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ELECTRIC MOBILITY PARADIGM SHIFT

CAPTURING THE OPPORTUNITIES

2018

TITLE	**ELECTRIC MOBILITY PARADIGM SHIFT: CAPTURING THE OPPORTUNITIES**
YEAR	February, 2018
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FOREWORD

Electric Mobility Paradigm Shift: Capturing the opportunities

Electric Mobility, with a current market of USD 163 billion globally, is fast emerging as an unprecedented opportunity in low-carbon transition of the global economy, making transportation clean and efficient. Indian Government has also taken a target to shift to 100% Electric Vehicles (EV) by 2030. This, apart from feeding into nation's carbon emission reduction target, would lead to reduction of pollution in cities by 80-90% and curtail 10% of India's oil imports forecast for 2030, narrowing India's current account deficit. This ambitious target is providing the much required thrust to make electric mobility, with investment potential of USD 667 billion in India, a pragmatic reality in the near future.

Electric mobility landscape in India is currently at a nascent stage, with significant constraints to be overcome. India require nearly eight times the existing global stock of EVs, but with long timescales, auto industry would require enabling policy interventions to make sudden shifts in production. With 206 communities charging stations across the country against 56,000 fuel stations, there remains an urgent need to scale creation of an enabling infrastructure. Continuous upgradation and evolving technology also poses significant threat to financial structuring, requiring innovative financing mechanism to fuel this transition.

Considering this context, the report, '**Electric Mobility Paradigm Shift: Capturing the opportunities**', develops a six-point criteria to identify front runners (t*wo-wheelers, three-wheelers and buses*) which would propel the transition towards electric mobility. Further, the report highlights the potential of e-mobility in reducing carbon emission which is as high as 82% for complete electrification of two-wheelers by 2050. Critical policy mechanisms including setting up green zones, preferential tariffs and innovative financial instruments such as green bonds, fee-bates and demand aggregation mechanisms to support market creation for e-vehicles are also proposed in the report.

I am confident that this report will provide important insights and specific actionables for policy makers, industry, financial community and all other stakeholders to together accomplish this transformation towards the electric mobility paradigm.

Thank You.

Sincerely,

Rana Kapoor
Managing Director & CEO YES BANK
Chairman YES Global Institute

PREFACE

A transition to electric mobility, especially in urban areas, is at the top of the Government of India's policy agenda. This is driven by several factors, including the longer term implications of vehicular emissions on urban air quality, the macro-economic impact of the rising share of petroleum imports on the Indian economy, the challenge of enhancing the uptake of electricity from the power generation sector that is currently suffering from low capacity utilisation, and the ambition of moving towards a carbon free transport sector in conjunction with a power generation sector in which the share of renewable energy is steadily increasing.

This transition is being enabled by several policy-driven initiatives, including the Faster Adoption and Manufacturing of Hybrid & Electric Vehicles in India (FAME India) Programme, placement of battery electric vehicles in a low rate category in the Goods and Services Tax (GST) regime, the EESL (Energy Efficiency Services Limited) tender for 10,000 electric cars for central government offices, and the identification of eleven cities by the Department of Heavy Industries for running Multi-Modal Electric Public Transport pilot projects.

The central challenge in the transition to electric mobility today remains the higher cost of battery electric vehicles compared to internal combustion engines (largely because of high battery costs), and the lack of a ubiquitous charging infrastructure. There is a need, therefore, to identify measures which can provide an immediate push to key EV segments that enable us to achieve the scale and performance necessary to bring down costs and enhanced consumer awareness and acceptance.

We, at TERI, are delighted to collaborate with YES Bank in the preparation of this paper which identifies low hanging opportunities for the EV transition, and presents recommendations to upscale EVs in each of the identified segments. We suggest that the two-wheeler, three wheeler, and bus segments are the priority segments for the transition to electric mobility. We look forward to this paper enhancing the data and analysis based discussion on policies and measures to accelerate the large-scale adoption of electric mobility in India.

Dr Ajay Mathur
Director General, TERI

EXECUTIVE SUMMARY

Indian mobility sector is one of the fastest growing in the world with the number of motorized vehicles per 1,000 population seeing a threefold increase from 53 in 2001 to 167 in 2015. However, in comparison to developed markets like USA (795) and EU (573) it remains very low, indicating the growth potential of the mobility market in India. Currently, the transport sector in India depends almost unilaterally on imported oil to meet 98% of its energy requirements. Crude oil imports accounted for USD 86 billion or 22.6% of all imports in 2016-17. The sector emits 142 million tonnes of carbon, accounting for 7.5% of all emissions in the country, making emissions and air pollution critical sustainability challenges associated with it.

This report, "**Electric Mobility Paradigm Shift: Capturing the opportunities**", presents the triple benefits of increased energy security, carbon mitigation and improved air quality in cities that can be achieved by adopting electric mobility in India. In addition, India can potentially save USD 27.8 billion in foreign exchange annually by 2030 if the electricity is sourced from renewable sources. Government of India has rightly put its weight behind achieving 100% electrification of all vehicles in India by 2030. The report assesses the policy landscape and showcases the support measures provided by the Government towards increasing penetration of EV and transition to this new mobility paradigm.

The report sets the roadmap for transition by identifying three front runners including **two-wheelers, three-wheelers** and **buses** which can provide the initial momentum, scale and visibility for EVs. To identify these front runners, different segments in passenger vehicle space have been assessed through a six point review framework for their early adoption success, dependence on charging infrastructure, range of models available, local manufacturing capabilities, ease of implementation and Government support.

The report further highlights the growth potential of the front runner segments in different EV penetration scenarios. For example, complete electrification of two wheelers by 2050 is expected to decrease their energy consumption by 92% and CO_2 emissions by 82%. The report further outlines structural and financial challenges that are limiting the growth of EV and suggests plausible solutions which are apt for India.

Specific policy interventions have been shared in the report which can trigger exponential uptake of EV market in India. Policies have been suggested to enable the EV ecosystem through deployment of charging infrastructure, demonstration of EV pilots in cities, establishing research centers and enhancing consumer awareness. It would also be important to create dedicated demand for EVs through identification of Green Zones in the cities to complete the ecosystem. This ecosystem can be used to upscale other EV segments.

Given the role of finance as a key enabler for the transition, specific financial instruments have been suggested for each segment basis their financing needs and return expectations. The report also suggests mechanisms to help reduce manufacturing cost by aggregating demand for electric vehicles as well as specific components like batteries to make these vehicle affordable for the consumer. For instance, Green Bonds can be used to channelize climate finance for setting up EV infrastructure and Fee-bates may mobilize resources for providing rebates to EVs by levying a fee

on polluting vehicles. Lease financing with guarantees and interest subvention is also an option for reducing the financing cost to the consumers.

This report is an opportunity for all participants in the transition to electric mobility in India to identify the key drivers of growth, embrace solutions, and work towards creating the first electric-only transportation system in the World.

Namita Vikas
Group President & Global Head, Climate Strategy & Responsible Banking YES BANK
Distinguished Fellow YES Global Institute

Acknowledgement

The authors would like to thank all the Industry stakeholders and practitioners who took the time to share information, insights, and perspectives towards providing insights for the paper. Their exceedingly valuable observations and comments have helped make this report holistic. Key among them includes:

- Mr Abhishek Ranjan, AVP (System Operation) & Head - Renewables & Mr Chetan Pathak, BSES Rajdhani Power Limited (BRPL)
- Mr Alok Rai, Head-Corporate Affairs, Society of Manufacturers of Electric Vehicles (SMEV)
- Mr. Debi Prasad Dash, Founder and Executive Director, India Energy Storage Alliance (IESA)
- Mr Saurabh Rohilla, Deputy Director, Society of India Automobile Manufacturers (SIAM)

We are also grateful to Mr S Sundar, Distinguished Fellow, TERI for his kind review of the paper and his suggestions for improving it.

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1 INTRODUCTION

1 INTRODUCTION

India has been at the forefront of addressing climate change and has emerged as a key player towards achieving global commitment of limiting global warming below 2^0C. In order to achieve this goal, India has laid out clear direction in the Nationally Determined Contributions' (NDC) document submitted to the United Nations Framework Convention on Climate Change (UNFCCC). The document, which now serves as a guidance framework, pledges to reduce emission intensity of India's GDP by 33-35 per cent by 2030 from 2005 level. With a view to achieve this ambitious target, measures should be adopted by all key sectors to reduce emissions. Particularly, the automobile and transport sector which currently constitutes 7.5% of country's total emissions, contributing 142 million tonnes of CO_2 (MoSPI, 2015)

With the Indian transport sector, fuelled by rising incomes and developing infrastructure, tipped to grow at a far higher pace as compared to the developed economies, reduction of emissions from transportation would require aggressive and sustained policy mechanisms backed by corporate and consumer action.

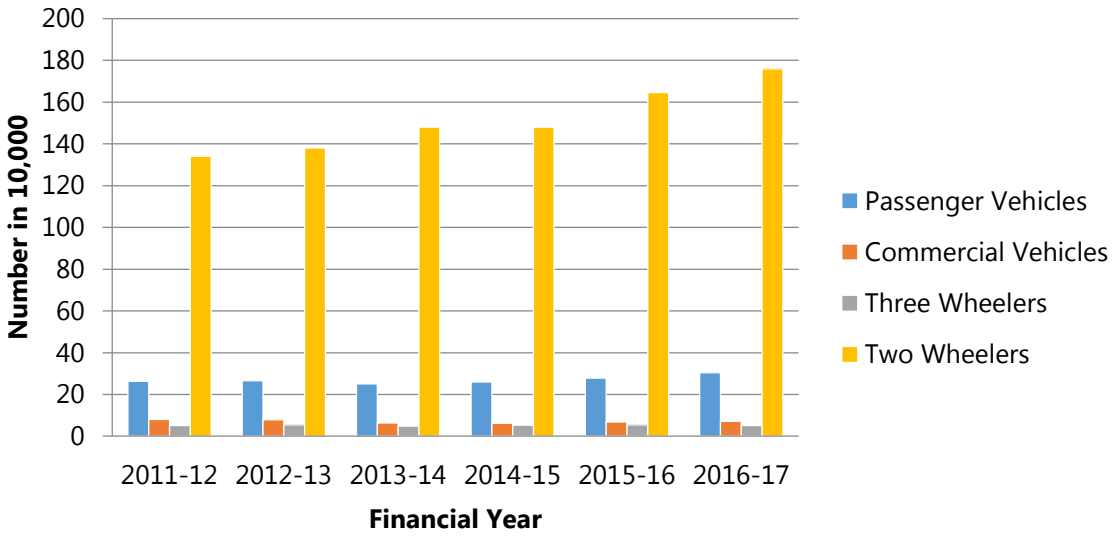
1.1 Indian Mobility Sector

Freight and passenger transport in India is primarily driven through road transport. According to the National Highways Authority of India (NHAI), about 65% of the freight movement and 86% of the passenger movement in the country is through roads (NHAI, 2014).

Country's rail network of 65,808 route kilometres and road network of 5.23 million kilometres provide last mile connectivity to 199 ports and 92 airports (TERI, 2017). On an absolute basis,

rail and road network may seem to be large, but India lags drastically in terms of road quality and per capita availability of roads. 61% of roads in India are rural and 39% of roads are un-surfaced, with only 4.18 km of roads per 1000 persons (MoRTH, 2016). This is the primary reason for Government's impetus of developing highways and roads which has led to an increased pace of highway development from 09 km/day in 2012-14 to 22 km/day in 2016-17 (Gupta, 2017). Given the growth of the road network across the country, the automobile industry is bound to grow considerably. Passenger motor vehicles in the country have grown over 25% over the last 5 years, (Figure 1) and are expected to triple by 2030 and increase seven times by 2050. Share of road transport in the total passenger and freight movement is also estimated to continue its dominance with an estimated share of 85% in passenger movement and 66% in freight movement in 2020, with these numbers expected to grow to 84% and 70% respectively in 2030 (TERI estimates).

Figure 1: Domestic sales trends of vehicles from 2011-17



Source: SIAM – Society of Indian Automobiles Manufacturers, 2017

1.2 Need for transition towards electric mobility

While the growing road transport sector is expected to contribute to the socio-economic growth of the country, the growth is accompanied by challenges such as:

- Dependence on oil imports
- GHG emissions and
- Local air pollution

1.2.1 Dependence on Oil imports

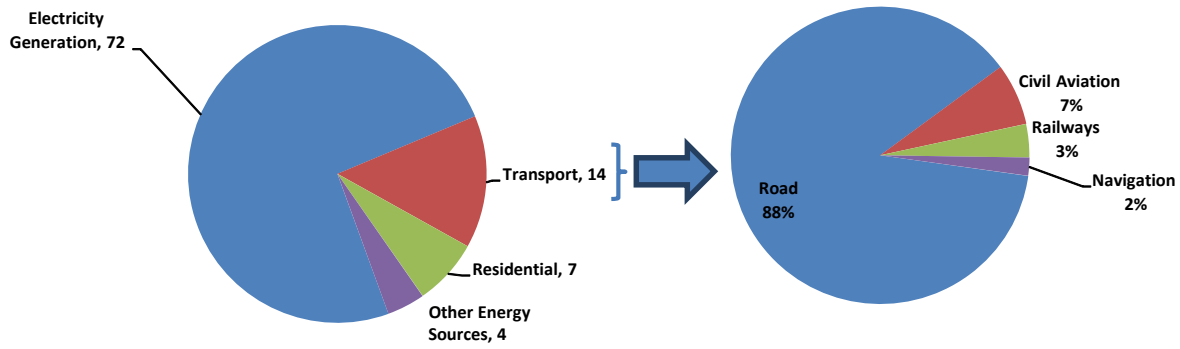
Indian transport sector is heavily dependent on liquid fossil fuels, which are primarily imported in India. The sector is the largest consumer of petroleum products in the country with nearly 55% of the consumption of petroleum products occurring in the transport sector (Ghate and Sundar, 2013). According to a study, 70% of diesel and 99.6% of petrol is consumed by the transport sector

(MoPNG, 2014). This dependence of the sector on petroleum products is expected to increase in future given the rapid pace of growth expected in the sector, especially in the road transport sector. This impacts India's energy security as India's oil import bill has been seen rising and is expected to reach USD 90 billion by March 2018 (Abdi, 2017). This would be a 29% rise from the last fiscal year and is bound to impact the current account deficit negatively. It is prudent that India explores alternate technologies that have low dependence on oil to enhance energy security.

1.2.2 GHG emissions

India is the fourth largest Green House Gas (GHG) emitter in the world (IEA, 2015). The Biennial Update Report submitted by India to the UNFCCC stated that India emitted 2,137mt CO_2 equivalent in 2010 (MoEFCC, 2015). According to the report, the energy sector, (which includes fuel combustion and transport), is the prime contributor to GHG emissions accounting for 71% of the country's total GHG emissions. The transport sector contributed to approximately 14% of the total emissions by the energy sector, wherein, road transport has been the major contributor (88%) resulting in 142 million tonnes CO_2e and 7.5 % of India's total emissions.

Figure 2: First pie - India's energy-related CO_2 emissions in 2010 – Share of different sectors; Second pie – Share of different transport modes in total CO_2 emissions from the transport sector



Source: MoEFCC, 2015

Given the continued dependence on fossil fuels, emissions from road transport are expected to rise to 850-900 mt CO_2 by 2030, an increase by nearly four times in comparison to the current levels (NTDPC, 2014).

1.2.3 Local Air Pollution

Several studies indicate the contribution of vehicular emissions to air pollution. As per a study conducted by the Central Pollution Control Board (CPCB) in six cities - Delhi, Kanpur, Bangalore, Pune, Chennai and Mumbai, transport sector contributes majority of NOx and 30-50% of the PM emissions in these cities (NTDPC, 2014). In 2011, the World Health Organisation (WHO) included many Indian cities in the top 100 most-polluted cities list (NTDPC, 2014), A study by ASSOCHAM suggested that Delhi NCR is likely to face a loss of INR 100 crore/day due to smog and poor air quality (ASSOCHAM, 2016).

Air pollution is an increasing area of concern for Indian cities given its negative impact on human health. Traffic related air pollution—especially PM and NOx—has been shown to lead to premature morbidity and mortality. A study supported by the WHO estimated about 1.54 lakh people died in India in 2005 as a result of ambient fine particulate matter (PM2.5) alone; the number has most likely increased since (NTDPC, 2014). From the perspective of promoting clean air in cities, it is critical to reduce the burden of vehicular emissions through use of low-polluting/clean transport technologies.

Given the triple threat of carbon emissions, air pollution and energy dependence, it is critical to identify and follow energy efficient and low-emission pathways that can reduce negative impacts of the sector on environment and society. **Electrification of transport sector is one such option** which has the potential of addressing the challenges highlighted. Electrification of road transport has the potential to reduce transport sector's dependence on oil imports apart from reducing emissions, health impacts and enhancing energy security of the country.

1.3 Growing focus on electric mobility in India

The transition from conventional fuel technology i.e. ICE (Internal Combustion Engine) to EV is a recent global phenomenon whereby countries like The Netherlands and Norway have rolled-out action plans to phase out all petrol and diesel cars by 2025 (ICCT and GIZ, 2016). Germany has also committed to converting it's entire fleet to electric cars by 2030, in spite of its miniscule electric car sales date (ICCT and GIZ, 2016). The UK recently announced plans to ban sale of new petrol and diesel cars by 2040, and requires all new cars to be electric (Financial Times, 2017). There are several other countries like China, Japan, France, Denmark and South Korea that have shown interest towards electrification of their road transport sector, indicating the beginning of a global shift away from fossil-fuel based technologies.

Realising the significance of electrification of the road transport sector in terms of its energy security and low emission benefits, Government of India has given thrust to promote electric mobility by setting an ambitious target of 100% EV sales by 2030. In order to move towards the goal of electric mobility, in 2015, Government launched a scheme for Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India (FAME India), which was successful in increasing the share of hybrid and EV in passenger vehicles from zero percent in FY 2012-13 to 1.3% in the FY 2015-16 (ICCT, 2016). Further, EVs have also been placed in a lower GST slab of 12% with respect to other large cars, which attract GST of 28% indicating a clear policy preference for these cleaner vehicles.

However, such a paradigm shift would require a clear roadmap in order to achieve the proposed electric mobility transition. An essential element of this roadmap would be the identification of vehicle segments (front runners) to be targeted initially to kick-start the transition. These low-hanging opportunities can provide the initial momentum, scale and visibility required for such a transition. The Government has already indicated in the roadmap through the National Electric Mobility Mission Plan (NEMMP) and most recently through the NITI Aayog report – 'India Leaps Ahead: Transformative Solutions for All' that the low hanging opportunities need to be captured immediately. Therefore, it is imperative that appropriate policy and financial interventions are adopted to scale-up the adoption of the front runners in short and medium term. Through this study, TERI along with YES BANK aims to suggest interventions for increasing the adoption of electric vehicles by capturing the front runners in EVs that can give the desired push to the electric mobility transition.

1.4 Objectives

1. To identify the vehicle segments that are the low-hanging fruits/ front runners from the perspective of providing a push to the EV transition in India.

2. To identify challenges and barriers impeding the large scale adoption of the identified front runners

3. To suggest policy and financial interventions required to upscale their adoption.

1.5 Methodology

This study is based on analysis and review of literature available on electric mobility with a particular focus on front runners and related policy mechanisms. Stakeholder interactions with key sector experts were also undertaken to gauge perspectives on the topic and identify key challenges and/ gaps that need to be fulfilled to build long-term solutions towards adoption of EV on a large scale in India. The study also draws learning from international models and best practices.

1.6 Scope of the paper

The electrification of road transport sector can be one of the pathways to reduce dependence on fossil fuel, carbon emissions and vehicular pollution. While there are several technologies like hybrid EV, plug-in hybrid vehicles, all-electric/battery EV and fuel cell vehicles that can help achieve the objectives of the electrification of road transport vehicles; this paper focuses only on all-electric/battery EV. Also, the scope of the paper is limited to passenger vehicles only.

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2 Electric Mobility transition in India

2 Electric Mobility transition in India

2.1 Electric Mobility transition

According to IPCC (Sims & Schaeffer, 2014), the emerging mobility paradigm of low carbon transition will be augmented through changes in:

- **Modal shift to lower-carbon transport systems**: would require an increase in investment in public transport, infrastructure development for walking and cycling, and modifying roads, airports, ports, and railways to encourage users and minimize travel time and distance
- **Improving energy efficiency**: through better vehicle and engine performance, using lightweight materials for vehicles, improving freight load factors and passenger occupancy rates and deploying new technologies such as EV
- **Reducing dependence on carbon intensive fuels**: by using cleaner fuels like electricity, ethanol and natural gas

Deployment of EV and substituting current Internal Combustion Engines (ICE) with EVs can serve the above three objectives. However, the transition from ICE to EV in India would be accompanied by a shift from personal mobility to shared and connected mobility, which would require enabling stakeholders along the value chain (NITI Aayog; Rocky Mountain Institute, 2017). The electric mobility transition should entail:

2.1.1 Research Integration in Manufacturing

Given the huge growth expected in the Indian automotive sector, India should utilize this potential for the adoption of EVs. As the automobile technologies continue to evolve, automotive manufacturers would need to look towards investing in Research & Development (R&D) and developing collaborative models within the supply chain to co-create new products and components for the EV ecosystem, which may not just serve the Indian market but the global market.

National Automotive Testing and R&D Infrastructure Project (NATRiP) is a Government of India initiative to aggregate technology development in the automotive industry. NATRiP, through its various centers, can carry out development of new technologies in collaboration with the industry for faster development and deployment of these new technologies. The collaborative approach would also be able to bring down the cost of critical components like batteries and would play an important role in accomplishing the technology advantage required to make this transition.

2.1.2 Energy Service Providers

As EVs are intrinsically dependent on electricity for charging needs, it is imperative that a strong, adequate and reliable network of charging stations is developed, which can support the quantum of EVs expected on road. Energy storage in form of batteries would be also important to support longer hauls of EVs. Since there is virtually no existence of public charging stations and battery swapping services, this would need to be established at a rapid pace. Availability of charging stations (energy services) would have to be in place for the consumers to be confident about adopting EVs at mass scale.

Considering the EV ecosystem, energy service providers would be a key stakeholder in enabling the development of charging infrastructure, on the similar lines of present day refueling at oil and gas stations. The service providers would also have to find solutions for fast charging of vehicles.

2.2 The EV policy landscape

Given the importance of the automobile sector in the Indian economy and the evolving mobility paradigm, the Government has been responsive in developing policies and schemes to direct the growth of this nascent sector in the right direction. Some of the key policies undertaken by the Government of India over the last one decade, which have provided support and push to cleaner mobility, are discussed below:

2.2.1 Integrated Energy Policy, 2006 and Draft Energy Policy, 2017

The Government of India had come up with an Integrated Energy Policy in 2006. The Policy recommended promotion of hybrid vehicles and electric vehicles and suggested that efforts should be made to develop low weight and high density batteries. The policy also emphasised on promoting commercially available hybrid vehicles in India, and commercially available flexi-fuel vehicles, which run on varying proportions of ethanol-blended fuels. The policy proposed fiscal incentives for automotive industries to support commercialisation of hybrid and battery operated vehicles in India.

The Draft Energy Policy, 2017 prepared by the NITI Aayog also lays emphasis on mainstreaming emerging energy technologies like EVs. The policy talks about setting up charging stations for electric vehicles need for appropriate sub-structures for Renewable Energy (RE) to support EVs

and energy storage solutions. The policy identifies hybrid vehicles, electric vehicles and fuel cell vehicles to be inducted in the transportation system of the future and indicates the need to utilize their complete potential.

2.2.2 National Electric Mobility Mission Plan 2020

National Electric Mobility Mission Plan 2020 (NEMMP) was launched by the Ministry of Heavy Industries and Public Enterprises in 2013 as a vision towards unveiling the demand for EVs. NEMMP aims to utilize electric mobility as an opportunity to achieve global leadership in manufacturing of EVs and expansion of domestic market by providing initial boost that can create demand for EVs, which would stimulate the manufacturing of these vehicles at scale. The four key principles that guide the future roadmap for EV penetration in NEMMP include:

1. Creating consumer acceptability for EVs
2. Developing infrastructure to support ownership and use of EVs
3. Development/acquisition of EV / battery technology
4. Creation of local manufacturing capability

The plan aims to achieve new vehicle sales of 6-7 million units for full range of EV (mild hybrids to full electric) by 2020. The bulk of this demand is expected to come from (pure) electric two-wheelers, followed by hybrid electric vehicles (HEVs) and other (pure) battery electric vehicles (BEVs).

2.2.3 Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles, 2015

While the NEMMP acted as a vision, the implementation was to be supported by Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles, 2015 (FAME India).

Under FAME, demand incentive is provided to buyers which can be availed by buyers upfront at the point of purchase and the same is reimbursed to the manufacturers from Department of Heavy Industries (DHI) on a monthly basis. *(Demand incentives shared in Annexures)*

Salient Features of FAME India

- Outlay of INR 795 crores
- Initially launched for two years of the 12th Plan period and extended to March, 2018
- Covers all vehicle segments including two, three and four wheelers, cars, LCVs, Buses and all forms of hybrid (Mild/Strong /Plug-in) and pure EV
- Incentive on hybrids was withdrawn when the Scheme was extended after March 2017

With the aim of boosting adoption of EVs, in January 2018, DHI approved pilots for 390 electric buses, 370 electric taxis, 720 electric autos and INR 40 crore for setting charging infrastructure spread across 11 Indian cities.

2.2.4 Automotive Mission Plan, 2026

Complementing the Government's 'Make in India' vision and establishing Indian automotive industry as one of the top three in the world, the Ministry of Heavy Industries and Public Enterprises

prepared a comprehensive Automotive Mission Plan (AMP), for 2016-2026. Specific focus was given to implementation of emission standards across India, in addition to pilot projects, charging infrastructure and component manufacturing for EVs.

2.2.5 New Draft EV policy

While NEMMP, FAME and AMP aim to guide the growth of EVs, an integrated electric mobility policy is expected to be in place soon. Given the need for inter-departmental/ministerial coordination, the Government has assigned NITI Aayog with the task to coordinate the development of the policy that can guide the penetration of EVs in the country.

The review of the emerging E-Mobility landscape suggests that newer business opportunities, propelled by favourable policy support, are reshaping the mobility landscape. However, further support may be required to support this pivotal endeavour as EVs barely constitute about 1.5% of the total market sales with only about 39,000 electric two-wheelers and four wheelers sold in FY 2016-17 (SMEV, 2017). To drive the adoption of EVs, it is critical to upscale the penetration of EVs in a short period of time, which in turn will require identification of the front runners which may trigger exponential uptake of EVs. The following section focuses on identifying such front runners, assessing their growth with electric penetration in the sector and challenges faced in their scale up.

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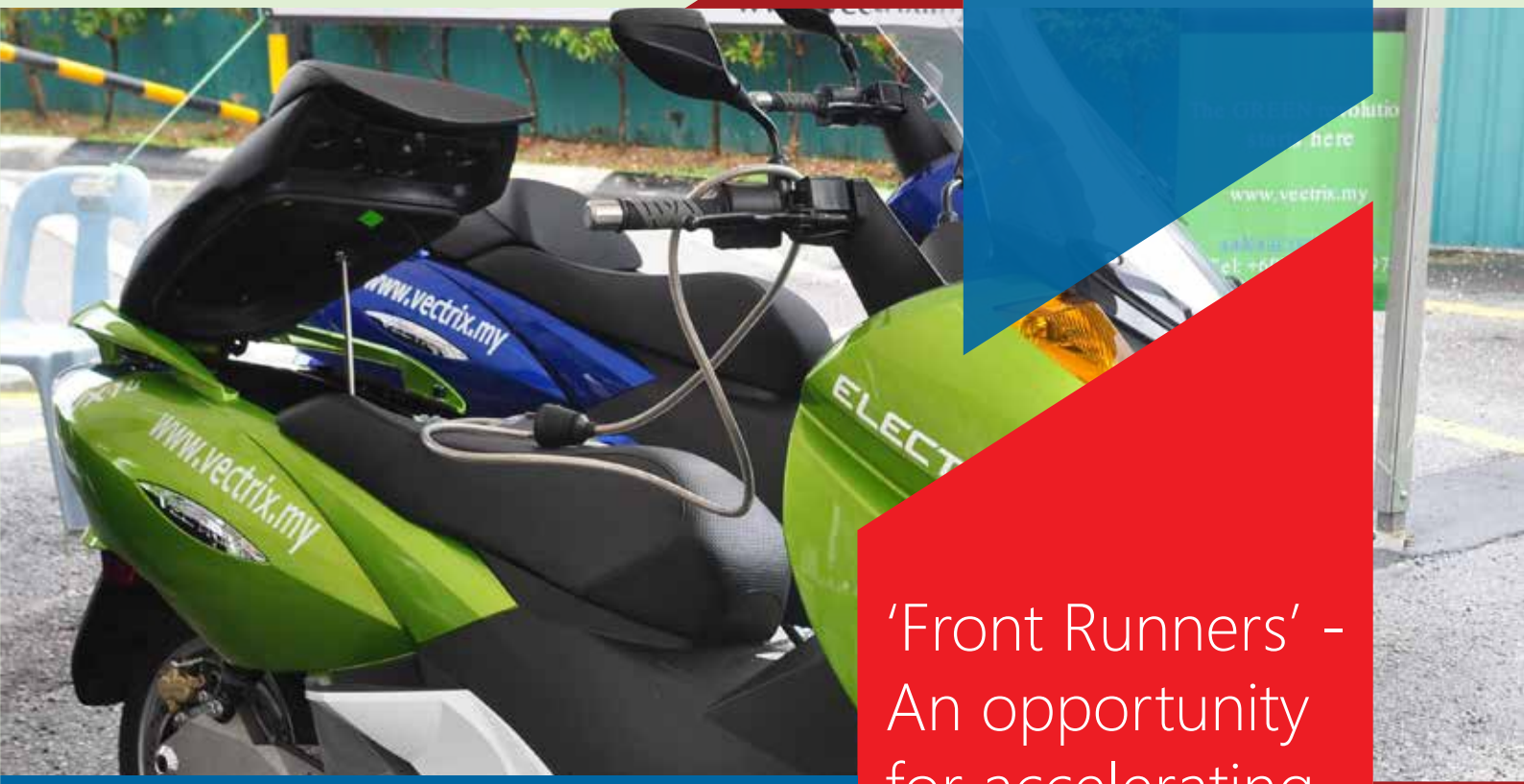
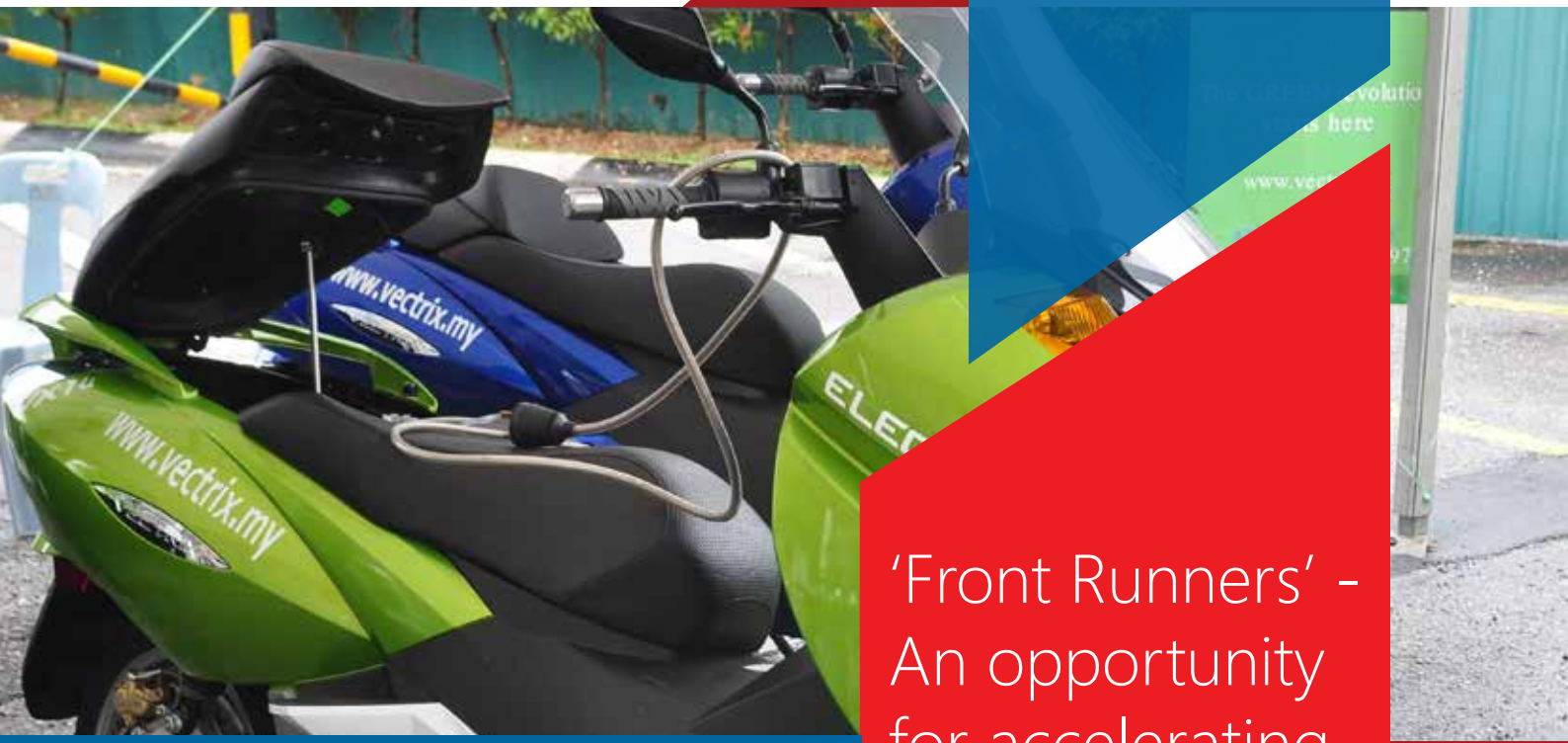


3 'Front Runners' - An opportunity for accelerating EV transition



3 'Front Runners' - An opportunity for accelerating EV transition

3.1 Identifying the front runners

'Front runners' in the EV context are being referred to segments that have potential to scale up with relatively lower investment, basic infrastructure requirements and minimal effort. For the purpose of the report the criteria for identifying these 'front runners' includes those which have:

1. Shown early adoption success
2. Minimal/limited dependence on charging infrastructure
3. Availability of model range
4. Local manufacturing capabilities
5. Ease of implementation
6. Available Government support

3.1.1 Early adoption success

Since 2009-10, electric two and three wheelers segments have recorded the maximum adoption. It is estimated that the total number of electric two-wheelers plying on the road is 4,50,000 while the number of three-wheeler e-rickshaws on the road is over 5,00,000 (Alok Rai, 2018). In comparison to the electric two-wheelers and electric three-wheelers, the overall sales of the electric cars has

not been strong with around 3,000 four wheelers sold in FY 17 (SMEV, 2017). Although e-buses have been adopted by certain State run transport corporations (*such as BEST in Mumbai and Himachal Road Transport Corporation*) the numbers have not been very encouraging.

3.1.2 Dependence on public charging infrastructure

EVs are dependent on charging infrastructure, however, public transport such as buses, commercial four-wheelers (i.e. fleet) and electric three-wheelers in particular are more dependent on public charging infrastructure. Conversely, for privately owned EVs, public charging infrastructure doesn't pose a significant barrier since the preferred mode of charging is home charging. This makes the uptake of private electric vehicles easier for private owners without requiring the initial investment in public charging infrastructure.

3.1.3 Local manufacturing capabilities

Local Manufacturing is critical for uptake of EV as they allow for better service in the long run as well as lower demand disruptions in the long run. India being the largest market for three-wheelers (ICRA, 2016), there are about 340 e-rickshaw manufacturers (*such as YC electric vehicles, Saera electric rickshaw, CEEON electric three wheelers, and Skyride electric vehicles*) in Delhi alone (*Battery Rickshaw Welfare Association*). Similarly, for electric two-wheelers, Indian manufacturers (*such as Hero Electric, Ather, Ampere, Electrotherm, Twenty Two, TVS and Avon*) are leading the way among various other manufacturers that support the entire supply-chain for electric two-wheelers. On the other hand, in electric cars segment, Mahindra & Mahindra and TATA motors are the only Original Equipment Manufacturers (OEM) as of now that are producing electric cars in India, out of which TATA motors is still supplying its products for aggregation and not for retail sales.

E-buses manufacturing is limited to Goldstone, Ashok Leyland and Hinduja Motors. The production capacity for e-cars and e-buses are limited as of now in comparison to electric two-wheelers and electric three wheelers.

3.1.4 Choice of models

Due to lack of OEMs in electric car and electric bus segment coupled with low demand, the choice of electric car and electric bus models is rather limited. On the other hand due to the presence of local manufacturing and demand for the product, the electric two-wheelers and three-wheelers have a range of models to choose from which not only promotes competitive prices in the market, but also ensures consumer satisfaction. Hero Electric alone has approximately 15 two-wheeler models as of now, while YC electrical has 6 electric rickshaw models to provide.

3.1.5 Ease of implementation

The successful proliferation of EVs is also dependant on Government control and ease of implementation. For instance, electric buses can be rather easily instituted given the control by public institutions (i.e. state transport undertakings). Similarly, other public transport modes such as electric autos, electric rickshaws, and electric taxis, which require Government permits to exercise their operations in a city can be pushed by the Government for their conversion to EV technology. Any such control over passenger segment in private ownership is difficult, as it entails consumer's choice and willingness.

3.1.6 Government support

DHI under FAME India, has an outlay to provide INR 437 Crore as subsidy to 11 cities for launching pilots for electric buses, taxis and three-wheelers. This initiative by the Government can prove to be instrumental for the EV agenda to gain momentum and is also indicative of the Government's intention towards promoting these vehicle segments.

Basis these six criteria, front runners have been identified that can be targeted to scale up electric mobility in India. The various vehicle segments were compared qualitatively on the basis of these criteria (*as presented below*).

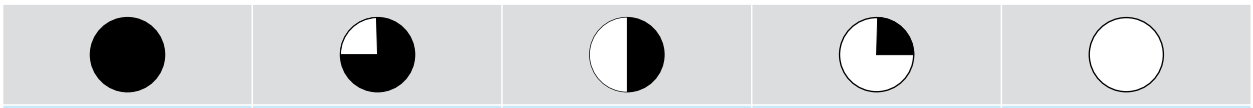


Figure 3: Identifying 'front-runners'

Electric Vehicle Type	2-wheelers	3 - wheelers		4-wheelers		Bus
		Auto-rickshaws	Rickshaws	Passenger	Commercial	
Early adoption success	●	◔	●	◑	◔	◔
Local Manufacturing capabilities	●	◕	●	◑	◑	◕
Dependence on charging infrastructure	◕	◔	◔	◑	○	○
Choice of model	●	◑	●	◔	◔	○
Ease of implementation	◔	◕	◕	◔	◑	●
Government support	◕	●	◕	○	◑	●

Source: TERI-Analysis

An analysis based on the above criteria, indicates that the front runners with the potential of providing the early push to e-mobility in the country are:

1. Electric two-wheelers
2. Electric three-wheelers (e-rickshaws and e-autos)
3. Electric Buses

The electric two-wheelers emerge as the segment requiring least effort to push the EV transition due to their limited dependence on public charging infrastructure, along with availability of a range

of models and presence of local manufacturing in the country. While the commercial electric two-wheeler fleets were not included in the analysis, they also seem to present an opportunity in terms of electrification. The two-wheeler fleets used by companies for home/commercial deliveries can be mandated to switch to electric over a period of a time. Their operations, however, will require provision of a well spread out public charging infrastructure, which could require more effort and investments initially.

In addition to two-wheelers, electric three-wheeler segment also emerges as a front-runner due to the early adoption success in this segment and the ability of Government agencies to push the uptake of clean electric autos.

While electric buses did not emerge on the top of the list of front runners, emphasis given by the Government to increase electrification in this segment, especially the benefits accrued to the state public transport corporations in terms of lower operational cost. Given the direct involvement of the Government in procurement and success of some initial pilots, this segment could be scaled up subsequently. This segment, however, would also require heavy investment and dedicated charging infrastructure.

The front runners, electric two-wheelers and electric three-wheelers followed by electric buses, are the vehicle segments that have the potential to trigger the e-mobility transition in India.

3.2 Current trends and unfolding the potential and its benefits

3.2.1 Electric two-wheelers

Out of the total two-wheelers sold in India, nearly 84% have the engine capacity of 100-125cc, which is good enough to fulfil the demand of urban and rural commuters alike (SIAM, 2017). The electric two-wheelers had just about 2% sales share of this market in 2016-17, of which a majority are low-powered e-bikes with maximum power of 250 watts available in the price range of INR 35,000-60,000. However, good quality electric motorcycles available in the range of INR 80,000-90,000 also have lower acceleration and top speed and inferior performance (comparison provided below) in comparison to the conventional two-wheelers (i.e. petrol-based). With enhanced performance and improved technology, these vehicles will be able to compete with the conventional two-wheelers provided that the prices are competitive.

Figure 4: Comparison between electric two-wheelers and gasoline-based two-wheelers

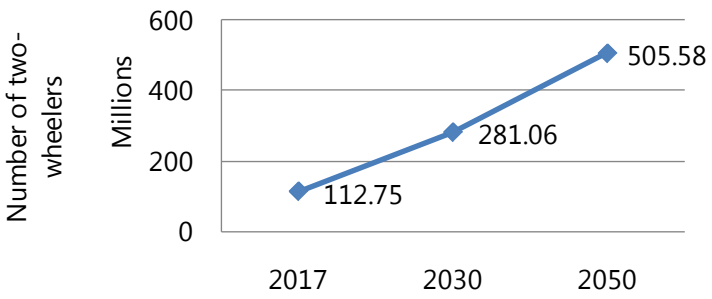
	Electric Two-Wheeler	Gasoline-based Two-Wheeler (100-125 cc)
Acceleration	0-20 km/h in 1.1 sec	0-20 km/h in 0.4 sec
Top speed	45-55 km/h	80-90 km/h
Range	60-80 km (single complete charge)	600 km (for 10 litre tank)

Source: Society for Indian Automobile Manufacturers and Society for Manufacturers of Electric Vehicles, 2017

Two-wheeler number on Indian roads could increase from about 112 million in 2017-18 to 281 million in 2030 and further to 505 million in 2050. This expected growth in two-wheeler market is indicative of the huge potential of the segment from an electrification perspective.

Even a conservative conversion of 30% of all two-wheelers by 2030, would result in 28% decrease in electric energy consumption and 27% reduction in CO_2 emissions, as compared to the Business As Usual (BAU) scenario. Further, if all the two-wheelers plying on the road were to become electric by 2050, 95% decrease in energy consumption and 82% reduction in CO_2 emissions can be expected, as compared to the BAU.

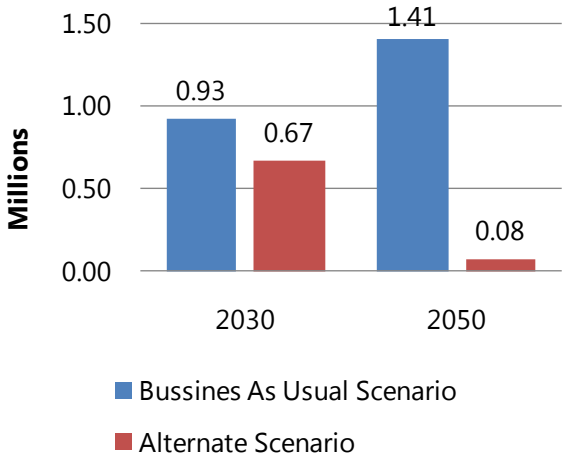
Figure 5: Growth of two-wheelers in India



Source: TERI Estimates 2017

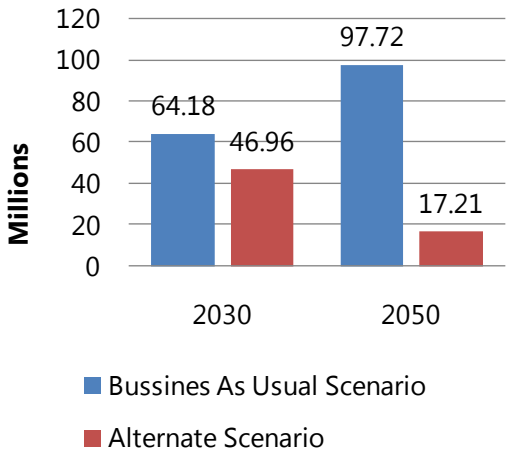
The reduction in energy consumption and CO_2 emissions in an alternate scenario (ALT) in comparison to Business As Usual (BAU) [ALT Scenario: EV uptake = 30% by 2030 and 100% by 2050]

Figure 6: The reduction in energy consumption due to electric two-wheelers (Terra Joules)



Source: TERI Estimates

Figure 7: The reduction in CO_2 emissions due to electric two-wheelers (tonnes)



Source: TERI Estimates

Note: The CO_2 estimates are based on improvement in grid emission factor by 25% in 2030 and 50% in 2050, as compared to the current levels on account of increased generation of electricity from cleaner sources like renewables.

3.2.2 Electric three-wheelers

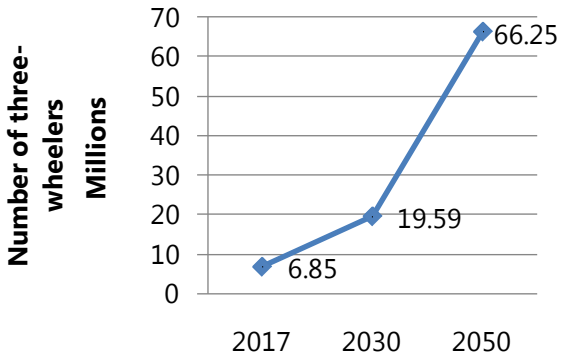
The three-wheelers i.e. auto rickshaws, is a mode of intermediate public transport in India. They provide mobility solutions for intra-city and inter-city travel in sub urban and rural areas. Although serving the same purpose, both e-rickshaws and auto-rickshaws vary in terms of design, top speed, seating capacity and functions. While auto rickshaws have higher top speed and are used

in all kinds of mobility services, e-rickshaws on the other hand are slower (top speed of 25kmph) and are generally used for first and last mile trips, accommodating more people for shorter hauls.

Three-wheelers could increase from 6.8 million in 2017-18 to 19.5 million in 2030 and further to 66.25 million in 2050, which provides a scope for leapfrogging towards e-rickshaws and replacing the conventional three-wheelers.

A 30% conversion from conventional three-wheelers to electric three-wheelers by 2030 would result in 21% decrease in energy consumption and 7% reduction in CO_2 emissions, as compared to the Business As Usual (BAU) scenario. Further, if all the three-wheelers plying on the road were to go electric by 2050, the scenario would account for 75% reduction in energy consumption and 18% decrease in CO_2 emissions, as compared to the BAU.

Figure 8: Growth of three-wheelers

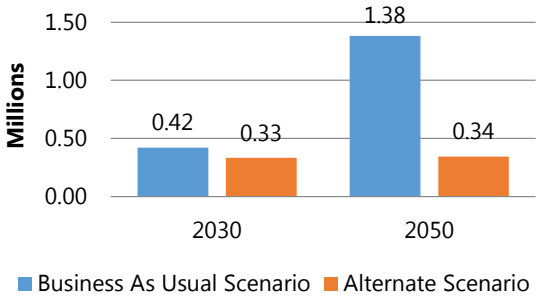


Source: TERI Estimates 2017

Note: The CO_2 estimates are based on improvement in grid emission factor by 25% in 2030 and 50% in 2050, as compared to the current levels on account of increased generation of electricity from cleaner sources like renewables.

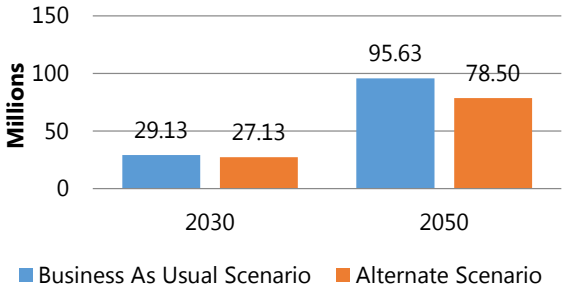
The reduction in energy consumption and Carbon Emissions in an Alternate scenario (ALT) in comparison to Business As Usual (BAU) [ALT Scenario: EV uptake = 30% by 2030 and 100% by 2050]

Figure 9: The reduction in energy consumption due to three-wheelers (Terra Joules)



Source: TERI Estimates

Figure 10: The reduction in CO_2 emissions due to electric three-wheelers (tonnes)



Source: TERI Estimates

Note 1: The analysis includes only auto-rickshaws (e-rickshaws are not included in this analysis).

Note 2: The CO_2 estimates are based on improvement in grid emission factor by 25% in 2030 and 50% in 2050, as compared to the current levels on account of increased generation of electricity from cleaner sources like renewables. The analysis includes only auto-rickshaws (e-rickshaws are not included in this analysis).

3.2.3 Electric Buses

Buses form an integral part of India's public transport system providing mobility services for intra-city, as well long distance travel. Buses sold in India largely fall under the category of 7-12 tonnes (SIAM, 2017), of which 7 tonne buses are generally used by the State Transport Undertaking (STUs). The buses under STUs are generally diesel based, except in Delhi and Mumbai where CNG is used for fuelling bus transport.

The acceptance and uptake of electric buses has been slow in India mainly due to their high cost as an electric bus is 1.5-2.5 times more expensive than a diesel bus. Also, the availability of electric bus models in the Indian market is limited with almost no locally manufactured model available.

Figure 11: Comparison between Electric, CNG and diesel buses

Parameters	Diesel Bus	CNG Bus	Electric Bus
Seating capacity	30-40	30-40	30-40
Gross weight	16,200kg	16,000 kg	18,500kg
Cost	INR 35-75 lakhs	INR 35-75 lakhs	INR 2-2.5 Crore
Fuel efficiency	3-4 km/L	2-3 km/kg	0.66 km / kWh
Running cost	INR 12-18/km	INR 13-19/km	INR 10/km
Range	480-560 km	260-390 km	220-250 km
Fuel tank size	160-220 L	720 L	NA
Charging time	NA	NA	4-6hr
Max. power	170-300 BHP	200-250 BHP	180 kW

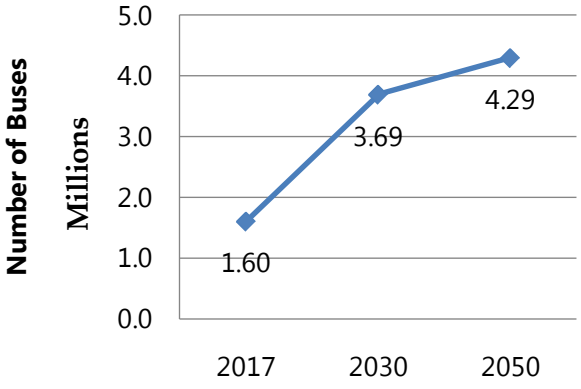
Source: International Association of Public Transport, 2017

Note: The electric bus considered for comparison is BYD K9, and CNG and Diesel Buses considered were TATA STARBUS

In spite of higher upfront cost and the low uptake numbers, the electric buses still have high potential because of the ease of implementation, as the implementation authority for public sector buses lies with the State Government agencies. There is already a push by the DHI to promote electric buses in cities. DHI recently announced a pilot for 390 buses spread across 11 cities under the FAME India scheme. The uptake of electric buses will require creation of charging infrastructure to support the refuelling of buses especially at the bus depots. STUs will have to consider making adequate investment in procuring buses.

According to TERI estimates, buses plying on Indian roads could increase from 1.6 million in 2017-18 to 3.6 million in 2030 and further to 4.2 million in 2050. These estimates include

Figure 12 The projected growth in the number of buses on Indian roads from 2017 to 2050



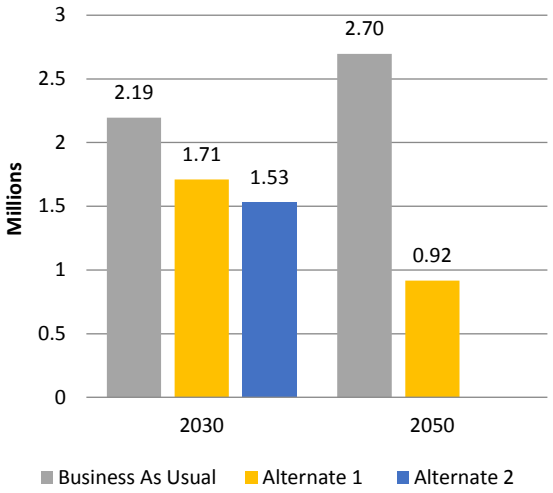
Source: TERI estimates, 2017

both public and private sector buses. The growth of buses is indicative of the huge potential of this segment from an electrification perspective.

According to TERI estimates, if the total market share of electric buses becomes 30% by 2030, the energy consumption for the segment can decrease by 22% and the CO_2 emissions may decrease by 20%, as compared to the Business As Usual (BAU) scenario. Furthermore, if 50% buses become electric by 2030, then the energy consumption may decrease by 30%, while the CO_2 emissions may decrease by 32%, as compared to the BAU. Also, in a scenario where total bus population is 100% electric by 2050, energy consumption decreases by 66%, while the CO_2 emission may decrease by 45%.

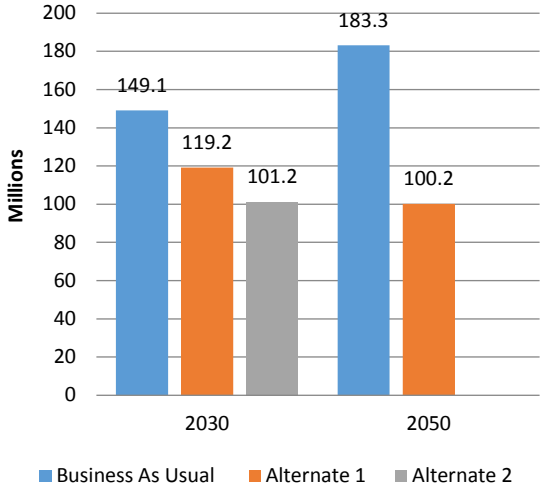
The reduction in energy consumption and Carbon emissions in an Alternate scenario (ALT) in comparison to Business As Usual (BAU) [ALT 1 Scenario: EV uptake = 30% by 2030 and 100% by 2050; ALT 2 Scenario: 50% by2030]

Figure 13: Reduction in energy consumption due to buses (Terra Joules)



Source: TERI Estimates, 2017

Figure 14: Reduction in CO_2 emissions due to Electric Buses (Tonnes)



Source: TERI Estimates, 2017

Note: The CO_2 estimates are based on improvement in grid emission factor by 25% in 2030 and 50% in 2050, as compared to the current levels on account of increased generation of electricity from cleaner sources like renewables.

3.3 Challenges

The automobile market globally is advancing towards EV technology. This transition is fuelled by the need to reduce energy consumption and emissions coupled with technological improvements such as cost reduction in energy storage. The Government of India has been swift in realising the potential of electric mobility; however, overcoming the barriers to 100% electrification of automobile sector will involve a number of challenges.

3.3.1 Cost of Electric Vehicles

EV have higher upfront cost in comparison to internal combustion vehicles available in each segment. In comparison to the conventional vehicles, EV happen to be 1.5-3 times more expensive.

For instance, a conventional 125-150 cubic capacity two-wheeler is available at a price range of Rs 50,000-60,000, while a comparable electric two-wheeler with similar performance and a range of 80 km is available at a price range of Rs 80,000-90,000. Similarly, an electric bus with a range of 230-250 km is priced at Rs 1.5-2.5 Crores, while a conventional bus operating on Diesel or CNG is available at a price of Rs 40-80 lakhs.

The higher cost of EV is largely attributed to the nascent technology and high battery cost; battery constitutes about half the vehicle cost and weight (UNEP, 2014). The Lithium Ion Batteries (LIBs), which are most commonly installed in EVs constitute of rare and expensive materials such as Cobalt, Nickel and Graphite.

3.3.2 Nascent technology

Being a nascent technology, EVs face a stiff competition with the incumbent ICE based vehicles. The conventional vehicles have a range of tried and tested (reliable) models available for the consumers, while the EV lack choices. The electric two-wheelers, for example, have low top speed, sub-par performance and stumpy grade-ability in comparison to the conventional vehicles (SIAM R. S., 2017). Similarly, electric three wheelers offer limited-range and low- top-speed in comparison to the conventional models.

Battery technologies are still evolving and the reliability in real road condition for longer terms is still to be tested for various technologies. It is also expected to have higher integration of digital technologies and the buyers may like to wait for better offerings to evolve. Range is a critical barrier which needs strong technology intervention, especially for the commercial vehicles like three-wheelers and buses, as it will have an impact on productivity per vehicle, which may be critical from the business model perspective.

3.3.3 Consumer Acceptance and awareness

One of the key challenges faced by the EV globally is the lack of consumer awareness about EVs and scepticism that persists among consumers while choosing between EV and conventional technology. The consumer's perception about practicality, potential advantages and functionality are varied on the basis of cost, convenience of fuelling, charging and travel range (Accenture, 2014). An established supply chain for conventional vehicles also gives it higher acceptability among consumers. Electric buses might not face the challenge of consumer acceptance as they would be operated by STUs. However, there may be concerns with regard to performance of buses under different load conditions experienced by the STU operators.

3.3.4 Charging Infrastructure

Another important requirement for promotion of EVs is the charging infrastructure. Interestingly, electric vehicles outnumber public charging stations by more than six to one globally, indicating that most consumers rely primarily on private charging stations; this however will change/be different in the case of electric three-wheelers and buses, which will certainly require public/ specialized charging infrastructure. In 2016, India only had 326 slow charging station and about 25 fast charging stations which were publicly accessible (IEA, 2017). The challenges associated with established of charging infrastructure include - issues related to regulations governing sale of power, power tariffs for transport sector, land ownership / leasing cost.

3.3.5 Technology, Research and Development expertise

As mentioned earlier, the major models available in the Indian market have been limited sub-par models which have low top speed, acceleration and range limiting their large scale uptake. The locally manufactured 3 wheelers have also been low on safety of passengers limiting their full scale commercial use.

Lack of local technology, research and development facilities becomes a very critical challenge in upgrading the quality of the local manufacturing which in turn is limiting the large scale mainstream uptake of these vehicles in India.

3.3.6 Import dependence and lack of local manufacturing facilities

Import of components and batteries is a major challenge in scaling EV uptake in India. For example, high density batteries that ensure better performance need to be imported, thereby raising the cost of vehicles in India. Indian manufacturing capacities need to be improved considerably in order to reduce dependence on imports.

3.3.7 Financing Challenges

The financing challenges in the emerging landscape for different stakeholders include:

- **Original Equipment Manufacturers (OEMs)**

  OEMs make large investments in terms of setting up the manufacturing facilities and supporting development of new vehicles in the market. The new paradigm would push OEMs to make additional investments for increased R & D. Given the changes in the businesses, financing mechanisms may have to adapt for the OEMs, and the financiers may need better understanding of the changing risk profiles to evaluate EV manufacturing finance.

- **Public transport**

  As India urbanizes in the new paradigm, the need for public transport would increase multifold. But the public funds available may be restricted to make heavy infrastructure investments, especially in tier 3 and tier 4 towns leading to huge financing gaps. Innovations in financing may be required in bridging this gap along with encouraging private sector participation.

- **Personal Vehicles**

  The personal vehicle segment is poised for a strong growth in India driven by increasing middle class and growing real income. The new paradigm of changing technology of travel may not impact the financing mechanism for the private vehicles as repayments are linked to the repayment capacity of the borrower. However, there may be higher upfront cost to the vehicle owners which may put additional financing constraint to the user.

- **Commercial Vehicles**

  Technology and cost of vehicle would play the biggest role in adoption of the electric mobility paradigm in this sector. The financing of high cost vehicles with lower operational cost would require adaptation to new structures of financing similar to the renewable energy ecosystem for the vehicles especially in the commercial segment as the buyers would like attractive cost per kilometer of operation.

- **Energy Service provider**

  The charging stations installed by energy service providers would be heavily dependent on the number of customers using them. This number may not be substantial at the start of operations. Hence adequate financing support would have to be provided to augment the businesses.

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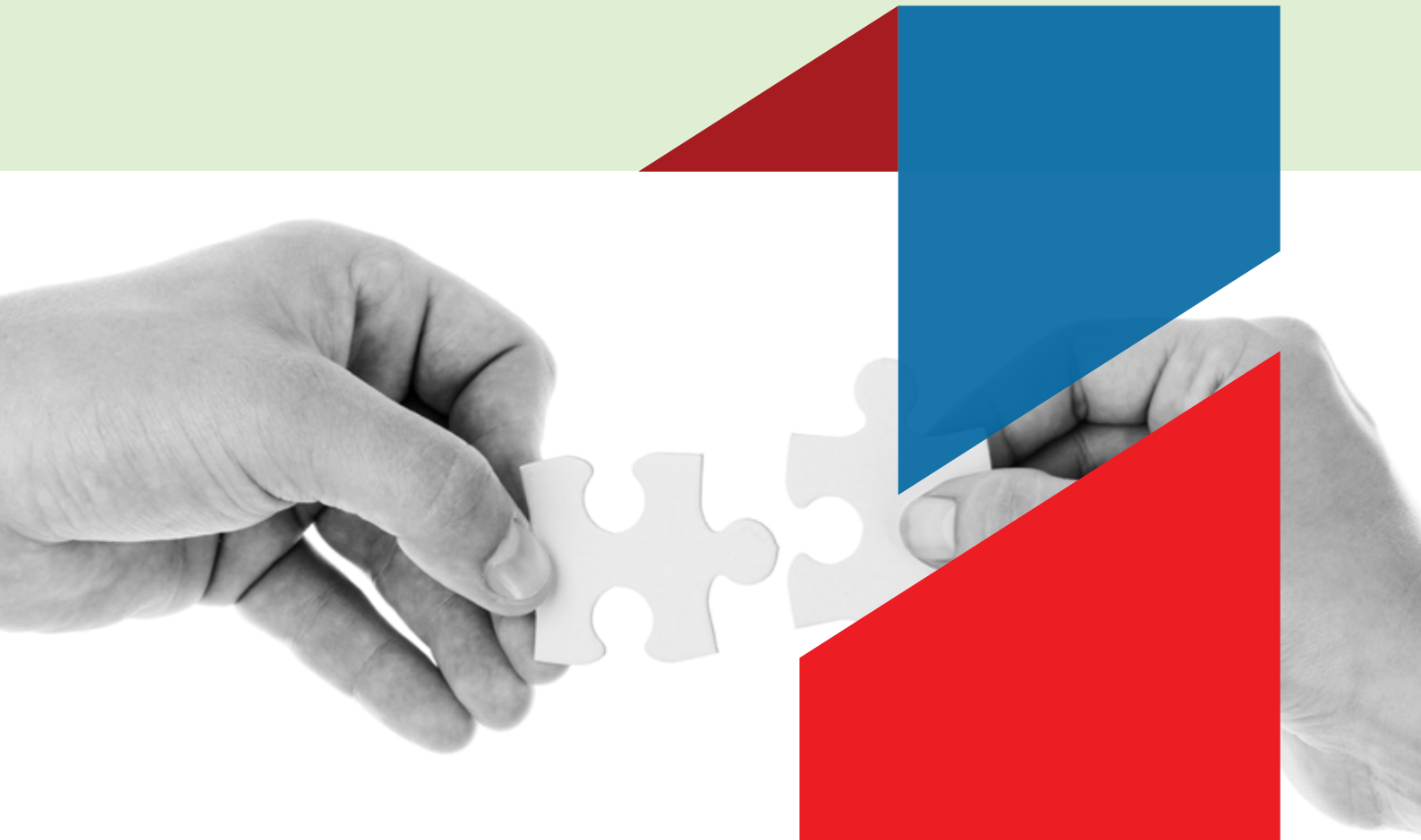
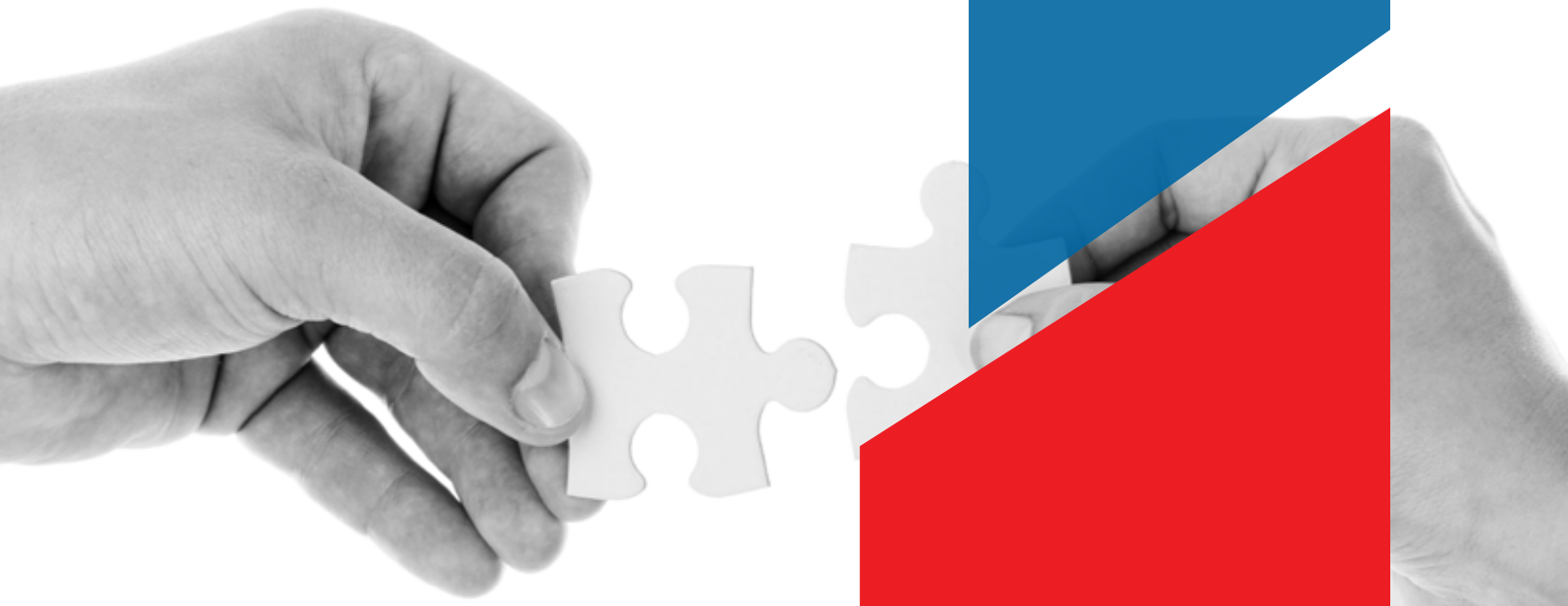


4 Potential Solutions



4 Potential Solutions

4.1 Learning from global practices

Countries worldwide are implementing several policies and adopting different mechanisms and approaches for promoting the growth and uptake of EVs. It is important that India learns from global best practices in the EV space, translates the learning to the Indian context and addresses the associated challenges around the adoption of EVs. Basis the analysis conducted in this study, 2-wheelers, 3-wheelers and buses have emerged as the front runner opportunities which need to be captured in order to drive the EV agenda. To this end, global case studies showcasing the approach adopted for promoting electric two-wheelers, three-wheelers and buses and financing mechanism used by EV manufacturers have been studied to derive lessons for India.

4.1.1 Electric two-wheelers in China

Two wheelers, due to their low cost and easy operations, especially in congested traffic, have provided energy-efficient transportation to an estimated 40 to 50 million people in the People's Republic of China (PRC) (ADB, 2009). The electric two-wheelers operating in China can be categorised into two categories- the low range electric bicycles (e-bicycles) and the standard range electric scooters (e-scooters) or electric motorcycles (e-motorcycles). The faster adoption of electric two wheelers in China was ensured using the following three driving mechanisms/policy levers.

- **Cost reduction through technology up-gradation** - Since the late 1990s, there have been improvements in battery lifetime (160%), energy density (30%), and motor efficiency (60%), which has led to steady decrease in prices of electric two wheelers. Between 1999 and

2005, the average price drop was nearly 30% from $380 to $240 for electric two wheelers (ADB, 2009). The better electric two wheelers made it to the market attaining speeds of 60–80 kilometres per hour (km/hr). Additionally, the practise of open modular industry has ensured standardisation, mass production and lower costs, which has all resulted in greater uptake of electric two-wheelers

- **Government policy initiatives and traffic restrictions** - The traffic restrictions of gasoline-powered motorcycles in many large and medium-sized cities has driven the adoption of electric two wheelers in Chinese cities. This policy, driven by air quality concerns has led to complete or partial bans on motorcycles in 29 cities (ADB, 2009). Besides banning gasoline based motorcycles, other local regulatory approaches include policies allowing electric two-wheelers to ply in dedicated lanes and financial incentives for e-bikes

- **Provision of Charging Infrastructure** – The State Grid Corporation of China (SGCC) proposed a series of charging station standards and established about 1700 EV charging stations and 3 million charging posts in China (Liu, 2012). Several cities initiated building up of charging stations, which boosted the uptake of electric two wheelers. Shenzhen for example, implemented the China Southern Power Grid (CSPG) development plan, which included 150 charging stations and 225,000 charging posts (Liu, 2012).

4.1.2 Battery operated electric three-wheelers in Kathmandu, Nepal

In order to initiate faster adoption of electric three wheelers in Kathmandu Metropolitan Corporation area, the Government along with the Global Resources Institute with support from United States Agency for International Development (USAID) and US-Asia Environmental Partnership Program started a pilot project for designing and converting diesel three wheelers to electric three wheelers. The initiative involved a pilot of 600 electric three wheelers. Key features of the initiative are summarized below.

- **Support of external agencies**: In its initial years, the initiative led to plying of pilot of 8 electric three-wheelers on one of the major routes in the valley for 6 months carrying over 200,000 passengers and travelling more than 175,000 km

- **Indirect facilitation by the Government**: Ban on plying of diesel three wheelers created a demand for electric three-wheelers

- **Direct facilitation by the Government**: Fiscal benefit in the form of reduced import custom tariff and waiver on annual vehicle registration fee was provided on electric three wheelers. Additionally, custom duty was reduced on parts and accessories of electric three-wheelers to 1% and sales tax was completely waived off. (Global Resouce institute, 1993)

- **Transport management initiatives**: Favourable routes were allocated to electric three-wheelers

- **Fuel based initiatives**: The state owned Nepal Electricity Authority provided electricity at low tariff rate for battery charging. Since majority of electricity in Nepal comes from run-off-river hydro power plants, there was also reduction in the emissions as well

4.1.3 Promotion of electric buses in Shenzhen, China

In order to reduce vehicular emissions in cities, it is important to encourage commuters to shift to public transport such as buses. China, has taken initiatives to curb vehicular pollution by the deployment of more than 1,70,000 electric buses operating in cities like Beijing, Shanghai, Shaoguan, Shenzhen, Tianjin, Dalian, Nanjing, etc. (ZeEUS, 2016).

In 2009, the People's Republic of China adopted the New Energy Vehicle (NEV) Program to promote electric and hybrid vehicles. Under the program, pilots were launched in various cities for the deployment of electric buses. Shenzhen city, for example, has deployed 16,359 e-buses since 2009. The various measures that were taken in Shenzhen to develop the largest electric bus fleet, globally, are discussed below:

- **Infrastructure**: The electric bus fleet was provided with 510 charging stations along with 8,000 charging poles across the city. The charging poles could fuel-up the bus entirely in two-hours and serve up to 300 vehicles each day (Cooper, Daniel, 2017)

- **Incentives**: In 2013, a subsidy of up to USD 81,600 was announced for an e-bus by the National Development and Reforms Commission (CER, 2013). Subsequently, in 2017, Shenzhen city offered USD 490 million in subsidies for e-buses and the construction of charging facilities.

- **Leasing Model**: In this pilot, a unique business model was adopted. The buses were purchased by Shenzhen Government and the charging infrastructure installed by a state owned company, Putian. To make the buses affordable, the Government sold the buses sans batteries to local bus companies and provided batteries on an 8 year lease. Government ownership of the batteries allowed Putian to monitor and manage battery conditions, charging state, and driving conditions in real time, alerting bus operators in case of any problems (Sabrina Howell, 2014).

4.1.4 Financing support for Electric buses: Poterra Inc, USA

Proterra Inc is one of the leading manufacturers of zero-emission-vehicle in the USA. Established in 2004, it made its first electric bus sale in 2009 and since then has sold them to more than 40 customers. Since then, it has innovated on the technology and provides buses which can go up to 350 KM in one charge making it possible to be used for long hauls like inter-city / state transit operations.

The biggest challenge of an electric bus is the upfront cost which is more than 50% of the current cost of a diesel vehicle. However, it is more efficient and economical in comparison to diesel buses thus making it more cost effective in the long run. The brief break up of the operational cost comparison is illustrated in the figure 15 below

Figure 15: Comparison of operating cost between diesel and electric bus

Source: Proterra Inc

To capture the long term cost benefit of electric buses and reduce the upfront cost for its customers, the company offers the following financing options for its customers:

- **Municipal Capital Lease**: A low-cost financing tool for municipalities and local governments with investment-grade to raise finance and lease the vehicles. It offers structured ownership of the vehicles enabling the municipality to own the bus at the end of lease term
- **Operating Lease**: The bus owner may take the vehicle on an operating lease contract with the company for a long period. The owner may use the bus over time and pay a cost which is lower than the combined fuel and operational cost of the diesel vehicle in a structured manner. The bus may also permanently transition to the owner at the end of cycle
- **Bus Rental Program**: The optional 'rental' program is offered for fleet operators looking to 'test drive' the bus before making a long-term commitment. An option to rent a bus for up to 12 months before making a purchase is generally offered in such programs.
- **Battery Lease**: The option of battery lease enables user to buy a bus for roughly the same price as a diesel bus. Proterra is responsible for the performance of the batteries through the life of the lease, removing operator risk.

An important part of the above models is the state support for the buses for different users which draws the financial commitment from both private and public players. JLL, a major commercial real estate services company, recently entered into an operating lease for 10 Proterra buses with a support of USD 150,000 from the federal grant, that provides service to its tenants at the Aon Center and Prudential Plaza buildings in Chicago.

From the global practices discussed above, some of the key learning that can be derived for each segment are:

- **Electric two-wheelers**: A holistic plan with a multi stakeholder approach was the key to the successful uptake of electric two-wheelers. The multi stakeholders being- the State Grid Corporation of China for providing charging infrastructure, the transport department

for formulating policy initiatives and manufacturers for providing technology up gradation solutions.

- **Electric three-wheelers**: The launch of the pilot initiative by the Government of Nepal gave the adoption of three wheelers an initial boost. This led to the surge in demand for electric auto rickshaws in Nepal. This brings out the role of pilots in promoting EVs like electric auto rickshaws.

- **Electric buses**: The success of the deployment of electric buses can be attributed to the launch of pilots combined with incentives for purchasing electric buses. Additionally, charging infrastructure was also developed to complete the ecosystem.

- **Financing** plays a key role in deployment of electric fleets with support of the Governments in terms of initial incentives for reducing the upfront cost or tax incentives. However, leasing models where the upfront cost of the vehicles is recovered through the operational income of running the vehicle presents a sustainable method of long term financing.

4.2 Recommendations

4.2.1 Policy Interventions

As discussed in an earlier section, several incentives have been provided by the Government for both demand and supply creation under the FAME scheme. However, it is important to boost the existing initiatives to achieve the ambitious target of EV transition. Certain urgent actions can give the desired push to boosting the existing initiatives and efforts towards the promotion of EVs in India. The paper recommends that all existing policies and measures should continue as proposed by the Government for promoting EVs. Additionally to kick off early adoption in identified low hanging segments, the paper recommends the following.

- **Creating immediate demand in focused segments-** The high upfront cost of EVs persists to be an issue impeding the growth of EVs. It hence, becomes essential to bring down the cost of EVs in order to popularize them. To begin with, this can be achieved through strategies and measures that will increase the demand for EVs in focused segments. An increase in demand means more vehicles plying, which in turn will be instrumental in lowering the cost, as market forces come into play. The policy measures that can help in increasing the demand for EVs are:

    - **Regulating movement of polluting vehicles in certain zones in cities -** With 33 Indian cities featuring in WHO's list of top 100 most polluted cities in the world, India has the largest number of polluted cities (WHO, 2016) in the world. Automobile exhaust is one of the key sources of pollution in Indian cities. To combat air pollution, these cities may plan to create low-/zero- emission zones that regulate operations of polluting vehicles in these areas allowing only clean/low polluting vehicles in these zones. This will help in creating a demand for clean vehicles like EVs.

    - **Promoting EVs in first and last mile connectivity** - The Government programs directed towards improving first and last mile connectivity can lead to promotion of EVs such as electric auto-rickshaws, mini buses and e-rickshaws. Cities that have metros should initiate pilots of electric three wheelers and electric mini buses for first and last mile connectivity. 'Only E-Auto-rickshaw'/E-rickshaw metro stations' can be

declared/implemented in a phased manner in addition to creating pre-paid E-Auto Rickshaw stands at metro stations for increasing passenger convenience and demand. Metro parking may provide charging points to start this transition.

- **Pilot initiatives:** The Department of Heavy Industries, Government of India has identified 11 cities for running the pilot project of Multi-Modal Electric Public Transport targeting electric buses and three wheelers. This will give the much needed push to boosting electric mobility, especially buses and three-wheelers. For the agenda of electric mobility to gain momentum, it is recommended that these and more such pilots are implemented at the earliest. The national urban schemes such as smart city program and AMRUT could also promote implementation of pilots of electric mobility solutions. E-bike sharing schemes can also be introduced, as they can help towards creating awareness on electric two-wheelers besides providing clean last mile solutions in urban areas. Cities may also implement pilots for charging infrastructure at select locations, thereby fostering an EV ecosystem.

- **Charging infrastructure:** Dedicated public charging infrastructure needs to be developed to support charging needs of EVs. Apart from the provision of public charging stations, this should be achieved through the provision of charging points at parking spots in places like office buildings, malls, and market places. Charging provisions for buses will also need to be created at bus depots and bus stops. Reduced electricity tariffs could also be considered for encouraging people to charge at designated charging spots reducing loads on residential supply and the operating cost of the vehicle. The DISCOMS in Delhi and Andhra Pradesh have already announced lower tariffs for electric vehicles which other states may follow. Also, the Oil Marketing Companies (OMCs) which have the largest chain of fuel stations in India may be encouraged to set up electric charging stations.

- **Consumer awareness and capacity building -** EVs are still a nascent subject in India and there is a lack of awareness amongst consumers about the technology and the benefits it offers. In order to popularize EVs, it is important to educate and sensitize people on the EV technology and its overall costs and benefits as compared to conventional technologies. The Government should launch awareness programs and campaigns which will guide consumers on aspects such as purchase of EVs, available subsidies, performance of EVs and location of charging stations. Apart from sensitizing consumers, it is also important to build capacities of relevant Government officials, consultants and practitioners in transport departments, DISCOMS, urban local bodies for smoother adoption and facilitation of EVs by different users. Government may consider launching special 'Green Heroes' campaigns that recognize and reward early adopters in different categories.

- **Technology and Innovation -** Apart from all the demand based incentives and measures for promoting EVs, focus should also be on building the supply and manufacturing capabilities in the entire EV ecosystem. Dedicated R&D capabilities would be required for critical EV components like batteries, electronic components and associated charging equipment for different vehicle segments. Further, innovations may be required from the industry to work on the limitations of EVs such as cost, range, performance, and speed. Research collaborations like NATRiP may be considered for EVs in order to provide impetus to the industry.

- **Green procurement by the Government -** Government can kick start the EV transition by procuring electric vehicles for its own consumption/usage. This kind of bulk procurement would not only set an example for others to follow but, more importantly help in reducing

the upfront cost of EVs. The Government of India has already initiated this; the State Governments, and PSUs could also replicate similar bulk procurement of EVs.

4.2.2 Policies for the Front runners

The front runners may require some specific recommendations for pushing their demand and adoption.

- **Three wheelers:** Some of the policy interventions may include
  - Transport Permits
    - No permit renewal of ICE powered auto rickshaws (at least in highly polluted cities) or no permit requirement/Open Permit System for E-Auto Rickshaws
    - Reduced permit fee for E-autos
    - Permit renewal period for e-autos can be increased in comparison to ICE autos
    - Flexible carriage system for e-auto rickshaws
  - Driving Licenses:
    - Creating a separate licence category for e-vehicle drivers
    - Lowering of/creating differential in driving licence application and renewal fee between ICE auto and e-auto drivers
    - Renewal period of driving licence can be increased for e-auto drivers
    - Differential in driver license obtaining duration for drivers of e-autos and ICE autos
  - Costs:
    - Upfront subsidies for purchasing new vehicles and retrofitting old vehicles - additional subsidy by local governments, in addition to FAME incentive
    - Low interest rates on loans for e-autos
    - Tax waivers such as road tax exemption
    - Lowering the GST on batteries (when bought separately for replacement)
  - Ecosystem:
    - Provision for charging at auto stands at high traffic areas
    - Separate lanes / stands at public locations like railway stations/ airports/ metro stations
  - Public awareness:
    - Promotion of electric rickshaws as green and environment friendly transport in localities
- **Two wheelers**: To ensure a substantial shift away from petrol two-wheelers and increase the immediate demand for electric two-wheelers, efforts need to be taken towards lowering the price of electric two-wheelers. Incentives in addition to FAME incentives should be provided that will make its costs comparable to petrol two- wheelers; these incentives could be provided by state/city governments. Non-fiscal incentives like lower parking fees could further make e-two wheelers attractive for potential consumers. These initiatives

should be coupled with technology improvement in performance and durability of electric two-wheelers. Consumer awareness campaigns should be taken up to create awareness about electric vehicle technology among potential consumers. Additionally, two wheeler logistics providers such as home/commercial deliveries may be mandated to switch to electric over a period of time.

- **Buses**

  The Government of India has laid emphasis on the electrification of buses by recently announcing the pilot in 11 cities. Even though the buses under these pilots are incentivised under the FAME scheme, the upfront cost can be further lowered through adoption of innovative models like bulk procurement and lease model (sans battery), as adopted in Shenzhen (section 4.1.3 above). The Government may also look at exploring other leasing models proposed by the suppliers to reduce the initial capital cost for the STUs. State Transport Undertakings (STUs) may be given targets for phased adoption of electric buses in their fleets. In addition, city bus services and other bus services like school buses, company buses could be mandated by the government to become electric in a phased manner.

4.2.3 Financial Interventions

Finance will play a key enabler role in making the transition possible for each segment of the ecosystem. Financing would also have to adapt to the emerging needs of the new business models. The financing requirements may be evaluated based on the following three factors to suggest suitable financing instruments for each (Table 3).

- **Financing challenges**: The financing challenges for promoting the new mobility paradigm in the segment. These are critical for evaluating financing needs and gaps of the business.
- **Financial success factors**: Identify the key financial metric that the business evaluates towards growing its business. These factors need to be continually evaluated for the financial and non-financial support provided for the business.
- **Support**: Suggested business support from the Government to drive adoption of the new paradigm.

Figure 16: Financial Instruments which may be leveraged for each business / usage segment

Business / Finance requirements	Financing challenges	Financial success factors	External Support needed	Financial instruments
OEMs Manufacturing Facility Research & Development	• Higher R&D investment required	• Sales Revenues • Hurdle Internal Rate of Return from Equity	• Demand Guarantee • Battery R & D	• Demand aggregation mechanism • Fee-bates
Public Transport Infrastructure creation Purchase of vehicles	• Limited revenue realization • Larger scale of finance	• Cost recovery • Lifetime Service to the society	• Financial support for Capital and Operating Expenditure	• Fee-bates • Green Bonds • Structured PPPs
Commercial vehicle owners Purchase of new vehicle fleet	• Additional up-front cost of the vehicle	• Average running Cost till end of life	• Financial support for Capital cost gap	• Demand aggregation • Interest Subvention • Viability Gap Funding for Capital expenditure • Guaranteed Lease finance
Personal vehicle owners Vehicle Ownership	• High cost of vehicle • Limited reliability	• Monthly Cost of EMI, Fuel & Maintenance	• Preferential treatment with tax, toll, parking and other charges • Lower EMIs	• Interest Subvention • Viability Gap Funding for Capital expenditure
Energy Service provider Setting up charging and battery infrastructure	• Limited market size for charging	• Electricity and Operational Cost per vehicle	• Guaranteed demand of charging	• Long gestation loans • Green Bonds

Source: YES BANK Analysis

The above table explains the complexity of stakeholders and their financing needs to the electric mobility transition.

4.2.4 Financial Instruments

Some of the financial instruments which may be used by different users to meet their financing needs include

- **Demand aggregation mechanism:** Aggregating demand to bring down technology costs has been effectively used by EESL, a public sector enterprise, to reduce the cost of LED bulbs in India. The recent auction of 10,000 BEVs by EESL has set an example of demand aggregation and guarantee for the OEMs to build up new capacities. A roadmap of such auctions may be instrumental in attracting multiple OEMs to the market. Batteries and storage cost form a very important component of the EV costs. Lack of local expertise and ever evolving technology may act as a deterrent for large scale production of batteries in India. Demand aggregation from different OEMs and creation of a streamlined import market may be a useful technique for mitigating these challenges. Such mechanisms should be undertaken in conjunction with the creation of R&D and manufacturing capacity in battery technologies to reduce long term dependence on imports.

- **Green Bonds**: Green bonds have established themselves as one of the key financing mechanisms for raising money from capital markets for environment friendly business activities and interventions. Since the maiden issuance of INR 1000 Crores (USD 160 billion) in 2015, the green bond market has grown steadily in India, becoming a USD 6.3 billion market by the end of 2017. Though the green bonds have been used to finance predominantly renewable energy in India such instrument holds enormous potential for other sectors. Electrified public transport and charging infrastructure are key sectors which can draw upon the funding from Green Bonds market. The Indian Railways Finance Corporation has already leveraged this platform to raise a 10 year USD 500 million certified green bond at the London stock exchange (IRFC, 2018).

- **Fee-bates**: Fee-bates are special financing structures which present a revenue neutral policy regime to incentivize a positive technology like low carbon transport. Fee-bates have been used in different countries like Norway, France, Germany to fund rebates to the purchasers of new electric vehicles by charging a fee from the new ICE vehicle purchasers. A NITI Aayog–RMI (Rocky Mountain Institute) report has studied the potential of Fee-bates based policy in India in supporting the electric mobility transition in India. These may generate resources for the incentives to the EVs as prescribed in different Government policies and scale the reach of these policies to promote the sales of EVs (NITI Aayog; Rocky Mountain Institute, 2017). A similar fee and rebate system may also be utilized to nudge users towards public transport by implementing local taxes on polluting personal vehicles.

- **Structured Public Private Partnerships (PPPs)**: Public Private Partnerships have been an effective mechanism for channelizing private funds for infrastructure development. The PPPs can be structured to generate appropriate financial returns for the investors in public transport. An example is the L&T Hyderabad Metro which has been provided a viability gap grant funding of INR 1,458 crores with loan component of INR 11,478 crores and equity of INR 3,349 crores brought in by L&T (Kumar, 2017). The project was undertaken in a PPP mode under the design, build, finance, operate and transfer (DBFOT) basis for a 35 year operation period. The metro project would further undertake transit-oriented development of 18.5 million sq ft in the earmarked Parking & Circulation areas and depots to generate further revenues through rentals and advertising (L&T IDPL). Such models

can be further explored to capture the additional benefits generated by large scale public transport development to reduce Government costs.

- **Interest Subvention**: Interest Subvention has been extensively used in the agriculture to reduce the cost of farm loans and enabling farmers to migrate to formal structures of lending. Since the EMI cost is a major cost component for the vehicle owners, and interest subvention for a long term vehicle loan would allow the users to prefer the electric variant given the lower EMIs and lower operating cost. The system may be undertaken as a fee-bate discussed above with equivalent annual fees on the polluting vehicles. The interest subvention may also be factored in leasing models of vehicles widely used by commercial transport systems.

- **Viability Gap Funding for Capital expenditure**: Viability gap Grants are being used under the FAME scheme by the Government of India to fund the Initial capex gap to promote the initial uptake of EVs (particularly buses and three-wheelers). This may be a very high cost method for the Government and may be difficult to sustain in the long run.

- **Guaranteed Lease finance**: Lease financing may be an effective tool for electric vehicles which have higher upfront cost and lower operational cost similar to the renewable energy. A similar model becomes optimal financing model for emerging mobility paradigms like Mobility as a Service as capital expenditure is not undertaken by the users/ operators. Leased models have been used internationally for segments like (Section 4.1.4 above) buses. As Indian market may be in nascent stage, there is a need to provide further comfort to the financial institutions lending to the sector. A guarantee instrument may be designed for provide risk coverage to the loan providers for EV fleet owners who lease their vehicles.

- **Long gestation debt finance**: Infrastructure sector uses long gestation debt financing as the construction periods are larger and revenue realization takes substantial time to start. Such loans would be effective in allowing charging stations to take ground as initial revenues may not be sufficient to serve interest payments.

4.2.5 Financing the Front Runners

The paper identifies three front runners which can pave the way for other vehicles to make the electric mobility transition namely two-wheelers, three wheelers and buses. Each of the segments has different requirements as illustrated below.

- **Three wheeler services**

Three wheelers, specially providing last mile connectivity services for passenger and freight transport would be front runners in terms of acceptability among the users. The three wheelers are also the lowest cost with maximum modularity in terms of performance. However financing would play a key role in overcoming the initial capital barrier in this sector. The operators own fleets of three wheelers which are leased out to individuals who run these vehicles to generate revenues. In some cases, operators also bear the maintenance cost along with the capital cost of the vehicles. The current three wheeler market of EVs also has very high penetration of low quality low cost variants which may create a problem in the long term. The following instruments may be used to increase penetration of EVs in the market

  - Viability Gap funding for high quality vehicles to weed out low quality vehicles which have safety concerns.

- Guaranteed lease finance may be used to bring the combined capital and operation cost equivalent to currently available ICE models. This would allow the individual drivers to opt for the electric vehicles and weed out ICE models.

- **Two wheelers**

Two wheelers account for the highest sales comprising more than 80% of all personal vehicle sales in India. This segment is also considered to nearly as economic as the ICE vehicles (NITI Aayog; Rocky Mountain Institute, 2017). However the high upfront cost of the vehicles would require financing solutions which may reduce the cost of financing the vehicle like Interest Subvention for reducing EMIs to target reducing the effective ownership cost of the user closer to the ICE counterparts. These may be coupled with the tax measures suggested in the policy section.

- **Buses**

As identified earlier, buses are low cost and effective public transport both for city commute and medium length inter-state travels. The intra-city travel migration to electric vehicles will not only provide cleaner and cheaper transport but also provide for the customer base for the initial electric charging infrastructure. As public transport represents a high cost low revenue structure the buses run by the transport corporations may use a blending of multiple mechanisms discussed above to make them viable. Some of the mechanisms which can be used include:

- Since public transport especially electrified transport can help to achieve multiple climate targets, it may be important to leverage International Climate funds like GCF and GEF in achieving public transport penetration in the country. The private climate investment may be channelized further through Green Bonds issued by the SPV. These funds can be brought into channelize commercial finance in terms of debt or equity to catalyse this market.

- o Structured PPPs may be used to bring in private capital to run transit model. The private sector uses other revenue sources like leasing and advertising to generate addition revenues beyond the ticketing revenues.

- o A feebate system may be used further to reduce the Government grant component through the road taxes charged to new polluting vehicles. Special congestion/parking charges may be levied in the high traffic areas to generate further revenues for the operating phase and nudge users towards using public transport.

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5 Conclusion

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Electric Vehicles and the new mobility paradigm are expected to transform the way India moves it goods and people across this large country. It is also expected to reduce carbon emissions and air pollution along with enhancing energy security. It also has the potential of propelling India in the lucrative automotive export market. The Government of India has taken a step forward by taking electric mobility in a mission mode. However, given the challenges in the transition, we have to take a methodical approach in transforming this ecosystem. Identifying the frontrunners is a critical first step towards designing the next steps in promoting electric mobility and gaining experience for moving forward. Focusing on the frontrunners would enable us to create the necessary ecosystem of charging and overcome perception barriers. They would also set the platform for quickly scaling up other segments. The transition to electric mobility would require changes in the business models for Indian industry as well as changes in the usage patterns for the customers. Innovations in finance would be a critical enabling factor in supporting this transition. Mechanisms like Fee-bates, Green bonds and Demand aggregation would be able to catapult the market to the next trajectory.

6 Annexures

6 Annexures

6.1 FAME India Scheme

The break-up details of the two-year allocation of funds under various components in the FAME-India scheme

Components of the scheme	2015-16	2016-17
Technology Platform (Including testing infrastructure)	70 cr.	120 cr.
Demand Incentives	155 cr.	340 cr.
Charging Infrastructure	10 cr.	20 cr.
Pilot Projects	20 cr.	50 cr.
IEC/Operations	5 cr.	5 cr.
Total (Rs.)	260 cr.	535 cr.
Grand Total (Rs.)	795 cr.	

Incentives under the Fame-India scheme for various vehicle segments

Vehicle Segment	Minimum incentive (INR)	Maximum incentive (INR)
2 wheelers (scooter)	1800	22,000
Motorcycles	3500	29,000
3 wheelers (Auto-rickshaws)	3300	61,000
4 wheelers (cars)	11,000	1,38,000
Low commercial Vehicles	17,000	1,87,000
Bus	30,00,000	66,00,000
Grand Total (Rs.)	795 cr.	
Retro Fitment Category	15 % or 30,000 if reduction in fuel consumption is 10-30%	30 % of Kit price or 90,000 if reduction in fuel consumption is more than 30 %

Source: Press Information Bureau, Government of India, 2015

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Notes

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