of batteries have been considered. Other applications such as consumer electronics, naval and aerial applications etc. have not been considered.

185 Centre for Strategic and International Studies

186 US Department of Energy

187 BNEF

188 SIAM

189 Rocky Mountain Institute

190 Stakeholder Consultation
meets ~80% of its crude oil requirement through imported oil and therefore expects to reduce this dependence through proliferation of EVs. EV sector in India is still in the nascent stage and therefore the present demand for EVs and batteries can be met through imports. However, an EV uptake in India without a domestic battery manufacturing industry poses the risk of transferring a part of India's import dependence from oil to foreign-manufactured batteries. India's average annual oil import bill over the past decade (FY2010 - FY2020) has been US$ 107 billion. About 40% of this oil consumption (quantity wise) was used as diesel and petrol in the transportation sector.

In a hypothetical scenario where all the 2W, 3W, 4W, SCVs and Buses sold in FY19 were electric, the import bill for the EV batteries will amount to US$ ~25 billion (as highlighted below in Table 13).

India currently has no cell manufacturing capacity while China currently holds almost two-thirds of global battery manufacturing capacity and is a global exporter.

- **Leverage the global industrial opportunity to boost GDP and create jobs**

The annual global battery demand is projected to reach ~2600 GWh, ~14 times the current demand, by 2030. This rise in demand presents opportunities for nearly US$ 260 billion investment and creation of 10 million jobs.

### 7.2 Current Scenario

- **Globally, China leads with the highest battery manufacturing capacity (75% of...**

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**TABLE 12: Battery cost percentage of total vehicle cost**

<table>
<thead>
<tr>
<th></th>
<th>2W</th>
<th>3W</th>
<th>4W</th>
<th>Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average battery capacity (in kWh)</td>
<td>1.5</td>
<td>3</td>
<td>25</td>
<td>240</td>
</tr>
<tr>
<td>Average battery cost (in INR)</td>
<td>45,000</td>
<td>90,000</td>
<td>75,000</td>
<td>72,000,000</td>
</tr>
<tr>
<td>Average vehicle cost (in INR)</td>
<td>75,000</td>
<td>2,20,000</td>
<td>13,00,000</td>
<td>1,50,00,000</td>
</tr>
<tr>
<td>Battery cost % of vehicle cost</td>
<td>60%</td>
<td>40%</td>
<td>57%</td>
<td>48%</td>
</tr>
</tbody>
</table>

**TABLE 13: India's estimated, hypothetical battery import cost for 100% electrification of FY19 sales**

<table>
<thead>
<tr>
<th>Vehicle segment</th>
<th>Annual sales (in million)</th>
<th>Battery size (in kWh)</th>
<th>Annual battery requirement (in GWh)</th>
<th>Annual battery import (in US$ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2W</td>
<td>21</td>
<td>1.5</td>
<td>31.5</td>
<td>5.5</td>
</tr>
<tr>
<td>3W</td>
<td>0.7</td>
<td>3</td>
<td>21</td>
<td>0.4</td>
</tr>
<tr>
<td>4W</td>
<td>3.3</td>
<td>25</td>
<td>82.5</td>
<td>14.4</td>
</tr>
<tr>
<td>Small CVs</td>
<td>0.5</td>
<td>10</td>
<td>5</td>
<td>0.9</td>
</tr>
<tr>
<td>Buses</td>
<td>0.08</td>
<td>240</td>
<td>19.2</td>
<td>3.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>140.3</strong></td>
<td><strong>24.5</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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191 Hero Optima (2W), Tata Tigor (4W), Mahindra eTreo (3W) and Olectra K9 (bus) considered for prices. INR 30,000 per kWh used as battery cost.
192 Ministry of Petroleum and Natural Gas (Indian Petroleum & Natural Gas Statistics 2015-16).
193 Petroleum Planning and Analysis Cell, MoPNG, Government of India.
194 US$ 175 per kWh assumed for battery cell cost.
195 World Economic Forum.
196 Setting up 1 GWh lithium ion battery manufacturing capacity requires US$ 100 million in capital. Source: NITI Aayog.
197 World Economic Forum.
global capacity), followed by the US (9%) and South Korea (7%). The sector is led by five manufacturers - LG Chem, CATL, BYD, Samsung SDI and Tesla – which capture 41% of the global capacity. Companies such as CATL, LG Chem and Samsung SDI are pure battery vendors and provide different types of battery products to electric vehicle OEMs and stationary storage project developers. While Tesla and BYD are vertically integrated as their manufactured products are mainly intended to meet the internal demands from their EV divisions.

The battery manufacturing value chain can be divided into four main value segments. The key component of the battery, the cell (including all raw materials and components), can constitute up to 50% of the battery’s cost.

NMC and LFP chemistries, with 55% and 17% of the existing 367 GWh global lithium-ion cell manufacturing capacity, are the existing chemistries of choice amongst global battery manufacturers. However, the battery chemistries are in a status of continuous flux with new chemistries being evolved for high efficiency, cost effectiveness and other considerations.

Even for NMC, the technology is in continuous development to reduce the dependence on scarcely available cobalt. Manufacturers are gradually transitioning towards lower cobalt chemistries - from NMC (1,1,1) and NMC (6,2,2) to NMC (8,1,1) as technical and financial feasibility is achieved. Tesla too has reduced cobalt content in its batteries by 88% since 2010 and is aiming to reduce it by 97% by 2021.

India currently has 2 GWh capacity of assembling battery packs. However, it lacks any manufacturing capacity for battery cells which comprise up to 35% of the battery cost and are the most technologically intensive component in a battery.

All Indian OEMs currently use imported battery cells in their vehicles. Indian OEMs have the manufacturing capabilities to locally manufacture all EV components except battery cells. Investment for battery assembly is not a huge challenge, but cell manufacturing would need large amount of investment because the cell market is fragmented by multiple cell technologies.

The Government of India, considering the strategic importance, has undertaken the following supply-side initiatives to attract investments in domestic battery manufacturing.

- Setting up of a National Mission on Transformative Mobility and Battery Storage:

  Launched in March 2019 with an Inter-Ministerial Steering Committee consisting of representation (Secretaries) from all key ministries such as MoRTH.
MoP, MNRE, MoHIPE and DST and is chaired by CEO, NITI Aayog. It is responsible for providing policy recommendations for developing a domestic EV and battery manufacturing ecosystem

- **Scheme for incentivizing establishment of domestic battery manufacturing**

  The Union Cabinet has approved the Production-Linked Incentive (PLI) Scheme in the 10 key sectors for Enhancing India’s Manufacturing Capabilities and Enhancing Exports – Atmanirbhar Bharat. Advance Chemistry Cell (ACC) Battery is one of the these key sectors with a financial outlay of US$ 2.4 billion over a five-year period. The scheme for ACC battery implemented by NITI Aayog and Department of Heavy Industries will incentivize large domestic and international players in establishing a competitive ACC battery set-up in the country.

As per NITI Aayog, Advanced Chemistry Cells (ACC) and batteries are defined as new generation cells and batteries such as lithium polymer, lithium iron phosphate, lithium cobalt oxide, lithium titanite, Lithium Nickel Manganese Cobalt, Lithium Manganese oxide, Metal Hydride, Zinc air, Sodium air, Nickel Zinc, Lithium Air and other chemistries that may be notified by the government from time to time.

Alongside the scheme, the Government has also launched a phased manufacturing plan (PMP) which effectively inverts the basics custom duty (BCD) structure applicable on batteries and battery components thereby making it more feasible to manufacture batteries domestically than importing.

- **Proposing the introduction of single-window clearance mechanism for manufacturers**

  The NITI Aayog is in discussions with various states to provide state-level incentive packages consisting of:
  
  - Identified and acquired encumbrance-free land
  - Requisite trunk infrastructure such as electricity, water, road connectivity, etc. at the project site
  - Other state-level tax benefits

A grand challenge amongst the states is planned to be conducted to match states with suitable manufacturers.

- **To ensure demand for domestic content, the Department of Heavy Industries, Government of India has also mandated a minimum percentage of localization criterion for EVs applying for subsidy under the FAME-II scheme.**

  The current localization criterion stands at 40% and 50% of total vehicle cost for buses and other vehicles respectively (2W, 3W and 4W).

### 7.3 Key Market Challenges

#### 1. Lack of domestic supply chain for cells and cell components

The battery manufacturing value chain consists of mineral processing, component manufacturing, cell manufacturing and pack assembling. Of the four value chain segments, India currently has extremely limited manufacturing capabilities (2 GWh) and that too only in assembling battery packs. China, on the other hand, has a global dominance across the value chain. Two-thirds of cell manufacturing and cell-component manufacturing capacity lies in China. These local supply chains have been developed by promoting Chinese battery manufacturers through policies such as mandatory domestic procurement of batteries by OEMs and battery manufacturer-specific fiscal incentives.

The robust domestic supply chains and the huge manufacturing scale make Chinese manufactured batteries globally cost competitive. Battery packs assembled in India are 15-20% more expensive than...
a battery pack imported from China\textsuperscript{203}. Given the lack of scale in domestic demand, manufacturing capacities in India are 10 to 20 times smaller than in China; at such scale difference, the manufacturing cost turns out to be 15%-20% higher in India compared to China.

The US and the European Union have also ensured the development of an end-to-end domestic battery manufacturing supply chain by funding and incentivizing battery players across the value chain\textsuperscript{204} including component suppliers, material processors etc.

2. Lack of clear demand visibility for battery manufacturing industry

As mentioned above, battery packs assembled in India are [15-20\%] more expensive than a battery pack imported from China. This has driven Indian EV manufacturers away from domestically assembled battery packs. The existing cost difference was aimed to be bridged by subsidies provided under FAME-II scheme for domestically sourcing at least 50\% of EV components.

However, the subsidy levels under current FAME-II scheme are inadequate to cover the cost of more expensive India- made batteries, thus driving Indian EV manufacturers, particularly e-2W OEMs, to procure cheaper Chinese batteries and forego subsidy in order to manufacture cost competitive EVs.

7.4 Key Issues in Implementation

1. Inadequate R&D support on Advanced Chemical Cells (ACC) and batteries

India has always been dependent on the imported batteries for fulfilling its growing distributed energy needs. The increasing dependence on batteries for various applications would require an enhanced approach on the R&D of batteries for different applications such as electric vehicles and energy storage.

2. Global battery manufacturers have already made investment commitments in other countries

The existing annual global lithium-ion cell manufacturing capacity is 367 GWh. Over 75\% of this capacity lies in China, followed by US (33 GWh, \textasciitilde 9\%) and South Korea (27 GWh, \textasciitilde 7\%). According to the announced plans and under construction manufacturing battery manufacturing plants, the existing annual cell manufacturing capacity is expected to increase by 237\% to 1,238 GWh by 2023. This addition of 871 GWh over the next 3 years will witness expansion of existing capacities in China (61\% of all capacity additions will be in China), Europe (13\% of all capacity additions) and US (11\% of all capacity additions).

3. Inadequate battery localization (for Indian conditions) and testing infrastructure for the same

India currently imports 100\% of battery cells\textsuperscript{205}. However, the cell technologies developed abroad (China, Japan, South Korea, USA) are generally optimized for relatively colder climate and may not be suitable for hot and humid climatic conditions in India. For example, the ideal temperature range for operating Li-ion batteries is between 15 to 35 degree Celsius. The cycle life of Li-cell begins degrading rapidly beyond this range. According to research, at 15 degree Celsius, an LFP cell loses around 7\% capacity after 2,628 cycles while at 45 degree Celsius, it loses 22\% capacity after only 1,376 cycles\textsuperscript{206}.

With such high temperatures constantly observed in large parts of India during summer, battery performance could be impacted, if not optimized for Indian conditions. Losses in battery capacity will reduce the vehicle range and hasten battery replacement. Further, the speed of charging may

\textsuperscript{203} Stakeholder Consultation
\textsuperscript{204} American Recovery and Reinvestment Act, 2009 – 111th US Congress
\textsuperscript{205} Department of Science and Technology, Government of India
\textsuperscript{206} Auto Tech Review
have to be reduced to avoid battery overheating, thereby increasing the time required for charging. Even power discharge rate may need to be reduced at high temperatures thus reducing top speed and acceleration. In extreme cases, the vehicle operations may have to halted until the battery pack cools down, otherwise overheating might cause severe safety risks^207. These factors highlight the need for investments in R&D towards developing indigenous battery technologies that are optimized for Indian conditions.

7.5 Recommendations

1. Provide long term policy clarity and firm target commitments in downstream applications such as electric vehicles and battery storage power systems in a technology agnostic manner

The ticket sizes of battery manufacturing investments are quite large (< US$ 1 billion for 10 GWh) due to requirement of scale for cost effective production and to compete with similarly large (or larger) global battery suppliers. Further the payback periods are long. To justify such large and long- term investments, demand clarity and policy direction is very important.

Government should provide a clear long-term roadmap for battery manufacturing and electric vehicles sector and enshrine certain targets through a formal policy declaration. Such a roadmap could aim to provide clear targets of the Government of India for expected manufacturing capacity, investments, incentives, timelines and demand generation support. The government should also increase the duration (years) and budget (INR crores) of FAME-II scheme intended to provide support for adoption of electric vehicles and creation of charging infrastructure.

In addition, the government should provide firm trajectory for battery storage projects in the power sector along with adequate policy and fiscal support and ensure that tenders are not cancelled. Such firm commitments for battery demand creation are critical to provide confidence to companies to invest battery manufacturing sector in India.

While implementing the above, the government should adopt technology agnostic approach and avoid putting too many constraints or specifications for subsidy eligibility and subsidy computation.

2. Provide long term demand creation incentives and favorable regulatory support for the electric vehicles and power sector

Demand, the primary driver for setting-up battery manufacturing, can be stimulated through government programs, policy measures and regulatory mechanisms. Globally, major battery manufacturing hubs such as China, the US, etc. have strong government-led demand creation programs and regulations across the vehicle and grid segments.

A few possible demand creation initiatives across the vehicles and power sector applications are enlisted in the Table 14.

EV demand creation initiatives have been discussed in detail in the EV deployment segment.

3. Support battery OEMs in setting up battery manufacturing facilities through provision of trunk infrastructure and single window clearance

Across the battery manufacturing value chain, sourcing and production are mostly dependent on the manufacturer’s supply relations, manufacturing capacity, technology and business competence. These value segments therefore require minimal to moderate government support, particularly since success in these value chain segments depends on the manufacturer’s competence.

The government should support battery OEMs through provision of trunk infrastructure. Battery

^207 Stakeholder consultation
manufacturing parks could be set up, providing all requisite trunk infrastructure\(^{208}\), as in the case of solar parks, can be developed by the state governments. And a single window clearance mechanism should be implemented for provision of all regulatory, environmental and other clearances. Such parks will encourage domestic manufacturing and job development and can also be used for setting-up recycling plants.

4. Implement a stable customs duty regime on battery imports in consultation with automotive OEMs and battery OEMs

A suitable and stable customs duty regime which enables domestic manufacturing opportunities should be implemented by the Government over a 5 to 10 years period (instead of just a one to two years period). This will support the industry in planning for capacity, investments and pricing.

5. Increase investment in battery R&D to develop new battery technologies optimized for local conditions

The Government of India should include funding towards R&D for indigenous battery technologies in the FAME-II scheme or other suitable schemes. Challenge grant programs should be initiated and opened to public and private sector organizations engaged in battery R&D. Further, technical collaborations and knowledge-exchange program with R&D labs and organizations in other countries should be supported.

6. Increase investment in testing infrastructure and ensure strict testing standards to alleviate consumer concerns around battery performance and safety

Currently only government funded testing labs are eligible to conduct testing. This has often led to constrained testing capacity\(^{209}\). To support its ambitions in electric vehicles and battery manufacturing sector, the government should increase investments in testing infrastructure. It could also allow private sector labs to conduct certain types of testing while ensuring integrity in the process through accreditation and strict monitoring.

The government should also ensure that certain strict standards for determining performance. Otherwise a difference could emerge between OEMs claims of battery range and the real-world performance, which will significantly undermine consumer confidence in EVs.

### 7.6 Further Analysis and Studies Recommended

The government could undertake further work on the following aspects:

- Possible cost-competitiveness of developing a li-ion battery ecosystem in India for domestically manufactured batteries against imported batteries.

\(^{208}\) Land, power, water, drainage, connectivity with highway & port

\(^{209}\) Stakeholder consultation
- Economic impact (additional incentives to be allocated) due to inclusion of material processing and cell component manufacturing under the NITI Aayog battery manufacturing scheme.
- Development of pricing and incentive frameworks for ancillary services. Conduct assessments to determine pricing for different services across different states.
- Assessment of battery performance standards with a view to reduce the variation between claimed performance and real-world performance.
- Existing capacity of policy makers, regulators, grid operators, transmission and distribution organizations on ancillary services. Design capacity building programs suited to the needs of the above-mentioned stakeholders.
- Economic impact (additional incentives to be allocated) of introducing the demand creation initiatives mentioned in the recommendations section.
8.1 Strategic Importance

The key elements in a lithium ion battery such as lithium, cobalt, nickel, manganese and aluminum can be recovered through recycling processes. But the transportation, disassembly and recycling of used batteries is an expensive process and strong demand is required to justify capital investments. Around the world, close to 96% of the lead acid batteries are recycled\textsuperscript{210}. The corresponding recycling percentage for li-ion batteries is only around 5% globally.

\textbf{FIGURE 25: Battery value chain}
An estimated 11 million tonnes of batteries would reach end of life and they would have to be discarded by 2030\textsuperscript{211}. In view of this, both from sustainability and energy security perspectives, battery recycling becomes important.

The battery value chain of use, reuse and recycle is depicted in Figure 25\textsuperscript{212}.

Battery recycling is important for India as it has extremely limited reserves\textsuperscript{213} of critical minerals required to manufacture lithium ion batteries. To reduce the burden of importing raw materials, it is essential to recover as much as possible of the raw components from the used batteries. Recycling will also help solve the problems of waste disposal and pollution due to hazardous chemicals present in batteries. Further, mining and purification processes consume high energy and therefore recycled metals can reduce energy consumption and emission of greenhouse gases from these processes.

Second life of batteries is refurbishment of used batteries. Only if sufficient number of EVs are sold in the country, the end-of-life batteries would make a business case for reuse\textsuperscript{214}. If done properly, reuse and recycling, both would be more economically and environmentally benign than new li-ion battery energy storage packs. This would set up exciting possibilities for the Indian domestic market and for other developing countries. Focus on recycling and reuse is expected to increase as it would directly support circular economy initiative in India.

### 8.2 Current Scenario

The battery recycling ecosystem in India is still in its nascent stage. Some of the key issues and developments in this sector are given below.

- Lithium-ion batteries dominate the global market of rechargeable batteries. In India, a few companies are involved in lithium battery recycling. The list of companies involved in lithium battery recycling is given in the table below:

  From the table, we can see that mechanical and hydrometallurgy are two dominating recycling technologies implemented in India. It must

#### TABLE 15: Companies working on battery recycling in India\textsuperscript{215}

<table>
<thead>
<tr>
<th>No.</th>
<th>Recycler</th>
<th>Location</th>
<th>Recycling capacity (in MTA*)</th>
<th>Technology</th>
<th>Partnership</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Tes-Amm</td>
<td>Chennai/Singapore</td>
<td>1200</td>
<td>Mechanical and Hydro-metallurgy</td>
<td>Recupyl (Singapore)</td>
</tr>
<tr>
<td>2.</td>
<td>Attero Recycling</td>
<td>Noida</td>
<td>5000</td>
<td>Electro and Hydro-metallurgy</td>
<td>In-house patents</td>
</tr>
<tr>
<td>3.</td>
<td>SungEEL HiMetal</td>
<td>Anantapur</td>
<td>5000</td>
<td>Hydro-metallurgy</td>
<td>In-house patents</td>
</tr>
<tr>
<td>4.</td>
<td>E-Parisaraa</td>
<td>Bengaluru</td>
<td>2000</td>
<td>Mechanical</td>
<td>SungEEL India</td>
</tr>
<tr>
<td>5.</td>
<td>EcoReco</td>
<td>Mumbai</td>
<td>1200</td>
<td>Mechanical</td>
<td>Nippon Recycling</td>
</tr>
<tr>
<td>6.</td>
<td>Eco Tantra</td>
<td>Pune</td>
<td>350</td>
<td>Mechanical</td>
<td>Nippon Recycling</td>
</tr>
<tr>
<td>7.</td>
<td>Eximo Recycling</td>
<td>Vadodra/Surat</td>
<td>1200</td>
<td>Mechanical</td>
<td>N/A</td>
</tr>
<tr>
<td>8.</td>
<td>Surbine Recycling</td>
<td>Jamnagar</td>
<td>1500</td>
<td>Electro and Hydro-metallurgy</td>
<td>In-house patents</td>
</tr>
</tbody>
</table>

*Metric Tonnes per Annum

\textsuperscript{211} BNEF  
\textsuperscript{212} EY Analysis  
\textsuperscript{213} National Mineral Inventory  
\textsuperscript{214} Stakeholder Consultation  
\textsuperscript{215} India Energy Storage Alliance (2019) – Battery Recycling
be noted that the key advantage of these technologies is low energy consumption\textsuperscript{216} but these techniques are also highly resource-intensive and therefore strongly influenced by economic constraints\textsuperscript{217}.

- In September 2019, Tata Chemicals launched lithium ion battery recycling operation in Mumbai. Li-ion battery recycling could recover valuable metals like lithium, cobalt, nickel and manganese at 99% plus purity\textsuperscript{218}.

- In February 2020, the Ministry of Environment, Forest and Climate Change released the draft rules\textsuperscript{219} titled *Battery Waste Management Rules, 2020*. It was a significant step towards delegating responsibilities to stakeholders across the value chain.

### 8.3 Key Market Challenges

1. Currently unattractive business case for establishing battery recycling units

It must be noted that lithium-ion battery recyclers would have to first assess the used batteries and designate them for reuse or recycle based on the type of minerals and their quantities present in the battery. This process consumes time, energy and is expensive. Further, Lithium comprises of only 3.84% to 7.86% of the active cathode material of lithium-ion batteries. The table below lists the content of metals in lithium-ion batteries.

Therefore, it is not economically viable to recycle it as compared to sourcing raw lithium. Presently, the salvaged value of metals is low as compare to cost of recycling; this compounded with lack of demand for recycled lithium hydroxide and nickel makes recycling unviable in most cases.

2. Technology challenges and safety concerns

Around the world, the existing battery recycling infrastructure is geared towards lead acid battery recycling. There have been instances where fires have been reported when lithium ion batteries undergo recycling processes\textsuperscript{221}. Due to the chemical composition of lithium-ion batteries, it can cause runaway thermal reaction\textsuperscript{222} if exposed to excessive heat from inside or outside the cell.

Lithium cells contain organic electrolytes which are flammable and therefore any damage to the cell leads to discharge which generates heat and causes explosion. Due to uncertainty around battery technology, there cannot be a standardized process of recycling and all battery chemistries are not suitable for repurposing.

<table>
<thead>
<tr>
<th>Active cathode material</th>
<th>NMC(111)</th>
<th>NMC(622)</th>
<th>NMC(811)</th>
<th>LCO</th>
<th>NCA</th>
<th>LMO</th>
<th>LFP</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>34.1%</td>
<td>31.8%</td>
<td>31.1%</td>
<td>35.3%</td>
<td>30.4%</td>
<td>40.1%</td>
<td>32.2%</td>
</tr>
</tbody>
</table>

**TABLE 16: Typical lithium-ion battery cell composition\textsuperscript{220}**

<table>
<thead>
<tr>
<th>Lithium (Li)</th>
<th>7.86%</th>
<th>7.82%</th>
<th>7.79%</th>
<th>7.09%</th>
<th>7.22%</th>
<th>3.84%</th>
<th>4.40%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt (Co)</td>
<td>20.21%</td>
<td>12.07%</td>
<td>6.02%</td>
<td>60.21%</td>
<td>9.20%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Nickel (Ni)</td>
<td>20.13%</td>
<td>36.07%</td>
<td>47.93%</td>
<td>-</td>
<td>48.87%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
8.4 Key Issues in Implementation

1. Absence of specific regulatory framework on collection and recycling of lithium ion batteries from automotive applications

In India, there are no battery collection centers set up to collect used batteries. This leads to unsafe disposal of batteries leading to fires and battery explosions in garbage dumps. Transport, storage and disassembly form a large part of battery recycling costs. Also, there are chances of used batteries getting crushed, punctured or dropped during transportation. Disassembly of battery packs could also damage batteries because of the use of permanent assembly methods during product designing.

2. Lack of demand for recycled batteries in applications where they can meet the desired performance requirements

The batteries that have reached end of life in electric vehicles could be used for stationary energy storage applications depending on the health of the battery. Presently, in India there is no market for second-life application batteries which could be used in various applications as mentioned in Figure 26.

3. Lack of awareness among consumers and battery intermediaries on benefits of battery second life and battery recycling

Consumers are not aware of the process for collection of used batteries, which could lead to unsafe disposal of batteries. There is also a perception among consumers that recycled minerals may not be of the same quality as virgin minerals and therefore recycled products are not efficient or safe. Poor marketing of second-life materials and lack of consumer awareness may prevent the sale of products made from recycled materials.

4. Insufficient recovery rate of battery minerals with high purity during various recycling procedures

Popular recycling practices such as Hydrometallurgy (popular in Asia), Pyrometallurgy and Pyro-hydro all yield high recovery rates (90-100%) for minerals such as cobalt, nickel and copper. However, recovery rates are not the same as purity. Battery-grade minerals such as Lithium, needs extremely high purity which may not be achieved easily and economically. The economic aspect is more prominent especially if sales for recycled batteries are low223.

8.5 Recommendations

1. Impose Extended Producer Responsibility (EPR) norms on battery manufacturers and mandate battery sellers to maintain a database of all the batteries sold and collected

If the collection rate for used batteries is low, then it will lead to low recycling rate in the country. Collection of used batteries need to be managed in a more organized manner. Without knowing the background of the battery, it would be difficult to assess it for second life applications. The key actions recommended for efficient battery collection are:

223 BloombergNEF; PV-Magazine: Lithium-ion recycling rates
Consider mandating used battery collection by battery manufacturers and sellers from the consumers. Sellers could be directed to set up battery collection centers at all their retail outlets.

Consider mandating sellers to maintain a database of all the batteries sold and collected.

Evaluate penalizing battery manufacturers and sellers who do not comply with battery collection targets specified in the Battery Waste Rules 2020.

2. Provide innovation-challenge grants to encourage development of innovative designs for battery packaging

Manufacturers must innovate to design products without the use of permanent assembly methods (such as spot-welding), to facilitate the dismantling process and subsequent material recovery. Although there is no standardized process for battery recycling presently, in future recycling companies could develop a standardized process to optimize recycling of batteries:

- Assess provision of grants for organizations/individuals who work on innovative designs for battery packaging such that the batteries can be dismantled easily. The need is to develop a li-ion battery that has effectively balanced three core considerations: health and safety, second life applications and marketability.

- Consider compulsory labelling of battery chemistry on the outside of the battery pack casing for safe handling of the battery during transportation and recycling.

3. Provide fiscal and non-fiscal benefits for companies setting up battery recycling units

Although there is not enough volume in India, it can still become a global hub for recycling. Considering the unattractive business case for establishing battery recycling units, the Government of India should provide fiscal and non-fiscal benefits, for initial three to five years, to kickstart and scale-up battery recycling centers in India. The fiscal benefits could include providing tax breaks and capex subsidies while the non-fiscal benefits could include providing land, trunk infrastructure and fast-track approvals for setting up battery recycling units in India. Implementation of an electric vehicle scrappage policy in future will help determine the residual value of used batteries and help further develop the sector.

4. Encourage use of recycled batteries in grid-connected energy storage projects

When lithium-ion battery reaches its end-of-life, it is possible that only a few cells within the battery pack are not fit for use. Business models could be developed for reusing or repackaging used batteries for less demanding applications such as stationary energy storage. Support from the government to create demand for second-life batteries would attract investment in this sector:

- Consider implementing grid-connected battery energy storage system projects in all the states.

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CASE PRECEDENT

Patented compression assembly method for easy dismantling of batteries

Aceleron, the UK

Lithium-ion batteries are designed with their patented compression assembly method which is easier to disassemble and dismantle. This allows for single parts or cells of their batteries to be repaired or replaced when they no longer function. Aceleron also tests the battery packs, to determine which cells can still be used. After this, the company will repack the cells for whichever second-life application it is most suited. Aceleron is currently targeting electronic bikes, canal boats, caravans, coaches and home energy storage applications for their batteries.

Aceleron is a UK-based company that designs and develops advanced energy storage solutions. They are known for their patented compression assembly method, which makes it easier to dismantle and replace parts of their batteries when they no longer function. This method allows for single parts or cells of their batteries to be repaired or replaced, which is beneficial for extending the life of the battery.

Aceleron is currently targeting several applications for their batteries, including electronic bikes, canal boats, caravans, coaches, and home energy storage. By designing their batteries with a patentable compression assembly method, Aceleron ensures that their products can be easily dismantled and repaired, making them more sustainable and environmentally friendly.

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224 Aceleron

225 Stakeholder Consultation
5. Implement an information, communication and education program on battery recycling and second life targeted at end consumers

Creating awareness among consumers will help in battery collection and safe disposal of used batteries. As mentioned above, presently majority of the batteries are reaching landfills every year and polluting the environment:

- Inform the consumers on battery collection mechanism because low collection rate will not attract investment into battery recycling.
- Advertise the benefits of second-life batteries in print media, social media and electronic media. Dispel misconceptions regarding the performance and safety issues around recycled and second-life products.
- Consider promoting the use of second-life batteries as UPS systems for homes and offices.

8.6 Further Analysis and Studies Recommended

The government could consider undertaking further work on the following aspects:

- Conduct techno-commercial assessment for use of second-life batteries in the ancillary services and grid-storage market.
- Evaluate implementing a pilot grid-storage project with second-life batteries and study the impact on the grid.
- Undertake capacity building programs with national and international research organizations for north-south and south-south knowledge exchange on best practices in recycling and repurposing of used batteries.
- Conduct industry consultations to assess the possible incentive mechanisms for establishment of recycling facilities.
- Consider undertaking an assessment study on the impact of providing tax breaks and imposing tax penalties/fines for non-compliance by battery recycling companies, on the exchequer.
1. Scope, Research Methodology and Limitations of the Report

a) Scope of the project

To support India’s ambition on electric mobility, a study was initiated by The World Bank’s India Energy Practice to understand the main drivers of the electric mobility (e-mobility) from the power sector perspective. Further it was aimed to assess the implications of electric mobility and associated charging infrastructure on the power sector. To this end, an overview of different segments of the e-mobility value chain was undertaken. Broadly, the study had the following three key objectives:

1. To explore the following across the global and Indian electric mobility markets:
   - Policy and regulatory interventions by governments to spur electric mobility across the value chain, key learnings from them and their impacts.
   - Existing and future technologies across vehicles, charging infrastructure and batteries.
   - Existing and future/innovative business models across EV fleet operations and charging infrastructure operations.
   - Existing and future battery manufacturing capacities, battery technologies, Government programs and policies for support and key manufacturer profiles.

2. To identify existing market and implementation challenges across the Indian e-mobility value chain.

3. To recommend potential policy and regulatory interventions to address the identified challenges.

While the study has its genesis in the power sector, during research for the study and consultations with multiple stakeholders, it became evident that the dynamic interactions between the various segments of the value chain and relevant government policies will determine the scale at which India can meet its e-mobility ambitions. It was also identified that coordinated action on multiple fronts (across various ministries and departments in central and state governments and various private sector organizations) will be needed to meet desired EV adoption goals. Therefore, the report starts with power sector specific observations and then briefly covers other critical areas, which will have a bearing on how e-mobility will scale-up.

b) Research methodology

EY conducted desk research, interviewed 20+ industry representatives and conducted industry stakeholder consultations as follows:

- Extensive desk research on policies, regulations, technologies and business models across China, US, Europe and India.
Interviewed 20+ representatives from government ministries, city authorities, state utilities, global and Indian battery manufacturers, automotive OEMs, EV fleet operators and other industry participants.

Conducted 2 industry virtual stakeholder consultations along with the World Bank with representation from DISCOMs, global and Indian battery manufacturers, automotive OEMs, EV fleet operators and other industry participants.

c) Limitations of the report

Considering the potential breadth of such a cross-sectoral and cross-functional study, EY undertook the study while keeping in accordance with the following boundary conditions:

- **Vehicle segments**
  - Plug-in hybrid electric vehicle (PHEVs), hybrid electric vehicle (HEVs) or battery electric vehicle (BEVs) in the 2-wheeler, 3-wheeler and 4-wheeler, LCVs (Light commercial vehicles) and buses have been considered.
  - Medium and Heavy commercial vehicles (MCVs and HCVs) have been excluded.
  - Other non-road transport applications in sectors such as agriculture, mining and aviation have been excluded.
  - Ferries and ships (used for water-based transport) are also excluded.

- **Charging infrastructure technologies**
  - Charging infrastructure technologies (including battery swapping) mentioned in the Ministry of Power’s Charging Infrastructure Guidelines have been included.
  - Technologies such as wireless charging, overhead cable charging have been excluded.

- **Battery technologies**
  - Lithium-based chemistries such as NMC, NCA, LFP, LTO, etc. have been included.
  - Fuel cells, Hydrogen fuel are considered only in “Module 2: Technology Landscape” but are excluded from other modules.

- While the study has conducted comparison of various Lithium battery technologies, it does not aim to recommend a preferred technology for the present and future market applications.

**Recommendations**

- The study analyzes the electric mobility sector predominantly from the power sector perspective and does not explore future impact of EV adoption in areas such as transport systems and urban planning.
- Recommendations have been developed from the policy and regulatory perspective only. Recommendations on preferred technologies, financing models, business models and operational models are excluded.
- Recommendations on capacity building and training requirements have not been included.
- Fiscal impact of recommendations on the central government’s and state governments’ budgets has not been considered.

Recommendations are made on select areas of future research which could help in further acceleration of EV adoption in India.

2. Description of the Chapters

The eight chapters of the report are each dedicated to one value chain segment and provide details across the six sections. The order of the chapters is in line with the stages involved in the evolution of electric mobility in India. A brief definition of each of the segments is provided below:

- **Chapter 1: Power supply and grid infrastructure**
  - Energy supply refers to the provision of electrical energy at desired locations through necessary energy infrastructure such as transformers, meters, cables, substations and ICT equipment.
  - Grid management refers to the efficient management of energy infrastructure through various techniques (such as ToD
pricing, V2G, demand response, etc.) to enable cost-effective and stable operations of the grid. These techniques are explained in Module-5.

**Chapter 2: Charging infrastructure deployment**
- Charging infrastructure deployment refers to the planning and physical installation of charging equipment with the desired technology specifications at convenient locations for users. The charging equipment provides electrical energy for recharging batteries used in the EVs. The equipment allows a battery to be charged while it is inside the vehicle by plugging it into the electricity source or by removing it from the vehicle and charging separately (battery swapping).

**Chapter 3: EV financing**
- EV Financing refers to the process of appraisal and disbursement of funds (grants, loans, etc.) by financial institutions and Governments to enable the purchase of EVs (across vehicle segments). The financial institutions could include public and private commercial banks, NBFCs and development financial institutions.

**Chapter 4: EV deployment**
- EV deployment refers to fulfilment of transportation demand through EVs (2W, 3W, 4W and buses) in the personal segment, fleet segment and public transport segment.

**Chapter 5: EV manufacturing**
- EV manufacturing refers to the process of production of individual vehicle components (traction motors, battery packs, power electronics, onboard chargers, cooling systems, etc.) and their assembly into a vehicle. For the purpose of this report, battery pack production is treated as a separate section above.

**Chapter 6: Mining and mineral sourcing**
- Mining is the process of the extracting valuable minerals or other geological materials from the Earth. In the context of EV batteries, mining refers to extraction of lithium, cobalt, nickel and graphite.
- Sourcing refers to the process of identifying suppliers for a particular mineral in the raw or processed form, securing the supplies and successfully contracting to get the minerals delivered.

**Chapter 7: Battery manufacturing**
- Battery manufacturing refers to the process of production of individual cell components (cathodes, anodes, electrolytes, separators, etc.), production of cells and assembly of cells to form battery packs.

**Chapter 8: Battery recycling and second life**
- Battery recyling refers to process of collection, disassembly, material extraction and processing for further use of battery components. It also includes repurposing (using required physio-chemical procedures) and re-deployment of batteries in second-life applications such as grid storage, etc.

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226 EY Analysis, USGS
### 3. List of Studies Referred to Assess the Impact of Electric Vehicles on Power Sector

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the report</th>
<th>Organization</th>
</tr>
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<tbody>
<tr>
<td>7.</td>
<td>Electrifying Mobility in India</td>
<td>Brookings India (2018)</td>
</tr>
<tr>
<td>8.</td>
<td>Enabling the Transition to Electric Mobility in India</td>
<td>FICCI and RMI (2017)</td>
</tr>
<tr>
<td>9.</td>
<td>Charging India's Four-Wheeler Transport</td>
<td>Shakti Sustainable Energy &amp; AEEE</td>
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<tr>
<td>12.</td>
<td>Getting to 20 Million EVs by 2030</td>
<td>The Brattle Group (2020)</td>
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<tr>
<td>14.</td>
<td>India's Electric Mobility Transformation</td>
<td>NITI Aayog &amp; Rocky Mountain Institute</td>
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<tr>
<td>15.</td>
<td>Electric Vehicle Charging Infrastructure and Impacts on Distribution Network</td>
<td>United States Agency for International Development (USAID)</td>
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### 4. List of Industry Stakeholders Consulted

<table>
<thead>
<tr>
<th>No.</th>
<th>Nature of organization</th>
<th>Organization name</th>
<th>Person</th>
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<tbody>
<tr>
<td>1.</td>
<td>Battery manufacturer</td>
<td>Exide-Leclanche</td>
<td>Stefan Louis</td>
<td>CEO</td>
</tr>
<tr>
<td>2.</td>
<td>Battery manufacturer</td>
<td>Panasonic</td>
<td>Atul Arya</td>
<td>Head - Energy Systems Division</td>
</tr>
<tr>
<td>3.</td>
<td>Battery manufacturer</td>
<td>LG Chem</td>
<td>Prashant Kumar</td>
<td>Senior manager</td>
</tr>
<tr>
<td>4.</td>
<td>Auto OEM</td>
<td>Mahindra Electric</td>
<td>Uttam Nagaraj</td>
<td>Manager</td>
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<td>5.</td>
<td>Auto OEM</td>
<td>Ashok Leyland</td>
<td>Karthick Athmanathan</td>
<td>VP - EV solutions</td>
</tr>
<tr>
<td>6.</td>
<td>Auto OEM</td>
<td>Bajaj Auto</td>
<td>Suresh Kuttan</td>
<td>DGM</td>
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<td>7.</td>
<td>Auto OEM</td>
<td>Hero Electric</td>
<td>Sohinder Gill</td>
<td>CEO</td>
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<td>8.</td>
<td>Charging Infrastructure Operator</td>
<td>Magenta Power</td>
<td>Maxson Lewis</td>
<td>CEO</td>
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<td>9.</td>
<td>Battery Swap Operator</td>
<td>Sun Mobility</td>
<td>Yuvraj Sarda</td>
<td>Head of Strategy</td>
</tr>
<tr>
<td>10.</td>
<td>State Government</td>
<td>Karnataka Udyog Mitra</td>
<td>M R Shashidhara</td>
<td>Head</td>
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<td>11.</td>
<td>DISCOM</td>
<td>BESCOM (Bengaluru)</td>
<td>CK Sreenath</td>
<td>DGM</td>
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<td>12.</td>
<td>Auto OEM</td>
<td>Mahindra Electric</td>
<td>Satish Rajagopalan</td>
<td>Head of Strategy &amp; BD</td>
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<tr>
<td>13.</td>
<td>Think-tank</td>
<td>World Resources Institute</td>
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<td>Auto OEM</td>
<td>Olectra BYD</td>
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<td>Tata Capital</td>
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<td>16.</td>
<td>Auto OEM</td>
<td>Ashok Leyland</td>
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<td>Charging Infrastructure Operator</td>
<td>NN4 Energy</td>
<td>Ankit Singhvi</td>
<td>Co-Founder</td>
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<td>Battery Swapping Operator</td>
<td>Sun Mobility</td>
<td>Ajay Goel</td>
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<td>Goldie Srivastava</td>
<td>Co-Founder CEO</td>
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<td>Cedrick Neba Tadong</td>
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<td>Anmol Jaggi</td>
<td>CBO</td>
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<td>Vikash Mishra</td>
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<td>Shaam Jagtap</td>
<td>GM</td>
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<td>eBikeGO</td>
<td>Irfan Khan</td>
<td>Founder &amp; CEO</td>
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<td>Person</td>
<td>Designation</td>
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<td>BSES Rajdhani</td>
<td>Abhishek Ranjan</td>
<td>Head - Renewables &amp; DSM</td>
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<td>Battery manufacturer</td>
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<td>Rino Raj</td>
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<td>Advisor</td>
<td>Vinay Bajaj</td>
<td>Electric Mobility Market Expert</td>
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<td>Mehul Shah</td>
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<td>Sandeep</td>
<td>Head of EV, HA and ESCO Businesses</td>
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<td>Manasvi</td>
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<td>Shishir</td>
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<td>Fortum</td>
<td>Awadhesh Jha</td>
<td>Vice President</td>
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