AVALON Consulting

ELECTRIC VEHICLES IN INDIA

Prospects and Challenges

IMC
Chamber of Commerce and Industry

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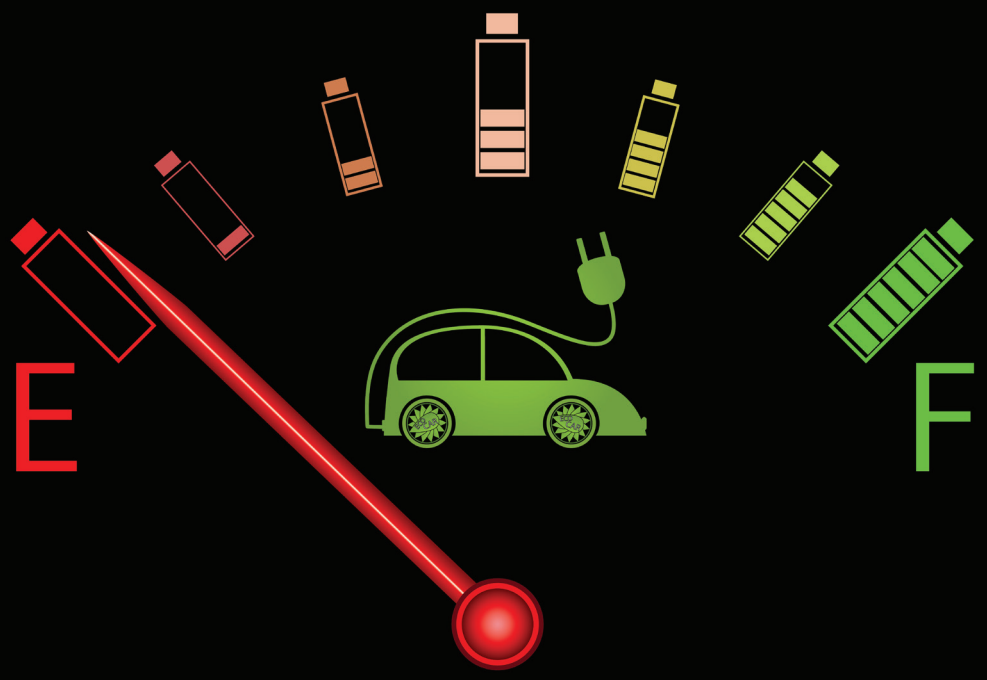


We are fortunate that in our lifetimes we are witnessing a second revolution after the IT and internet revolution – the energy revolution.

Awareness about the impact of fossil fuels on the environment led the world to start its move towards cleaner, renewable forms of energy some time back. Yet automotive remained a firm bastion of petroleum – the internal combustion energy engine triggered the automotive revolution in the world and proved remarkably resilient and adaptive to the needs of generations of humans.

However, with the advent of electric vehicles coupled with developments in lithium battery technology, charging infrastructure and other elements of the electric vehicle ecosystem, the era of ICE engines seems to be drawing to a close. With ambitious targets, India, like many other countries of the world is keen to embrace electric vehicles.

Ministers have talked about going 100% electric by 2030. New policies like the Transformative Mobility Solutions have been introduced. Yet, in India, traditionally there has been a big gap between policy and action.

This paper takes a critical look at the policies, identifies the pressure points, projects where we can reach in case the implementation challenges are resolved, and looks at the impact on our import bill replacing fossil fuel vehicles with electric vehicles will have.

Raj Nair
Vice President - IMC Chamber of Commerce and Industry
& Chairman – Avalon Consulting

I EXECUTIVE SUMMARY

Driven by powerful environmental, macro-economic and technological factors, the global transportation sector is undergoing a historical period of transition. New business models like Mobility as a Service and the increasing economic viability of technologies like Electric Vehicles (EVs) will soon reshape how we travel.

> "India's EV strategy revolves around demand aggregation and battery swapping. If both of these are successfully implemented, we expect India reaching EV sales of more than 1.6 million vehicles in FY23."

According to research by the International Energy Agency (IEA), the global EV parc has increased from just five thousand vehicles in 2008 to more than two million by 2016. This has been driven by key underlying trends including mounting environmental concerns, decreasing Lithium-ion battery prices and increasing availability of charging infrastructure. **All this has led experts to predict a rapid growth in EV adoption in the next decade – current year on year growth projections range from 27% to 33% until 2030.**

By many metrics, China is leading the world's EV revolution. China's share of the global EV parc grew to 32% in 2016, overtaking the US for the first time. Its share was only 11% in 2011. Private investment is pouring into China from major auto manufacturers like Daimler, BYD, Honda, Toyota and Ford, all of whom are actively exploring how to capitalize on China's expanding market. **Several lessons can be drawn from the China story, including its recent transition away from subsidies towards a dual-credit scheme that is expected to be launched in 2019.**

In contrast, the India EV story has been underwhelming so far. Absence of charging infrastructure, inconsistent government support and early product failures have all resulted in stagnant growth in recent years. However, 2017 may have marked a turning point in India's EV journey - a clear and ambitious goal of 100% EV adoption by 2030 has been laid out by the government, and the country's leading government think tank, NITI Aayog, has set the contours for a comprehensive, long-term mobility strategy. This has already led to concrete steps being taken to help spur EV growth. Energy Efficiency Services Limited (EESL) launched a tender for 10,000 4-wheeler EVs in 2017, the world's largest single EV procurement to date. In the 3-wheeler and bus segments, the government is looking to introduce battery swapping to decouple battery costs from vehicle costs and ease the re-charging process. Standards for the first generation of public EV chargers have been set, and a second generation is in the pipeline.

> "Despite the promising growth trajectory for EVs in India, the government's targets for 2030 are ambitious and are likely to be missed."

The strategy for EV growth in India revolves around two core assumptions – that demand aggregation from the likes of EESL can help

quickly grow scale, and that the battery swapping model can help reduce upfront EV costs and improve the charging experience.

While both assumptions are tenable, they each have their own complexities and potential hurdles. EESL has shown, with its Ujala Program for LED bulbs, that it can be an effective demand aggregator and market maker. However, replicating this success for EVs would involve overcoming a host of challenges. These include the significantly higher upfront costs of EVs as compared to LED bulbs, the dependency on charging infrastructure for increased adoption, complex distribution structures for vehicles like e-Rickshaws, to name a few. A subscription-based battery swapping model is likely to be adopted in some form for 3-wheelers and buses, though it faces a more tenuous future with 4-wheelers and 2-wheelers, where manufacturers are unlikely to accept common battery specifications.

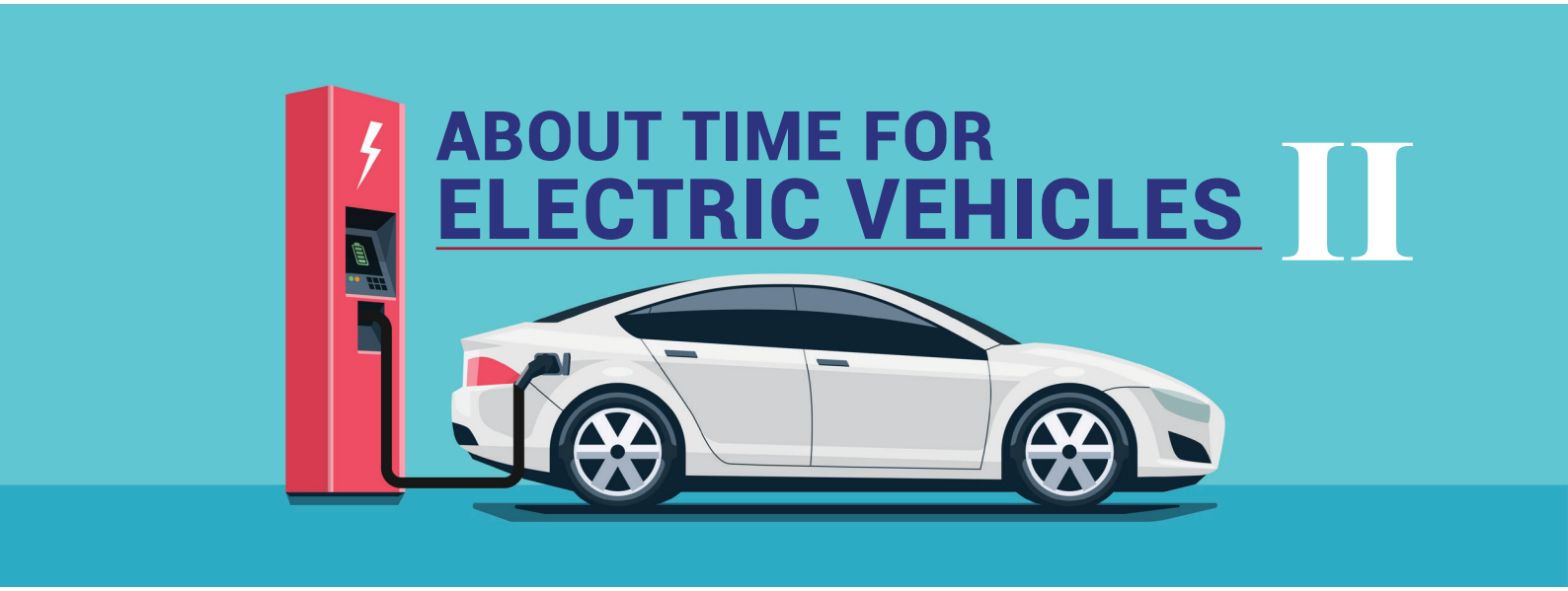
> "Even if India does meet its 2030 ambitions, it would not necessarily result in a significant reduction in our import dependency."

If both demand aggregation and battery swapping are successfully implemented, we project India reaching EV sales of more than 1.6 million vehicles in FY23. This is an overall Compound Annual Growth Rate (CAGR) of 35% from FY17. Government procurement and public transport will be the major drivers of this growth, through procurement of vehicles for Government use and 3-wheelers and buses for public transportation. Growth in the 4-wheeler space is also likely to be driven by investments by private fleet operators like Ola and Uber, where higher daily running makes EVs more economically viable. The 2-wheeler space will be largely private ownership and subsidy driven, and will be characterized by a migration from Lead Acid to Lithium-ion batteries and from low speed to high speed vehicles.

Despite this promising growth, **we expect that the government's targets for 2030 are ambitious and are likely to be missed due to the industry and consumers not being ready to adopt rapidly, given the relative economics.** Our growth projections suggest that EVs will account for less than 2% of total vehicle sales by 2023. From that position, reaching the government's goal of 100% penetration by 2030 seems far from achievable.

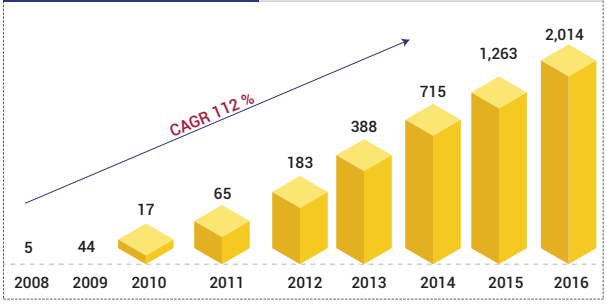
Even if India does reach its 2030 ambitions, **it would not necessarily result in a significant reduction in our import dependency.** While cumulative oil imports for the automotive industry from 2017-30 in a "Business as Usual" scenario are expected to amount to INR 40 Lakh Cr, India would still have an import bill of INR 15 Lakh Cr for Lithium-ion cells and INR 17 Lakh Cr for oil in case it completes its transition to EVs. This results in a savings of INR 8 Lakh Cr.

While India has a long way to go to achieve its EV ambitions, it is clear that EVs do present a short term high growth opportunity in key segments and will, no doubt, be an inevitable disruption in the long-run; one that requires a cohesive strategy at both - the government and corporate level.



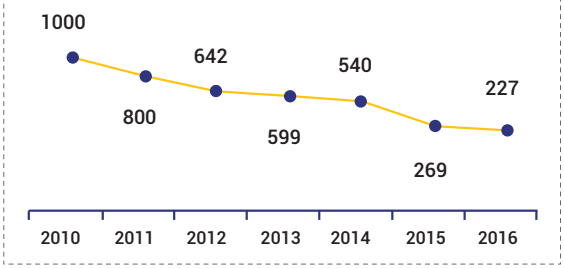
While the earliest adopters of EVs were only five thousand globally in the year 2008, the number of EVs on road has grown to two million, in just eight years. Clearly, there must be significant drivers of a growth this steep. Environmental concerns around greenhouse gas (GHG) emissions have contributed to societal acceptance of EVs. Worsening quality of air and noise pollution across cities have led to attention on the need for environmentally friendly solutions. This has further led countries around the world to consider phasing out Internal Combustion Engine (ICE) cars in the next decade, making way for EVs. Subsidies for EVs have also enabled this growth.

Global Electric Car PARC* (Unit'000)

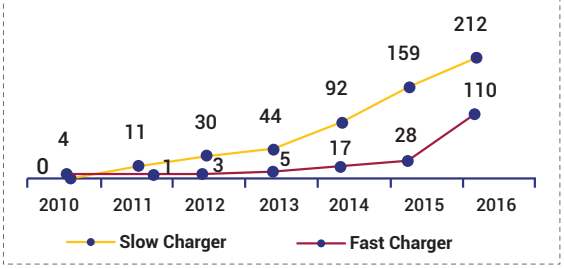


** Includes Battery and Plug-in Hybrid Electric Vehicles*
Source: IEA EV Outlook Report 2017, Avalon Consulting Research and Analysis

Average Battery Pack Price (USD/kWh)



Publicly Accessible Charger Stock (Unit'000)



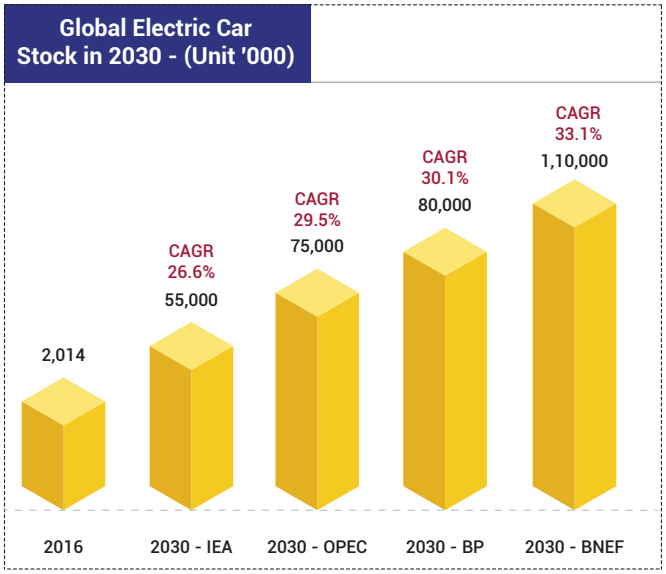
Source : IEA EV Outlook Report 2017. Avalon Consulting Research and Analysis

An important trend has a direct and causal relationship with the growth of EVs. That trend is the consistent decline in the average battery pack price and a steady increase in publicly accessible slow charger and fast charger stock.

At the current rate of decline, it is expected that by 2018, the cost and range of EVs will rival

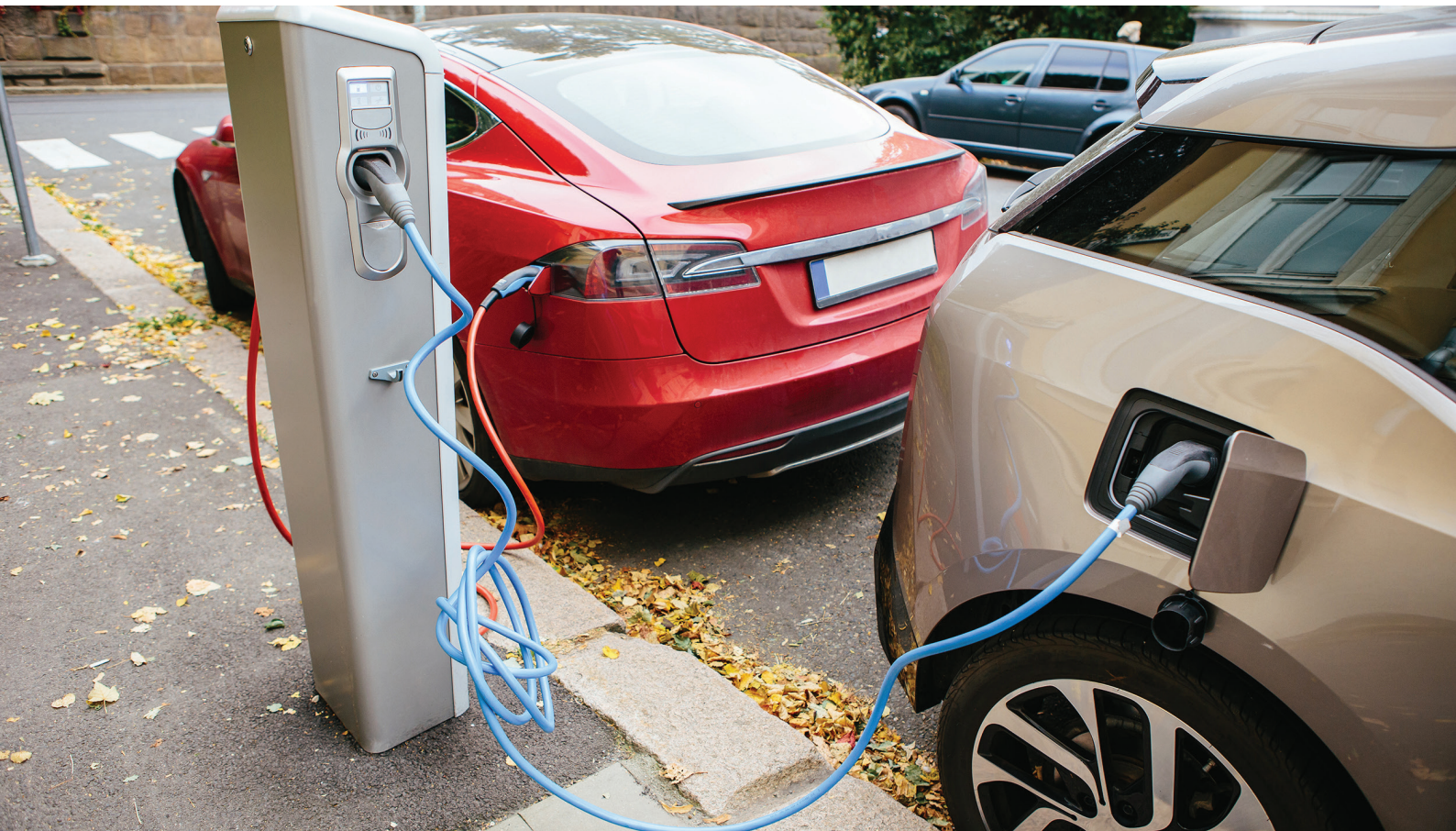
combustion engine vehicles in the sedan segment in the US, without subsidy. This could be the inflection point for EVs to potentially replace ICE vehicles in the next ten to fifteen years.

Another related driver of growth for EVs has been the improvement in charging facilities. In many countries, policy initiatives support the development of charging infrastructure. For example, local administrators in France are involved in EV infrastructure projects. The German government supports Research and Development (R&D) activities for inductive and quick charging technologies. The Netherlands has introduced tax incentives to support the creation of charging infrastructure.



Source: IEA, OPEC, BP, BNEF, Avalon Consulting Research and Analysis

Overall, several aspects have contributed to the growth of EVs. This growth is expected to be exponential as per predictions by organizations such as the International Energy Agency (IEA), Organization of the Petroleum Exporting Countries (OPEC), British Petroleum (BP) and Bloomberg New Energy Finance (BNEP). While each of them differ in their projection of the EV adoption, there is a unanimous agreement that there will be a steep growth. The country that is leading the EV disruption, is China.

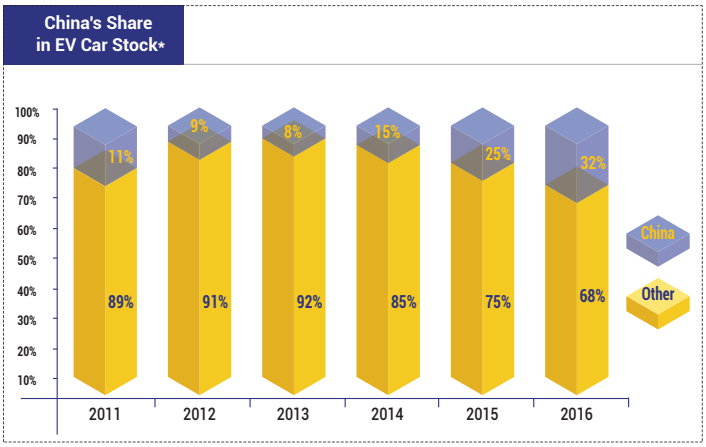


III LEARNING FROM THE CHINA STORY

In the last few years, China has established its dominance in EV car stock, with its share being one-third of the global stock in 2016. A plethora of research and new investments are making their way to the Chinese market. These include Daimler's JV with BYD and investments by SAIC, Honda, Toyota, Ford with Anhui Zotye, etc. China has been clear in its intention to lead the EV market. As per the industrial policy, Made in China 2025, it wants to either globally dominate or be a major competitor in 10 high-tech industries. New Energy Vehicles (NEV) and cars that are either partially or fully electric, are a part of that goal. To this end, China has been providing significant support to the industry through subsidies and policy decisions.

Some of the significant ones among them are:

- **Reduced taxes:** NEVs were exempted from the standard consumption tax that consumers pay on new automobiles, in as early as 2008.
- **Manufacturing subsidies:** Billions of dollars have been given in direct subsidies to NEV manufacturers. The quantum of subsidy was such that it contributed to sales quadrupling in 2015. For example, Shenzhen-based manufacturer BYD received USD 435 million in subsidies between 2010 and 2015, making it the state-sponsored champion of electric and hybrid vehicles in China. The central government allocated over USD 15 billion to support the development of energy-efficient vehicles and electric vehicle infrastructure. The generous subsidies and buoyant sales led to 200 companies announcing their intention to make and sell NEVs in China.
- **Customer subsidies:** The Chinese government began a consumer subsidy program



* Note: Includes Battery and Plug-in Hybrid Electric Vehicles
Source: IEA Global EV Outlook 2017, Avalon Consulting Research and Analysis

in 2010 providing approximately USD 8,700 per car. Local governments also created their own subsidy programs that provided additional discounts for NEV purchases through cash subsidies, free parking, or free license plates. Both local and central subsidies together accounted for about 20 to 40 percent of the cost of the vehicle.

- **Government procurement contracts:** In 2014, government mandated that NEVs should constitute 30 percent of all government procurement contracts. In 2016, the figure was revised to 50 percent.

One significant area that will require a ramp-up to meet China's goal of being a world leader in EVs, is charging station infrastructure.

Charging station ownership in China increased from 76 in 2010 to 5,600 in 2016 at a CAGR of 104 percent. The number of public charging piles grew from 1,122 to 150,000 at a CAGR of 126 percent during the same period. In addition to public charging piles, private charging pile ownership reached about 170,000 units in 2016, thus bringing the country's total number of charging piles to nearly 310,000 (the largest of any country in the world). However, given China's aggressive goals on charging station infrastructure, there is still a wide gap to be bridged. **China aims to build 12,000 centralized charging or battery swap stations and 4.8 million scattered charging piles across the country by 2020** to meet a charging demand of 5 million EVs, with the goal of achieving a ratio of one vehicle to one charging pile. As per the State Grid Corporation of China (SGCC), **the aim is to reduce the maximum distance between charging stations to less than 5 kilometers in suburban areas, 3 kilometers in inner suburbs, and 1 kilometer in urban areas.** To this end, China needs to invest approximately USD 19 billion.

Key EV Initiatives by China

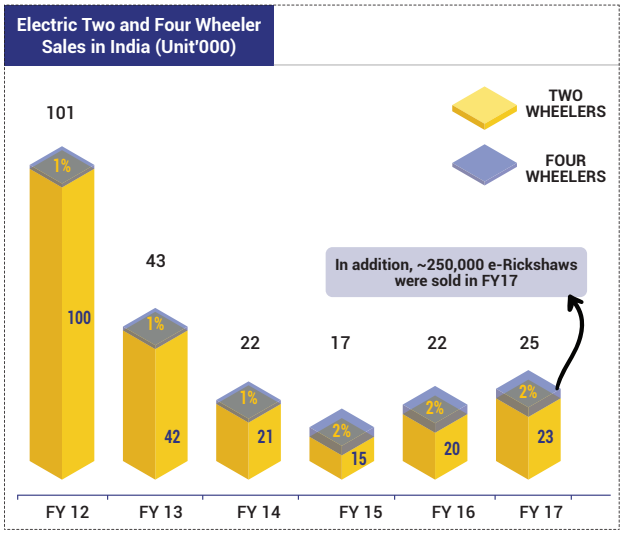
- **Exemption of NEVs from standard consumption tax**
- **Manufacturing subsidies**
- **Customer subsidies accounting for 20-40% of EV price (to be phased out by 2021)**
- **50% of government vehicle procurement to be EVs**

Another development to observe are the forthcoming changes in China's policy around subsidies. While the subsidies facilitated exponential growth in EVs, they also had unintended consequences of distorting the market and prompting carmakers to falsify sales numbers to obtain subsidies. China has begun phasing out direct subsidies and intends to remove them completely by 2021. As per a government announcement, the drop in direct subsidies will be replaced by a dual-credit scheme to be launched in 2019. The new scheme will require individual carmakers to produce a minimum number of EVs. Those failing to meet the minimum production targets will have to buy credits from competitors with surplus credits. Vehicles that meet their range targets will also earn credits. China is also planning to ban the sale of petrol and diesel cars, in line with some of the European nations like UK and France. However, it has not yet decided on a schedule.The China story serves as a good learning to countries like India which have been slow on the road to EVs so far.

IV
INDIA'S STRATEGY AND POLICY FRAMEWORK

The India story so far, is in contrast to that of China.

Sales of EVs dropped consistently between 2012 and 2015, before showing signs of a recovery. The Indian EV market has been dominated by 2-wheelers, accounting for more than 90 percent of the 2 lakh EVs in India today. Although the majority of electric 4-wheelers on the road now use Lithium-ion batteries, most electric 2-wheelers and almost all electric 3-wheelers still use Lead Acid batteries (in contrast to other countries).



* Source: Society of Manufacturers of Electric Vehicles, Avalon Consulting Research and Analysis

A variety of reasons, from infrastructure, policies to early product failures have contributed to this trend.

Significant among them are:

- Charging facilities are practically non-existent, though a small start has happened in 2017 with installations of charging stations through recent efforts by entities like Tata Power and NTPC.
- Government support has been erratic so far, with subsidies being rolled back and delays in the EV policy implementation
- Local manufacturers of components are few and there is a high dependency on Chinese imports.

> "The Indian EV market has been stagnant in recent years, due to a lack of charging infrastructure, inconsistent government policy and early product failures."

Overview of NITI Aayog Transformative Mobility Solution Framework

Source: NITI Aayog TMS – 2017

- Early products in both 2-wheeler and 4-wheelers have suffered setbacks. For example, the early entrants in electric 2-wheeler space in India were low powered Chinese electric mopeds that performed poorly in terms of power and durability. India's first entrant in the 4-wheeler EV space, Mahindra Reva, failed due to lack of charging infrastructure and high upfront costs.

However, 2017 has seen a small but definite change in a positive direction for India's EV aspirations. The country is embarking on an EV transformation journey, guided in part by the Transformative Mobility Solution (TMS) framework, developed by NITI Aayog.

Key opportunity areas highlighted in the TMS framework specifically relevant to EVs are:

- Encourage offering mobility as a service as demonstrated by app-based taxi services like Uber and Ola
- Build shared infrastructure for more efficient utilization by mobility service providers
- Create interoperable data services across service providers to create a more comprehensive consumer database that can be leveraged for improving services
- Build smart grids that enable bi-directional charging, allowing vehicles to charge themselves using the grid; and the grid to charge itself utilizing the vehicles that are not in use
- Encourage manufacturing of EV and its key components in India
- Enable widespread deployment of EVs in India

A core part of the strategy will address the early adopters of EVs in India, i.e. public transport vehicles and private fleet operators like Ola and Uber.
Public transport vehicles will include buses and e-rickshaws. Key players in buses are likely to be Ashok Leyland, Tata Motors and BYD. The e-rickshaw segment will consist of players like Bajaj, Lohia Auto and Ampere Vehicles.

> **"TMS offers a unique method to propagate EVs with the objective of reducing cost, increasing affordability and improving adoption, without any direct subsidy."**

Private fleet operators, with their need for low fuel cost per kilometer, will be next in line to adopt EVs. For example, the current Minister for Road Transport and Highways of India, Nitin Gadkari, has proposed to increase the Nagpur EV fleet run by Ola from 200 vehicles to 1000 in a year's time. Lithium Urban Technologies runs a fleet of more than 225 EVs in Bangalore and Delhi. Ola has launched a pilot project in Nagpur with 200 EVs including 4-wheelers, 3-wheelers and buses. Uber has tied up with Mahindra to operate eVerito and e20 Plus EVs in Delhi and Hyderabad by early 2018.

The Indian EV growth story will require significant encouragement from the government. Thus, the strategy and policy framework surrounding the EV ecosystem is mission critical. TMS offers a unique method to propagate EVs with the objective of reducing cost, increasing affordability and improving adoption, without any direct subsidy.

Not using the subsidy route may help India avoid the pitfalls China faced as a result of subsidies in its journey.

> **"The government is undertaking several key initiatives to boost EV growth in India, including launching a tender for 10,000 vehicles, working with 3-wheeler and bus OEMs to facilitate battery swapping and setting charger standards."**

In line with the solutions prescribed by TMS, the government is already working on concrete initiatives to encourage EV adoption in the country. Key among them are:

- Driving volumes using public procurement
- Enabling battery swapping
- Decoupling vehicle business (without battery) and energy business (with battery)
- Focusing on higher efficiency, i.e. decreasing Wh/km
- Boosting manufacturing of motors and drives, chargers, batteries, cells and battery chemicals in India

National Electric Mobility Mission Plan 2020 Projectons		
Vehicle Segment	2-Wheelers (Unit Millions)	4-Wheelers Range (Unit Millions)
India xEV Projections 2020	4.8	1.6 - 1.7
Total Vehicles Sales in India 2020 (ICE+xEV)	32	9
Penetration of xEV in Inda	15%	18% - 19%

Source: NEMMP, Avalon Consulting Research and Analysis

Key initiatives being taken by the government specific to each category of EV development are as follows:

3-Wheelers:

The government is driving public procurement through EESL. In a bid to ensure efficiency, a consensus is being facilitated across Original Equipment Manufacturers (OEMs) on efficiency and modular locked battery specifications. The latter is critical to ensure that swappable batteries are interoperable and cannot be tampered with. The government has been engaging with more than 50 manufacturers to enable common modular locked battery specifications. The goal is to use swapping with 50-kilometer range locked batteries and efficiency of 35 to 45 Wh/km. The government may issue a tender for 25,000 vehicles this year in this segment.

4-Wheelers:

In this segment, the focus is on taxi fleets, whose higher mileage makes the shift to EVs more economically viable than private owners. The government initiatives have been around enabling a combination of fixed and swappable battery in the future. A 10,000 vehicle tender for EVs has been issued, which was won by Tata and Mahindra in October 2017. EESL recently announced a plan to float an additional tender for 10,000 EVs in March to April 2018.

Buses:

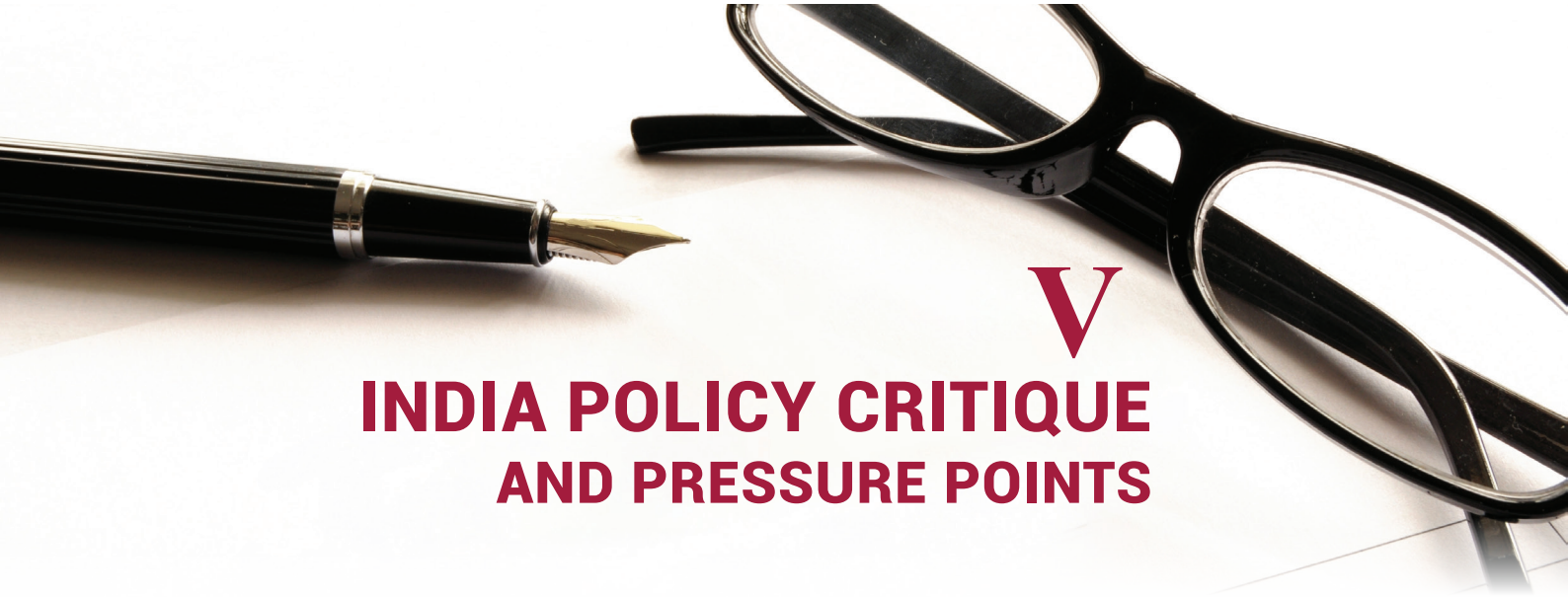
The government is enabling swapping with 50 km range locked batteries for buses. A key challenge with battery swapping for buses will be the effort required to load batteries. Hence, there are plans to use robotics at terminal points. In this segment too, the government is driving consensus on specifications of efficiency and locked batteries. It has engaged 30 manufacturers to enable common modular locked battery specifications. An efficiency of 900 Wh/km is being targeted. A tender for 2,000 buses may be issued in 2018.

Public Chargers:

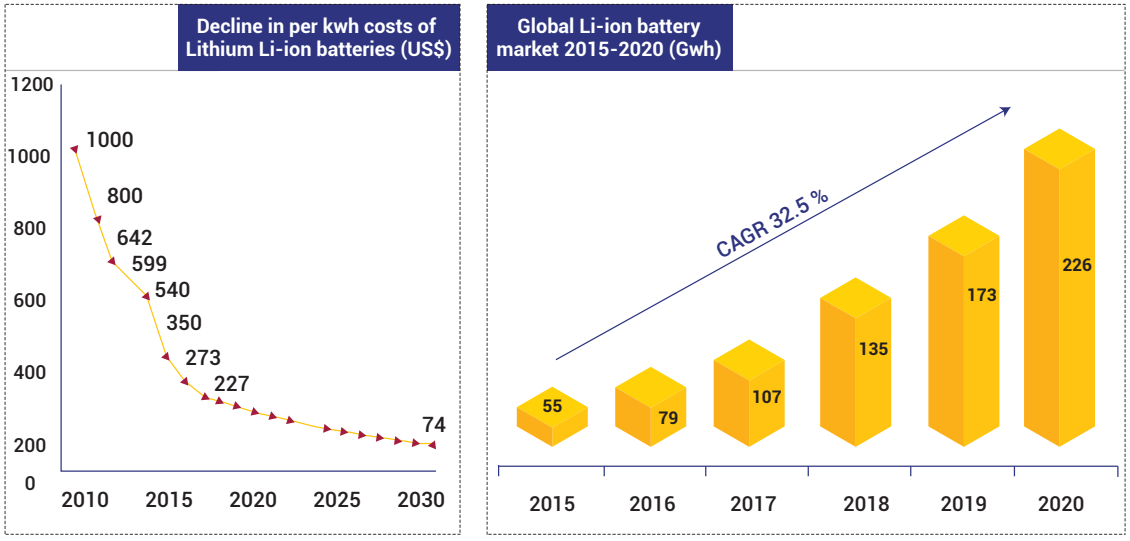
Applying the Public Call Office (PCO)/ Standard Trunk Dialing (STD) model to battery swapping would enable private involvement in the procurement of batteries and the operation of public battery swapping stations. This model will be key to achieving the scale and penetration required in charging infrastructure. The government has set the standards for Bharat Chargers AC-001 and DC-001 to be used for 2-wheelers and small to medium 4-wheelers. Standards for fast chargers for larger vehicles (AC-002, DC-002) are yet to be set. A tender for 4,000 chargers as per AC-001/DC-001 standards was issued in August 2017. An additional tender for 250 chargers was issued in November 2017.

These initiatives are to support the ambitious targets set by the Indian government for EV adoption across the country. Statements issued by key ministers have also expressed the ambition of doing away with petrol and diesel cars entirely by 2030.
While the government seems to be giving great impetus there is scepticism on whether these are achievable goals. The International Energy Agency (IEA) has praised the ambitiousness of India's 2030 targets, but has pointed out that they would require nearly eight times the current global stock of EVs. A recent Society of Indian Automobile Manufacturers (SIAM) white paper projected a 100% transition to EVs only by 2047, with 40 percent of new vehicles sold being EVs by 2030.

A key to bridging the gap between projections and successful implementation will be to identify the pressure points in the current framework and proactively address them.
As with China, the trend in reducing prices of Lithium-ion batteries will drive the Indian EV market.



V
INDIA POLICY CRITIQUE AND PRESSURE POINTS



Source : Bloomberg New Energy Finance, Technavio. Avalon Consulting Research and Avalysis

Having said that, India needs to gear up significantly to meet the challenge of making EVs an affordable and convenient option for the Indian user.

The Indian policy framework seems to rest on the assumption that affordability can be improved through demand aggregation and battery swapping. Demand aggregation pertains to leveraging economies of scale by having a single entity like EESL anchor activities like bulk procurement. Battery swapping involves making charged batteries readily available at distribution centres for vehicles to use, which will decrease upfront costs of EVs and significantly reduce the time taken to charge.

There are several critical aspects to consider in both these strategies, which appear to be at the core of the government's approach.

1. Demand aggregation

EESL has a pivotal role to play in demand aggregation. It has demonstrated the ability to be a market creator in the past, as evident in the Unnat Jyoti by Affordable LEDs and Appliances for All (UJALA) program.

Snapshot – The UJALA Program

The UJALA program was launched in 2015 with the goal of reducing India's high cost of electrification and increasing emissions by distributing 770 Million Light Emitting Diode (LED) bulbs by March 2019 cross 100 cities. EESL, through procurement at massive scale, has been able to directly distribute LED bulbs at a third of market prices across India, without the need for subsidies. The outcome of the program so far has been:

- More than 280 Million LED bulbs distributed so far
- 37,000 GWh in energy savings per year
- INR 14,800 Crore cost savings in energy per year
- 30 Million Tonnes of CO_2 reduction per year
- Stimulation of domestic LED bulb industry:
  - India is now the second largest LED bulb market globally
  - Penetration of LED bulbs has increased from 0.1 percent of domestic household lighting in 2014 to 25 percent in 2016
  - Bulk procurement by EESL has helped reduce retail prices from INR 800/bulb in 2012 to INR 200/bulb in 2016
  - Creation of 60,000 jobs

However, the success of EESL's UJALA program may not necessarily translate into similar success in the EV segment. This is because there are key differences that exist between LED bulbs and EVs from a procurement and distribution standpoint.

- Upfront costs of EVs are significantly higher than LED bulbs
- EV adoption is closely linked with complementary charging infrastructure, unlike LED bulbs
- Distribution structures between LED bulbs and EVs vary significantly

Therefore, EESL will need to address a few critical questions to be as successful with EVs as it was with LEDs. These include:

- ***Will EESL have the budget for the volumes required to reduce prices sufficiently?***
- ***Will state governments and State Transport Undertakings (STUs) fulfill the role they have to play, especially in buses?***
- ***Can EESL enable the supporting infrastructure creation for adoption of 3-wheelers and buses?***
- ***Given the high capital value and unproven technology of EVs, what liability will EESL bear in the case of product failure?***

Given the pivotal role of EESL in the current strategy, pre-empting and addressing these gaps will be necessary to meet the government's goals for EVs in India.

> **EESL will need to address several challenges in order to successfully implement a demand aggregation strategy for EVs – these include budgetary constraints, the need for adequate supporting infrastructure and issues relating to liability in the case of product failure.**

On the demand side, fleet operators such as Ola and Uber are expected to be the early adopters along with Government procurement. Private vehicles are expected to be laggards in 4-wheeler EV adoption. Demand across 3 market segments is as follows:

Government Procurement: The government is pushing the adoption of EVs through large tenders for private EV manufacturers. It has floated a tender for procurement of 10,000 EVs through EESL. This tender was won jointly by Tata Motors and Mahindra. A second tender is expected to be floated during the first half of 2018. Similarly, tenders for procurement of buses are expected in 2018.

Fleet Vehicles: Fleet owners such as Ola and Uber have confirmed plans of procuring EVs as part of their fleet. A case in point is Ola, which is running 200 cars in Nagpur as part of a pilot program and has plans on expanding their EV fleet in the future. Mahindra has also expressed plans of starting its own cab aggregator business competing with Ola and Uber, betting on the rise of EVs for use in ride sharing.

Private Vehicles: Penetration of Lithium Ion vehicles in the private owners' segment would be slow as it faces many obstacles. The initial cost of vehicle and battery remains high. Since the mileage of privately used vehicles is much lower than a taxi, in comparison, the opportunity to recover the cost through saving in fuel expenses is not as high. Also, lack of charging stations and anxiety of running out of charge lead to low incentive for private owners to switch to EVs immediately.

> **Battery swapping is expected to decrease upfront costs and accelerate adoption in certain categories of EVs. The model is likely to be adopted for 3-wheelers and buses.**

2. Battery Swapping

Battery swapping is expected to decrease upfront costs and accelerate adoption in certain categories of EVs. The model is likely to be adopted for 3-wheelers and buses. This is partly due to the inherent challenges in establishing swapping for 2-wheeler and 4-wheelers, where manufacturers are unlikely to agree on common battery specifications, as battery technology is a key differentiator. Adoption by e-rickshaws also stems from the fact that their routes are more standardized, making it easier to identify locations where swapping stations would see

sufficient demand. Buses similarly ply on fixed routes. For buses, existing bus depots can be used as battery swapping stations. Also, the high upfront cost of electric buses makes the battery swapping model ideal, provided operators can overcome certain technological challenges. Business models for swapping station operators for 3-wheelers and buses would vary basis how the vehicles are operated. However, both will involve investment in a large number of batteries and a subscription based revenue model.

2.1 Business Model for Battery Swapping for Electric 3-Wheelers

Batteries for 3-wheelers will be manufactured based on government standards for mass usage. An electric auto 3-wheeler's cost, without battery, is expected to be comparable to the cost of a regular internal combustion engine 3-wheeler. In this model, the cost of the battery and swapping station will be borne by the battery swapping service provider. An auto driver would buy a subscription of Lithium-ion battery swapping from one of the swapping operators in the market. The subscription will include a swappable battery. The subscription cost will include a nominal security deposit and the subscription will allow the driver to swap the battery at any of the operators' swapping stations for a fee. The operator will monitor the usage and life of all its batteries in circulation and remove any batteries which have exhausted their life. The batteries will have a locking mechanism such that they can only be charged by the operator's authorized swapping stations and can only be loaded in a subscribed 3-wheeler.

2.2 Business Model for Battery Swapping for Electric Buses

In this model, batteries will be manufactured based on government standards for mass usage in buses. Battery swapping will be done in already established bus depots across the city. The swapping of batteries will be assisted through robotic installations in the depots, due to the high weight of the batteries. This model would be much simpler as compared to the electric 3-wheeler model since the bus routes and depots are fixed.

One issue that many industry players have flagged as critical to ensure the success of battery swapping is the viability of the model in the face of declining Lithium-ion battery prices year on year. Potentially, new batteries in Year 3 will be >15% cheaper than in Year 1. Our analysis suggests that this has no impact on battery swapping operators in any plausible scenario.

Avalon's model considers a battery swapping operator with an initial subscriber base of ~1,000 individuals and deduces its Internal Rate of Return (IRR) from 7 years of operations, assuming the operator chooses to utilize batteries until the end of their useful life, rather than discarding them mid-way for a salvage value and replacing them with new batteries.

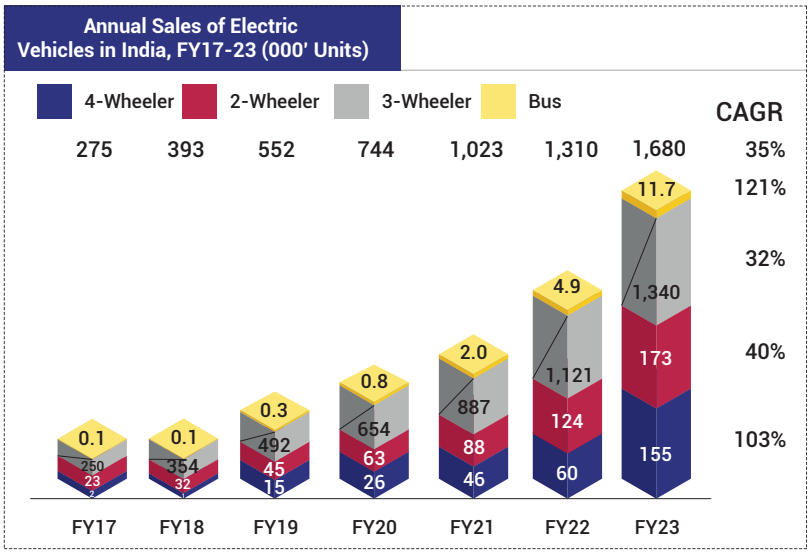
	Year 1	Year 3	Year 5	Year 7
Number of subscribers	1,100	2,200	3,300	3,300
Batteries bought	1,600	800	800	800
Price of battery (INR/kWh)	14,700	12,400	10,400	8,800
Capex (INR Lakhs)	1,200	500	420	360
Cash flow (INR Lakhs)	(810)	200	470	380
IRR (5 Years)	**7%**			
IRR (7 Years)	**17%**			

Key assumptions made in this analysis include:

- 3-wheelers are on-road for an average of 10 hours a day and travel 180 kilometers a day
- 1 battery per 3-wheeler at a module size of 5 kWh
- Average power requirement of 50 Wh/km and 3 hours charging time per battery
- Price per kilometer charged by operator reducing by 2% year on year due to reduction in battery prices
- Average cycle life of a battery for an electric 3-wheeler of 2,500 cycles
- Operating expenses include electricity cost, personnel cost and rent and utility cost

The model shows that a swapping station operator operating under these conditions is economically viable and generates sufficient revenue, even with declining prices, to achieve an IRR of 17% over 7 years of operations.

VI CONCLUSION: FUTURE OF ELECTRIC VEHICLES ADOPTION IN INDIA



Source : Avalon Consulting Research and Analysis

Our analysis leads us to 3 major conclusions about the future of EV adoption in India.

1. If both swapping and demand aggregation work as per plan, **India may reach an EV sales volume of more than 1.6 Million vehicles in FY23,** mainly driven by government procurement and 3-wheelers.

Government procurement is expected to be a major driver for growth in the coming few years, through procurement of 4-wheelers for government offices and 3-wheelers and buses for public transportation. Investment by fleet operators like Ola and Uber, as well as some food delivery operators, is also likely to drive initial growth in electric 4-wheelers and 2-wheelers. However, adoption of lower mileage, privately owned 4-wheelers and 2-wheelers could also reach an inflection point in 5-6 years, on the back of decreasing battery costs and increasing charging infrastructure availability. The customer mix and drivers for each category is expected to be as follows:

- **4-Wheelers:** This will be largely driven by government procurement and fleet operators in the early stage. Government procurement is expected to be 30,000 vehicles till 2023, by which time there could be an inflection point for adoption amongst low mileage private owners. Mahindra and Tata will continue to grow their presence to cater to government contracts and growing private demand. Entry is also likely by MNCs like Nissan, Hyundai and Honda in the coming years.

- **2-Wheelers:** The segment will be private ownership and subsidy driven, and will be characterized by a migration from Lead Acid to Lithium-ion batteries and from low speed to high speed vehicles. For example, all major OEMs like Hero, Ampere, TVS, Lohia have high-powered electric 2-wheelers in the pipeline. Numerous start-ups focusing on better performing vehicles are also emerging and will begin sales in 2018, such as Ather, Tork and Emflux. However, most of these manufacturers will continue to import electronic components.

- **3-Wheelers:** E-rickshaws are likely to be the fastest growing segment – OEMs like Mahindra, Kinetic Green and Autolite have already launched models or will be launching models in 2018, which will increase enforcement of standards and registration, creating a powerful market driver. E-Auto sales are also expected to grow through the entry of OEMs like Bajaj and TVS, though they will still account for a relatively smaller share of the overall electric 3-wheeler category. Demand aggregation through public procurement and battery swapping is expected to play an important role in early adoption.

- **Buses:** Major OEMs like Ashok Leyland, Tata and BYD, will continue to pilot and test in the coming years. Battery swapping will reduce upfront cost and spur greater procurement from EESL and STUs. However, ramp-up is likely to be slower than 3-wheelers.

In the long-run, innate economic and social attractiveness will make an EV boom in India inevitable. The continued fall in Lithium-ion batteries will drastically lower upfront costs. Improvement in battery technology will lead to affordable and higher range EVs. Private investment in infrastructure will likely be a function of demand driven by the above. To remain cost-competitive and enable faster scale up, EV OEMs will increase domestic sourcing.

2. **The target set by the government is ambitious and expected to be missed** due to the industry and the consumer not being ready to adopt rapidly, given the relative economics of EV vs. ICE becoming favourable only beyond FY23.

   Although we project a 6-fold growth in EVs from FY17, this will still not be enough to meet the government's target of 100% EV sales by 2030.

   Our projections suggest that EV penetration will reach a level of 1.82% by FY23, partly due to a low penetration of 0.60% in the 2-wheeler segment. Even if EVs grew at a CAGR of 50% from FY23 to FY30, they would still only reach a penetration of ~ 20% by FY30.

Category	FY17	FY20	FY23
4-Wheelers			
Total Sales	~ 3 Mn	~3.8 Mn	~ 4.8 Mn
EV Sales	2,200	26,000	155,000
EV Penetration %	0.07%	0.67%	3.30%
2-Wheelers			
Total Sales	~ 17.6 Mn	~ 23.0 Mn	~ 28.7 Mn
EV Sales	23,000	63,000	173,000
EV Penetration %	0.13%	0.27%	0.60%
e-Autos*			
Total Sales	512,000	548,000	586,000
EV Sales	0	40,000	280,000
EV Penetration %	0.00%	7.30%	47.74%
Buses			
Total Sales	47,000	58,000	71,000
EV Sales	100	800	12,000
EV Penetration %	0.21%	1.43%	16.54%
Total			
Total Sales	~ 21.2 Mn	~ 27.3 Mn	~ 34.1 Mn
EV Sales	25,000	129,000	620,000
EV Penetration %	0.12%	0.47%	1.82%

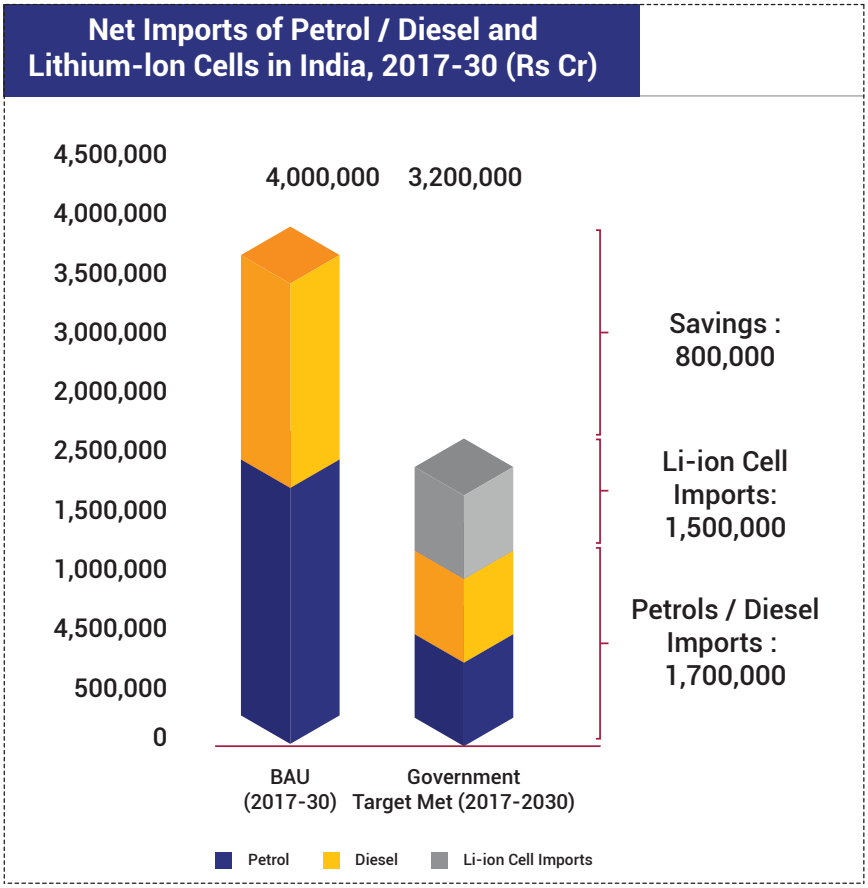
** E-rickshaw sales have been excluded from this table due to lack of reliable projections of rickshaw sales in India*
Source: Avalon Consulting Research and Analysis

3. If the government's 2030 objectives are met, India could save INR 8 lakh Cr (a 20% saving relative to a BAU scenario) in imports of petrol and diesel for the automotive industry over the period, after considering some level of domestic manufacturing of batteries. **Thus, shifting to EVs will not necessarily reduce our import dependency. However, the impact on the environment will be significant.**

   There could be two possible scenarios: a Business as Usual (BAU) scenario, where the dependency continues to be on fossil fuels for the automotive industry, or a scenario where the nation meets its 2030 EV goals.

- **BAU Scenario:** In the BAU scenario, India would need more than 1.6 Billion MT of petrol and diesel to fuel its automotive industry from 2017-30. At a crude-oil price estimate of USD 52/ barrel, this would amount to a value of USD 670 Billion or INR 44 lakh Cr. If India imports 90 percent of its oil, this amounts to INR 40 lakh Cr in oil imports for the automotive industry.
- **Scenario where India Meets its 2030 Ambitions:** Meeting the government's 2030 goals will require at least 3,500 GWh of batteries, amounting to a wholesale value of USD 300 Billion, which translates to approximately INR 20 lakh Cr. Indian manufacturers can capture 25 to 40 percent of the value of this market if they assemble packs domestically. Thus, cell imports would total INR 12-15 lakh Cr. Petrol and diesel imports are expected to reduce to INR 17 lakh Cr, creating a savings opportunity of INR 8 lakh Cr.

EVs are an inevitable disruption that is changing the way we commute globally. Developing an aggressive strategy for EV adoption in India and further ensuring a well-executed implementation, is both a challenge and an imperative for the government. The sheer geography and diversity of this country will present problems that require well thought through solutions, which are not yet visible on the ground.



Source: NITI Aayog White Paper, Avalon Consulting Research and Analysis

AVALON Consulting

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IMC
Chamber of Commerce and Industry

The IMC Chamber of Commerce and Industry, popularly known as The IMC, is a legendary organization which has relentlessly pursued the agenda of identifying opportunities, addressing critical issues and driving Indian businesses with the single minded focus of sustainable growth.

IMC's members and its network have been instrumental in Influencing policy frameworks and changes towards this goal and continually strengthening sectors that are critical to India's new phase of flourish.

IMC seeks out thought leaders and Industry spearheads to identify today's needs and catalyse the achievement of tomorrow's vision.

Set up in 1907, in the wake of the 'Swadeshi Movement' to represent Indian businesses. IMC is a premier Chamber of trade, commerce and industry in India.

Headquartered in Mumbai and a strong presence in Delhi, the Chamber has more than 3000 members, comprising a cross section of the business community. It plays an advocacy role on a wide range of matters and acting as an impetus to growth and development of businesses, on policy and implementation matters. It represents the interests of a variety of sectors like banking and financial services, environment, energy, water resources, geographic indications and protection of interests of artisans, tourism, information technology, education, construction, etc. IMC organizes interactive meetings with ministers, senior bureaucrats and others to express and drive home its views. Ladies Wing of IMC gives special focus to entrepreneurial development for women and IMC's Young Leaders Forum provides interactive platform to young entrepreneurs and professionals.

IMC hosts foreign delegations visiting India and provides a platform for interaction to expand business ties and address issues affecting growth of business between the visiting country's environment and India for doing business.

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