WORKING PAPER, NO: 566

Future of Indian Auto Industry: Choices and Challenges

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Year of Publication – March 2018

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Abstract

This study lays out the technological opportunities that stand in front of the Indian auto industry, with focus on the passenger vehicles, limited to cars. It attempts to understand the levers that will influence adoption of emerging new technologies and aims to explain the choices that will be pursued by the Indian auto players. The opportunities include connectivity, electrified powertrains, autonomous vehicles, and industry 4.0. Clearly Government regulations and market pull are the most important factors that will influence auto OEMs (Original Equipment Manufacturers) to venture away from their traditional models of business. Interviews with leaders in the industry have revealed that they would be forced to make a move towards gradual electrification of their fleet to keep in tune with the changing market context. The challenge for OEMs will be in creating the necessary market pull for electric vehicles despite the current product and eco-system challenges. Electrification will be the major focus once the challenge of BS VI implementation is completed. Though the other technologies like connectivity, autonomy, shared mobility etc. will gain importance, these would-be parts of supplementary product attributes that will help attract customers and will not be the major proposition by themselves in isolation. The government also strongly needs to keep itself in check in nudging the Industry towards a certain direction. It must withstand the temptation to take decisions on behalf of the industry and let the market forces decide which technology/opportunity should be adopted. We end by proposing a policy direction for the government which uses a weighted average based emission standard for every manufacturer.

Keywords: Autonomous vehicles, Battery swapping, Electrification, Government regulations, Market pull, Indian auto policy, EVs in India, BS VI challenges

1 Introduction

Currently, the global automotive industry is in a state of flux with companies pursuing different strategies to jump on to the next technological curve and capture the next set of customers who are becoming more time-conscious, tech-savvy and environment-friendly. Since the days Ford developed the assembly line for manufacturing, the auto industry's supply chain has vastly improved giving rise to a well-established structure, with an auto OEM at the top sourcing from different tiers of component suppliers. Today, governmental regulations, market conditions, and technological improvements are forcing auto OEMs to shift from their well set traditional models.

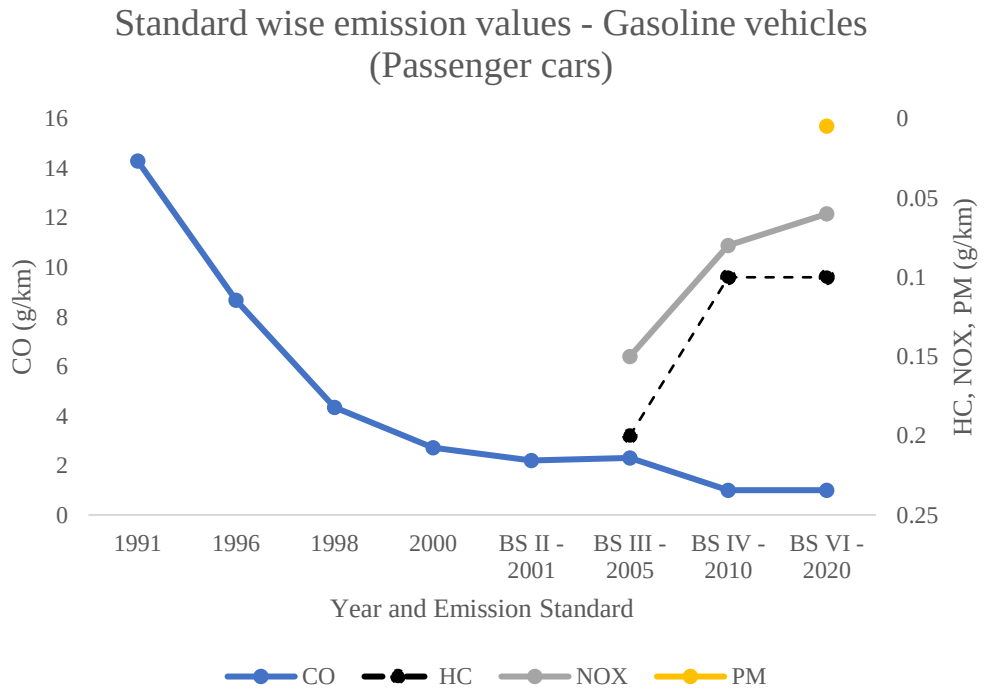


Figure 1. Gasoline vehicle emission standards
(Particulate matter levels introduced for Gasoline

Government regulations on emissions, safety etc. have pushed OEMs to make greener and safer vehicles. The first step towards this has been the notification from the Union Ministry of Road Transport and Highways enforcing BS VI emission regime from April 2020. This is in continuation to the nationwide implementation of BS IV emission standards in 2017. The graphs in Figure 1 and Figure 2 show the emission standards for gasoline and diesel passenger cars from 1991 stage

norms to BS VI in 2020. BS VI mandates a 68% reduction in NO_x and 87% reduction in PM (particulate matter) for diesel cars as compared to BS IV standards, while the gasoline cars have been mandated a 25% reduction of NO_x. Particulate matter levels have been added to the gasoline vehicles standard. It is pertinent to note the Government's decision to leapfrog from BS IV to BS VI bypassing BS V standards. The Bharat stage norms have been adopted from the Europe emission standards with little modifications. The BS IV stage was implemented in phases with certain cities adopting the BS IV norms since 2010; the nationwide rollout was completed only in 2017. The BS VI emission norms, on the other hand, will come into effect nationwide in a single go from April 2020[1]; To facilitate this transition, the Petroleum ministry has committed to providing BS VI fuel earlier than 2020. BS VI fuel will be made available in Delhi starting

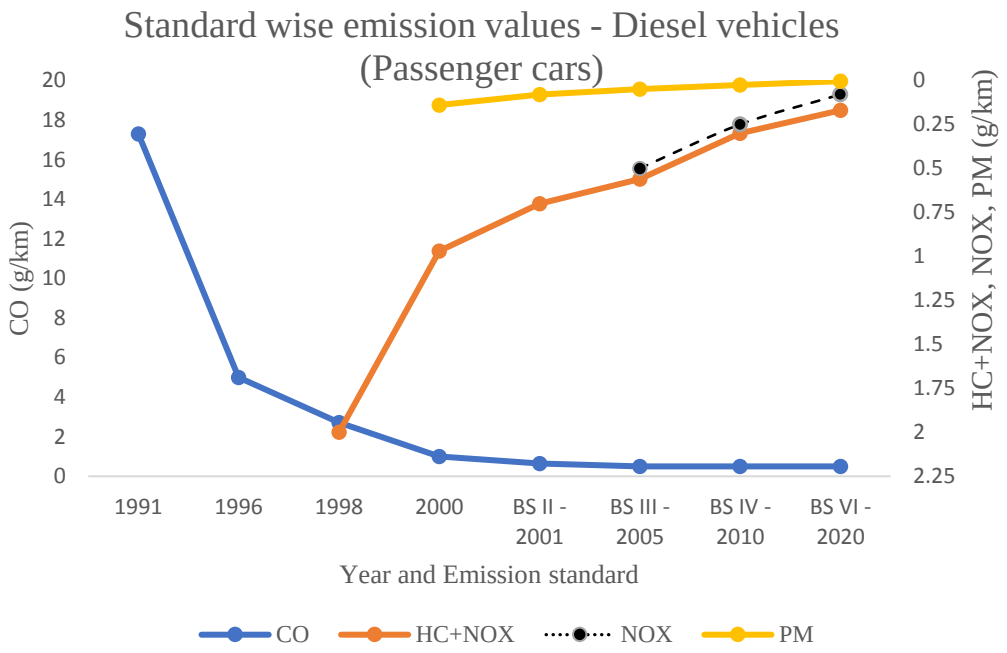


Figure 2. Diesel vehicle emission standards

[1] http://indianexpress.com/article/explained/delhi-pollution-smog-bs-vi-emission-norms-for-vehicles-so-near-and-yet-so-far-here-is-why-4945392/ (Retrieved on 21st March 2018)

April 2018 and if possible the same will be extended to the whole of National Capital Region (NCR) by April 2019[2]. Some automakers like Volvo are contemplating the idea of selling BS VI vehicles in these regions when the compliant fuel is introduced[3]. However, some other auto companies have revealed that they have no intention of selling BS VI compliant vehicles before the stated date (possibly due to cost and inventory considerations). Though BS IV vehicles running on BS VI fuels will not create a significant reduction in emissions, this move is being seen by the Government as a signaling statement, both political and policy-wise, showing its commitment towards a cleaner environment.

This push is important given that Delhi, the national capital of India has been reeling under hazardous levels (Particulate Matter 10 greater than 300[4]) of pollution. On Nov 8, 2017, Delhi recorded an air quality index reading of 999 which was significantly above the 'Hazardous' level of pollution and came to hold the dubious record of 'Most polluted city on earth'[5]. Vehicular exhaust is a major contributor to the poor air quality in the city and the state government of Delhi even had to enforce the 'Odd-Even rationing' move where only odd-numbered vehicles were allowed to ply on roads on odd dates and similarly for even dates (this move was not very popular). A similar move was made by the NGT (National Green Tribunal) which banned all 10-year-old diesel vehicles in the Delhi-NCR region. Another move by the government towards a reduction in vehicular pollution is the Voluntary Vehicle Fleet Modernisation Programme (V-VMP) that the Transport and Highways ministry has conceived. According to this, vehicles completing 15 years or more would be scrapped. The major reason for the scrappage policy is that 65% of pollution is caused by 15-year-old heavy vehicles. The draft V-VMP policy has proposed that vehicles sold before March 31st, 2005 will be brought under its purview and this number is estimated to be 28

[2] http://www.livemint.com/Industry/mUT5rMufjv2c5nvD07bX3L/BS-VI-norms-advanced-by-two-years-in-Delhi.html (Retrieved on 21st March 2018)

[3] https://www.bloombergquint.com/business/2017/12/03/volvo-mulling-launch-of-bs-vi-cars-in-india-before-april-2020 (Retrieved on 21st March 2018)

[4] http://www.livemint.com/Politics/GKomAuLKoUJclYkQYaJumJ/Delhi-pollution-beats-Beijings-as-air-quality-goes-off-the.html (Retrieved on 21st March 2018)

[5] https://www.vox.com/energy-and-environment/2017/11/22/16666808/india-air-pollution-new-delhi (Retrieved on 21st March 2018)

million vehicles[6]. The Indian government thus has been driving the industry to become more environmentally responsible. The Euro emission norms, which the Indian regulators tend to follow, are expected to release Euro 7 with implementation starting 2020 and it is believed that it will focus on reducing CO_2 limits instead of pollutants.

Another much talked about trend is the shift towards electrification of drivetrains. The USA, Europe, and China are the three regions where the automakers have started making inroads with their electric vehicle programs. This has been driven mainly by the carrot and sticks policies of the regulatory bodies in these countries, offering incentives to OEMs, tax-breaks to buyers and emission control norms.

China leads the global automotive market in FY 2017 with sales of 25.7 million cars, followed by the United States of America with sales of 17.23 million cars. India ranks 6th in the global market with 3.61 million car sales[7]; Of this, it is estimated that 0.8-1% of sales are electric vehicles which include BEVs (battery electric vehicles) and PHEVs (Plug-in Hybrid Electric Vehicles). China leads with 602,000 EV registrations followed distantly by the US at 200,000 EV registrations[8]. Figure 3 shows the electric car sales from 2012 to 2017.

In the USA, California and 9 other states have adopted a ZEV (Zero Emission Vehicle) program which functions on the basis of 'ZEV credits' assigned to each automaker based on the type of vehicle sold. The vehicles which qualify for the credits are fuel cell-based vehicles, battery electric vehicles, and plug-in hybrid electric vehicles. The ZEV credits to be maintained are based upon the percentage of non-electric car sales of each automaker, which is 4.5 % of non-electric car sales in 2018 and will steadily increase to 22 % by 2025. To ensure that automakers do not skip investing in electric technology, it is mandated that 55 % of the required ZEV credits each year come from the sale of BEVs (Battery Electric Vehicles) and FCEV (Fuel Cell Electric Vehicles). Credits are awarded based on the type of drivetrain technology and range of the battery. Plug in hybrids

[6] https://timesofindia.indiatimes.com/business/india-business/policy-to-scrap-15-yrs-old-vehicles-almost-finalised-gadkari/articleshow/62931701.cms (Retrieved on 21st March 2018)

[7] http://www.autocarpro.in/news-international/global-car-sales-key-trends-mean-future-28109 (Retrieved on 21st March 2018)

[8] http://www.ev-volumes.com/country/total-world-plug-in-vehicle-volumes/ (Retrieved on 21st March 2018)

receives between 0.4 to 1.3 ZEV credits whereas BEVs and FCEVs receive between 1 – 4 credits per car sold. Further, to level the field for all OEMs, carrying over excess credits to the next year and trading of credits between OEMs is allowed.[9]

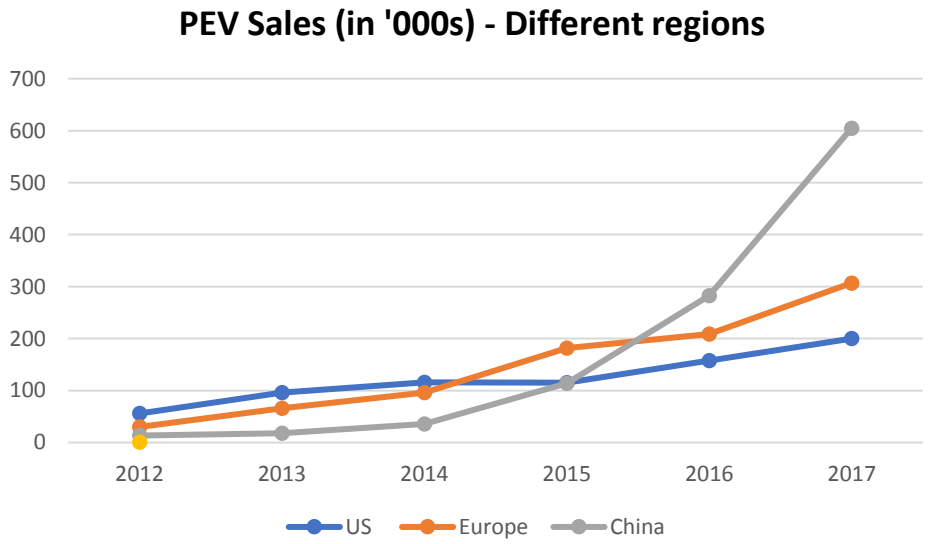


Figure 3. PEV Sales - Includes PHEV and BEV

On the technological front, improvements in machine learning, artificial intelligence, natural language processing have opened new radical opportunities such as autonomous vehicles with different levels of autonomy provided to the car. This push is being made by completely new players such as Google, Apple, Intel, and Uber which are primarily technology-based companies[10]. This has put enormous pressure on established global OEMs to either start their own programs or partner with the tech companies. IoT (Internet of Things) has grown into manufacturing with new applications. It has heralded a new phenomenon called Industry 4.0 which is the next frontier allowing for smart manufacturing facilities with increased connectivity between machines.

[9] https://www.ucsusa.org/clean-vehicles/california-and-western-states/what-is-zev#! (Retrieved on 21st March 2018)

[10] https://www.techworld.com/picture-gallery/data/-companies-working-on-driverless-cars-3641537/ (Retrieved on 21st March 2018)

Similarly, customer behavioral changes like car-pooling, ride-sharing etc. are moving the needle away from vehicle ownership and encouraging mobility as a service. Companies such as Uber, Ola, Lyft, Grab, etc. are enabling such a transition. This shift has created the need for new products like Purpose built Vehicles which bring down the cost of manufacturing and selling[11].

This Study...

The adoption of such opportunities by the Indian auto industry has not been studied (though there is a full stream of discussion around the same with regards to the auto OEMs in the US, European and Chinese markets). Through this paper, we attempt to understand and predict the adoption of these technologies, business models etc. by the Indian auto OEMs and the challenges they face, interposed against the Indian regulations and market conditions. We thus envision the Indian auto industry's direction in the next 5 years until 2023. We also propose a green vehicle policy direction that the government should take which would make it technology neutral and allow the market forces to act.

2 Methodology

We adopted a mix of primary and secondary research. We started with secondary research to predominantly shortlist the set of technology/opportunities that the Indian auto industry is confronting at present. This list was prepared from news articles, company financial statements and strategy plans, govt. regulatory notices etc., and was confirmed through expert interviews in the primary research. It included BS VI implementation, electrification of drivetrains, connected vehicles, Industry 4.0 (Smart factories), mobility-as-a-service and autonomous vehicles.

Primary research mainly consisted of in-depth interviews with 13 experts from leading companies in the auto ecosystem. After identifying the areas which the auto OEMs are contemplating to adopt, a detailed interview questionnaire was prepared. The interviews were conducted across four

[11] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry (Retrieved on 21st March 2018)

months to accommodate the changing regulatory and market environment. Through these interviews, we obtained perspectives not only from experts in auto OEMs and tier 1 suppliers but also from newer players in the value chain like bridge-makers (e.g. Accenture Ventures) and start-ups. The questionnaire was semi-structured and participants were encouraged to express their views on areas apart from the ones that were mentioned to them.

3 BS VI implementation

In September 2016, The Union Ministry of Road Transport and Highways had notified that BS VI emission standards will apply to all vehicles manufactured on or after April 1, 2020[12]. Vehicles conforming to BS IV standards manufactured before April 2020 will not be registered after 30th June 2020[13], thereby notifying auto manufacturers to plan their production and inventories accordingly. This notification is a challenge for the OEMs on both the technical and marketing front. This jump from BS IV to BS VI is unprecedented for the auto industry, not only in India but also a first for the global players. After the Supreme Court's ruling which enforced the sale of only BS IV compliant vehicles post-March 2017, auto OEMs have geared themselves for the strict adherence to the BS VI deadline. This came out clearly in the interviews with leaders from all major auto OEMs. They opined that BS VI implementation takes the topmost priority in day-to-day affairs, driven primarily by the engineering and technical teams to get their vehicles BS VI complaint. Diesel vehicles will need higher significant re-work to become BS VI compliant compared to gasoline vehicles. The leaders were of the opinion that marketing teams would need to follow a different strategy since BS VI compliance will become a point of parity and cannot be highlighted as a differentiator. This is despite the OEMs investing significantly into the upgradation of their product portfolio to ensure compliance with the regulations.

[12] https://timesofindia.indiatimes.com/business/india-business/India-notifies-BS-VI-emission-standards-experts-welcome-move/articleshow/54411589.cms (Retrieved on 21st March 2018)

[13] http://www.news18.com/news/india/government-proposes-to-register-only-bs-vi-vehicles-from-june-2020-1593481.html (Retrieved on 21st March 2018)

Almost all OEMs are ready with technologies to make BS VI possible with the final stages of testing going on. Except for the Indian homegrown auto OEMs such as Tata, Mahindra, etc. who had to invest significantly to make their offerings BS VI compliant, other OEMs who were selling cars in the European market already had the necessary technologies present in their cars which they would bring to their Indian business. The main trade-off in a BS VI compliant diesel engine design is between controlling PM (Particulate Matter) and NO_x (Nitrous Oxide) emissions. A low PM output shoots up the NO_x emissions while decreasing NO_x will increase the PM in the exhaust gases. The technologies that enable these two objectives are:

- Particulate Matter reduction: Fairly common with a Diesel Particulate Filter built-in
- NO_x reduction: There are multiple technologies such as EGR (Exhaust Gas Recirculation), lean NO_x trap, SCR (Selective Catalytic Reduction), etc.

OEMs are trying to optimize their NO_x and PM with a combination of the above technologies to achieve the best possible outcome in terms of cost, and performance. Implementing these exhaust treatment technologies in a vehicle along with the supporting systems such as software, fuel filters, etc., will increase the price of a diesel vehicle by 12~20% (for an INR 1 million-priced car) while the corresponding increase for a similarly priced gasoline vehicle might be around 4~6%. Considering the price sensitivity of Indian consumers, this increase in price may induce a shift towards gasoline cars. Volume OEMs will have an edge due to their economies of scale while the smaller players will take a hit on their diesel portfolio. New customers might switch to gasoline cars with diesel being restricted to SUVs, executive sedans, and luxury vehicles.

Another OEM leader opined that the BS VI implementation will be an easy target to meet since the company had to only modify their assembly lines to incorporate Euro VI compliant technologies already existing in their European plants and will not incur significant R&D costs. This statement is applicable to all global OEMs like Volkswagen, Ford, Hyundai, Renault, Toyota etc. who have the advantage of having developed BS VI powertrains for advanced markets such as Europe, North America, and Japan; The challenge would be for the Indian OEMs who have been limited to the Indian market and lack the backing of a global OEM. This includes companies like Tata Motors and Mahindra & Mahindra.

3.1 Challenge of payback period for BS VI implementation

Giving an Indian perspective, an Indian OEM executive felt that though auto OEMs will meet the 2020 deadline, it will be a challenge for them to realize returns on the investments made towards BS VI implementation. The OEMs would not be able to subsidize this additional cost and will have to pass this onto the customer. Frost and Sullivan predicts that the increased cost outlay for a 1.5 L diesel engine will be around Rs. 82,000[14]. The leadership does not seem overly worried about this shift on a technical front, but challenges remain on the marketing front. Assuming a 10-year period for selling BS VI vehicles, OEMs feel that a sudden shift to EVs completely by 2030 will not justify the huge R&D investments (there was an indication by the Government to move to 100% EVs by 2030). Also, selling EVs by 2030 would mean that OEMs would have to pump in more investments to develop their electric portfolio, stressing their balance sheets further. It would make financial sense only if OEMs, particularly those limited to India, are able to find export markets to amortize the development cost over a higher production volume.

3.2 Customer Preferences

The share of diesel vehicles in new vehicle sales has come down from almost 47% in 2012-13 to below 25% in 2017-18[15]. Figure 4 shows the decreasing market share of diesel vehicles in the Indian market. This change in preferences could be partly attributed to the falling difference between gasoline and diesel retail prices which have reduced from approximately INR 27 in 2012 to around INR 10 in 2017[16]. This fading consumer preference for diesel vehicles coupled with the introduction of greener technologies such as hybrids, EVs can create a viable opportunity to reduce the overall tailpipe emissions. Regulatory moves by the government have also played a major role in shifting customer preferences to the less polluting gasoline vehicles. Another reason for the

[14] https://auto.economictimes.indiatimes.com/autologue/implementation-of-bharat-stage-vi-norms-in-india/2229 (Retrieved on 21st March 2018)

[15] https://timesofindia.indiatimes.com/business/india-business/diesel-cars-market-share-dips-to-23-from-50/articleshow/62344768.cms (Retrieved on 21st March 2018)

[16] https://timesofindia.indiatimes.com/business/india-business/diesel-cars-market-share-dips-to-23-from-50/articleshow/62344768.cms (Retrieved on 21st March 2018)

decrease in share is the large number of entry level vehicles (hatchbacks) sold. These entry level vehicles come primarily in the gasoline format. Maruti Suzuki Ltd., India's largest carmaker (nearly 50% market share in 2017) has a bigger portfolio of gasoline vehicles than diesel vehicles. For example, in the Apr '17 – Nov '17 period, MSL sold more gasoline vehicles (71%) than diesel vehicles (29%)[17]

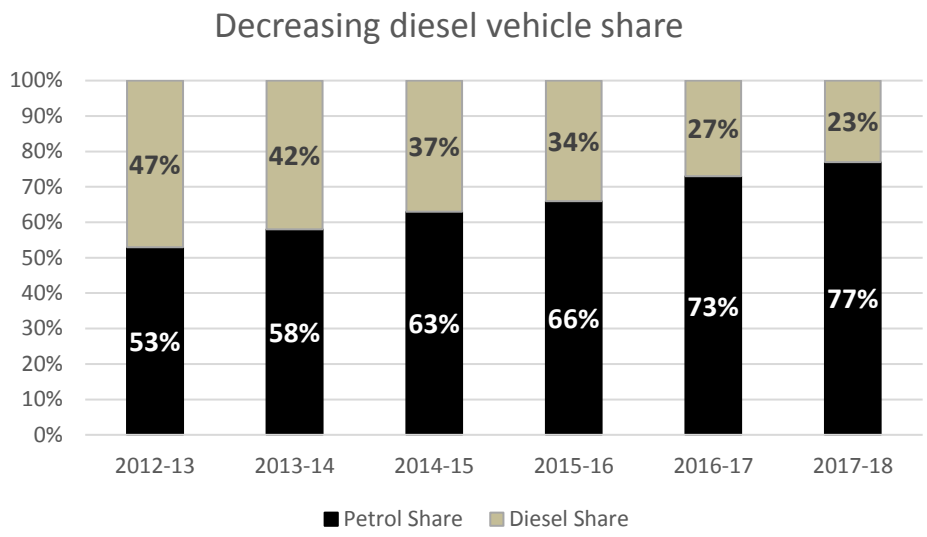


Figure 4. Gasoline versus diesel vehicle sales (Indian Market)

4 Drivetrain Electrification

4.1 Govt. Regulations – The driving factor towards change

In the initial phase, the electric vehicle market was unregulated and in 2013-2014, the country saw the mushrooming of electric rickshaws in various pockets of the country. Tripura was the first state to regulate the EV market, with a policy called 'Tripura Battery Operated Rickshaws Rules, 2014' under which registration of e-rickshaws was mandated[18].

[17] http://www.team-bhp.com/forum/indian-car-scene/193477-petrol-vs-diesel-car-wise-sales-figures-april-nov-2017-a.html (Retrieved on 21st March 2018)

[18] http://agartalacity.tripura.gov.in/act/AMC_Battery.pdf (Retrieved on 21st March 2018)

In parallel, the Union government of India, in 2013, unveiled the National Electric Mobility Mission Plan 2020 (NEMMP) with a vision to put 6-7 million new full range electric vehicles on the road including an estimated 4-5 million two-wheelers. This was done with an aim to achieve national energy security, mitigation of environmental impact and encourage domestic manufacturing[19]. The major push for EVs came when the FAME scheme was launched in April 2015. The scheme offered incentives for adoption in form of rebates and lower taxes. Depending on the vehicle, battery technology (hybrid or full electric) subsidies were fixed. It ranged from INR 29,000 for 2-wheelers to INR 138,000 for 4-wheelers. Phase 1 of the scheme, initially slated to continue for just 2 years, was extended until March 2018. Of the INR 1.27 billion spent through the FAME scheme till June 2017, around 60 % of the funds were used to support the purchase of mild hybrid vehicles[20]. In March 2017, the FAME scheme was amended to exclude mild hybrids from the demand-based incentives since most of the funds were used by them, with the government feeling that mild hybrids were not significantly accelerating the path to the development of full range EVs. This impacted the sales of Maruti Suzuki's Ciaz and Mahindra's Scorpio which were the best-selling models under the mild hybrid category[21]. As of November 2017, the FAME scheme had been extended to support the purchase of 163,997 vehicles[22]. Also, under the FAME scheme, support for research and development of batteries stands at INR 0.3 billion, with INR 2.4 million allocated for Non-Ferrous Materials Technology Development Centre, Hyderabad and INR 6.1 million allocated to IIT Kanpur[23].

The thrust to EV adoption was emphasized with the formation of Energy Efficiency Services Limited (EESL). EESL (Energy Efficiency Services Limited) is a joint venture of four public sector enterprises, created with the aim to reduce the carbon footprint of the nation, mainly through

[19] http://www.pib.nic.in/newsite/erelease.aspx?relid=91444 (Retrieved on 21st March 2018)

[20] http://www.financialexpress.com/india-news/fame-scheme-over-60-of-subsidy-goes-to-hybrid-4-wheelers/789866/ (Retrieved on 21st March 2018)

[21] http://www.autocarpro.in/news-national/government-subsidy-mild-hybrids-fame-scheme-withdrawn-24206 (Retrieved on 21st March 2018)

[22] http://www.newindianexpress.com/business/2017/dec/28/focus-on-e-mobility-in-public-transport-via-fame-scheme-government-1738961.html (Retrieved on 21st March 2018)

[23] http://www.autocarpro.in/news-national/government-spent-rs-crore-research-development-ev-battery-27566 (Retrieved on 21st March 2018)

efficiency intervention projects. It has taken an unprecedented step to procure EVs from auto OEMs and lease them to the government offices across the country, estimated to be around 500,000. Apart from the fuel savings and CO_2 reduction, EESL believes that this move will act as a catalyst in jump-starting the EV revolution, both to auto OEMs and developing the necessary charging infrastructure[24]. EESL, functioning under the Ministry of Power, Government of India floated a tender for procuring 10,000 EVs. Tata Motors had initially won the tender by quoting INR 1.12 million for each EV. Later Mahindra agreed to match the lowest bid. Mahindra started the supply of 150 e-Vertios on 15th November 2017[25] while Tata Motors delivered the first of 250 Tigor EVs on 14th December 2017[26]. In the second phase of the scheme, 9500 EVs will be procured, dates of which are yet to be finalized.

In December 2017, the government launched a pilot e-mobility project through which it aims to provide subsidies of INR 4.37 billion to 11 cities for the purchase of 320 electric buses, 370 taxis, and 720 three-wheelers[27].

Apart from the Union government, states are separately trying to encourage the EV adoption, primarily through industry-friendly policies and subsidies. Karnataka, Telangana, and Maharashtra are few Indian states to lead the EV movement.

4.2 Karnataka State Electric Vehicle and Energy Storage Policy 2017

Recognising the need for a transparent incentive mechanism to drive the adoption of EVs across the state, the state of Karnataka unveiled the Karnataka State Electric Vehicle and Energy Storage Policy 2017, intending to make Karnataka the preferred destination for the manufacture of EVs. The report recognizes 3 barriers to adoption of EVs.

[24] https://www.eeslindia.org/EN/evehicle/About/ (Retrieved on 21st March 2018)

[25] https://www.autocarindia.com/car-news/first-mahindra-e-verito-delivered-to-eesl-under-ev-tender-406593 (Retrieved on 21st March 2018)

[26] http://www.thehindu.com/business/tata-motors-delivers-evs-to-eesl/article21665201.ece (Retrieved on 21st March 2018)

[27] http://www.autocarpro.in/news-national/delhi-mumbai-jammu-guwahati-cities-selected-multi-modal-mobility-project-27629 (Retrieved on 21st March 2018)

- High cost of battery technology
- Limited range of current batteries and lack of proper charging infrastructure
- Consumer apprehension

Some of the policy measures are:

- Making land available, with power, water, sewage and other testing facilities
- Exemption of tax payment for all EVs including e-rickshaws and e-carts
- Encourage shared mobility services such as electric two-wheelers
- 1000 EVs buses to be introduced during the policy period
- Plans to come up with a BIS standard charging equipment, mandating charging infrastructure in public buildings
- Setting up a venture capital fund to invest in research into EV mobility

Some of the concessions detailed for both EV manufacturers and battery pack manufacturers & assemblers are:

1. Investment promotion subsidy

Size	Incentive	Cap
Microenterprises	25% of the value of Fixed Assets	INR 1.5 million
Small enterprises	20% of the value of Fixed Assets	INR 4 million
Medium Manufacturing enterprises	-	INR 5 million

Table 1 Investment promotion subsidy

2. Exemption from stamp duty on credit, hypothecation deeds
3. Reimbursement of land conversion fee
4. 50% subsidy for setting up Effluent Treatment Plant
5. Exemption from electricity tariff for the first 5 years of setting up

4.3 Drivers for EV adoption

Based on the discussions with experts working in the auto sector, the supply side drivers leading to the adoption of any new technology are as follows

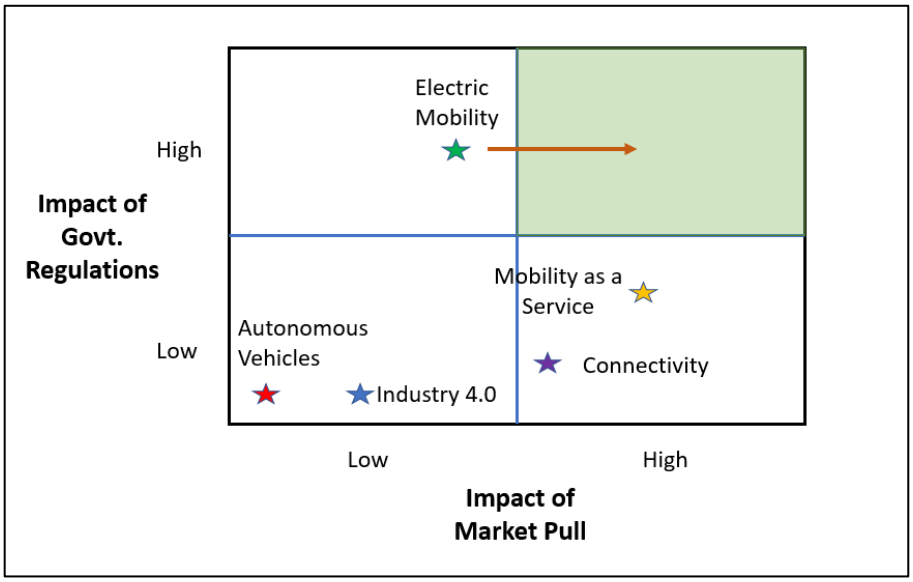
- Market pull
- Government regulations

Typically, it has been observed that market pull has been weak when it comes to vehicle safety, emissions, etc., but drives the adoption of auxiliary subsystems such as infotainment (Bluetooth enabled music players), cosmetic upgrades (Exterior fitments, alloy wheels, Day-light Running Lamps, etc.) and driver assist technologies (Park assist, Automated Manual Transmission, etc.). But the major upgrades have been through the way of government regulations such as Bharat Stage standards for both fuel and emissions, vehicle safety and crash regulations giving way to the development of airbags, ABS (Anti-lock Braking System), etc. being deployed onto cars. When it comes to the electrification drive, it is the latter which has been pushing OEMs to pivot their powertrain strategies. Nitin Gadkari – Union Minister for Highways and Road transport, had announced that India would have an electric vehicle policy by end of the year (2017)[28], but due to insistent pressure from SIAM and major automotive companies, he recently suggested that the country did not need an exclusive policy for electric vehicles. This is in continuation with the goal of having only electric vehicles from 2030.

Figure 5 gives a mapping of the different opportunities that the auto OEMs face today. The technologies and business models lying in the top-right quadrant which has both Govt. regulations and Market pull at a 'high' rating will be the ones which will be the fastest to get adopted. Currently, Electric mobility has been given the regulatory push which puts it in prime position for adoption; but, without the required market pull, OEMs face an uphill task to create the necessary customer pull. It is a double whammy for OEMs in a way. The Govt. on one side has been nudging the auto industry to go the electric route. But, the customers, on the other hand, are not very

[28] http://www.livemint.com/Industry/WpH0LsQHlSWxmeR21lEfDM/India-electric-vehicle-policy-by-December-Nitin-Gadkari.html (Retrieved on 21st March 2018)

convinced about the electric vehicle's proposition in its current state. The 3 major customer apprehensions about electric vehicles are



[29]

Figure 5. Impact of market pull and government regulations on automotive technologies

- **High Initial cost of Acquisition** – EVs are almost 1.5x the price of normal ICE vehicles of the same type. For example, the top end versions of Tata Tigor gasoline and diesel versions are priced INR 0.62 million and INR 6.95 million (ex-showroom price in February 2018) respectively[30] whereas, the Tata Tigor Electric is priced at INR 11.2 million[31].
- **Range Anxiety** – In comparison to ICE engines which the customers have now become used to, the driving range of an electric car on a single charge is significantly low. For example, Mahindra Verito' s electric version has a specified range of 110 km on a single charge. The diesel edition of Verito, on the other hand, has a tank capacity of 50 litres and an ARAI specified mileage of 21.77 kmpl which effectively translates into a full tank

[29] Developed by the authors, based on insights from the discussions with experts in the automotive sector

[30] https://www.zigwheels.com/newcars/Tata/Tigor (Retrieved on 21st March 2018)

[31] https://www.indiacarnews.com/news/tata-tigor-electric-21994/ (Retrieved on 21st March 2018)

driving range of more than 1000 km. Effectively, the customer is staring at a range which is almost 10x lower than the current product he/she is used to.

- **Lack of Charging Infrastructure –** The range anxiety of customers is further accentuated by the lack of a well-developed charging infrastructure. India has only 100 charging points across the country; the majority of them are symbolic ones like those at railway stations, premises of NITI AAYOG and others[32]. A further challenge for the customer is the rate of charging. eVerito, for example, takes 8.75 Hrs to charge from 0 – 100% on a slow charger and 1.75 Hrs to charge from 0 – 80% on a fast charger.

Another dimension which is playing a role in the electrification adoption by OEMs is peer pressure/competitive moves. The fear of missing out phenomenon is clearly visible because no player wants to miss on what might be the next big opportunity. This is visible from the fact that almost 50 electric and hybrid vehicles were showcased at the Auto expo at Noida in 2018[33]. Given that all players have been pushed into the game of electric mobility, a clear winner will emerge depending on how quick an OEM is able to adapt and create a market pull for its products.

4.4 Challenge of Change in Competency

With electrification of the drivetrain, the current core competency of the OEMs - powertrain manufacturing (including the engine and the gearbox) will become insignificant. A new value chain will emerge with battery manufacturing, battery management systems, electric drive manufacturing etc., playing a significant role. A typical EV architecture is given in Figure 6.

In an Electric car, the electric propulsion system consists of the electronic controller, inverter, AC motor and transmission. This is powered by the electric power source consisting of the battery pack and battery management unit. Traditional IC (Internal combustion) engine powered cars used the engine to drive the power steering, air-conditioning and hydraulic/air braking sub systems. In EVs, since the engine is absent, these sub-systems also need to be electrically powered.

[32] http://indianexpress.com/article/india/all-electric-cars-by-2030-nitin-gadkari-inaugurates-ev-charging-points-at-niti-aayog-5065099/ (Retrieved on 21st March 2018)

[33] https://auto.economictimes.indiatimes.com/news/passenger-vehicle/cars/auto-expo-2018-50-electric-and-hybrid-vehicles-to-be-unveiled/62784461 (Retrieved on 21st March 2018)

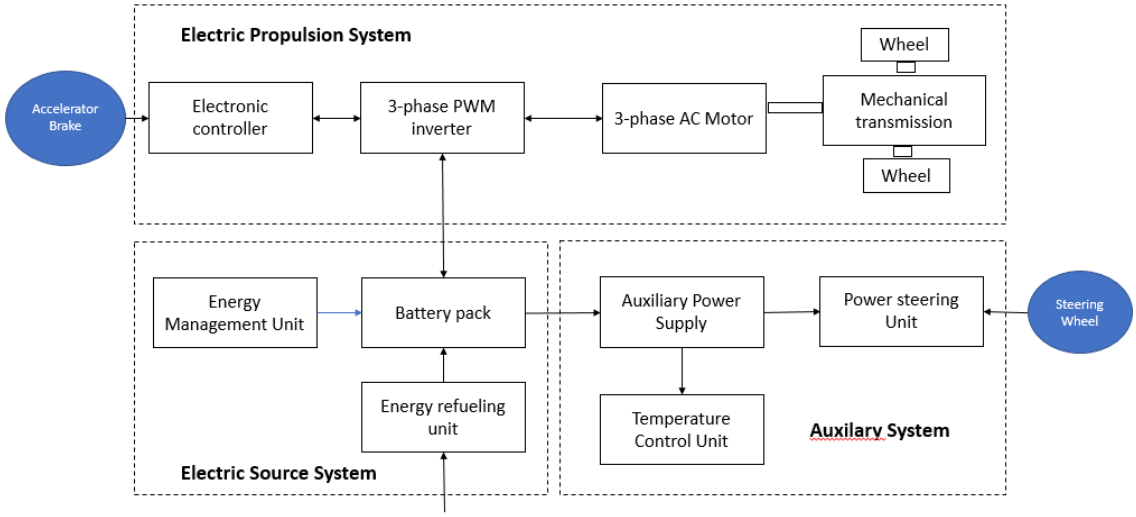


Figure 6. EV Powertrain & Auxiliary system[34]

OEMs will be keen to develop the battery manufacturing resource/capability since battery costs now make one third to one half of the vehicle's cost. The matrix shown in Figure 7 provides a framework for firms to decide on their strategy to outsource or develop the capability. If certain capabilities are needed to create differentiated products and if the capabilities' value in the end product is high, then it is necessary for firms to develop/learn that capability.

This scenario is panning out in the European, Chinese and American markets. Tesla's partnership with Panasonic, SAIC's link-up with CATL in China[35], BYD itself being a vertically integrated battery manufacturer, BMW's battery cell competence center – no major players have let go of control to the battery suppliers completely.

In the Indian context, experts feel that OEMs will start their foray into batteries with pack manufacturing and once a certain level of competency is achieved, battery cell manufacture might become the next area of interest. It is too early for OEMs to get into battery cell research given the

[34] https://nptel.ac.in/courses/108103009/download/M3.pdf (Retrieved on 21st March 2018)

[35] https://www.yicaiglobal.com/news/saic-motor-teams-china%E2%80%99s-largest-ev-battery-maker (Retrieved on 21st March 2018)

investments that need to be made. An example of this foray is Maruti's JV with Toshiba and Denso to set up an electric vehicle battery manufacturing plant in India[36].

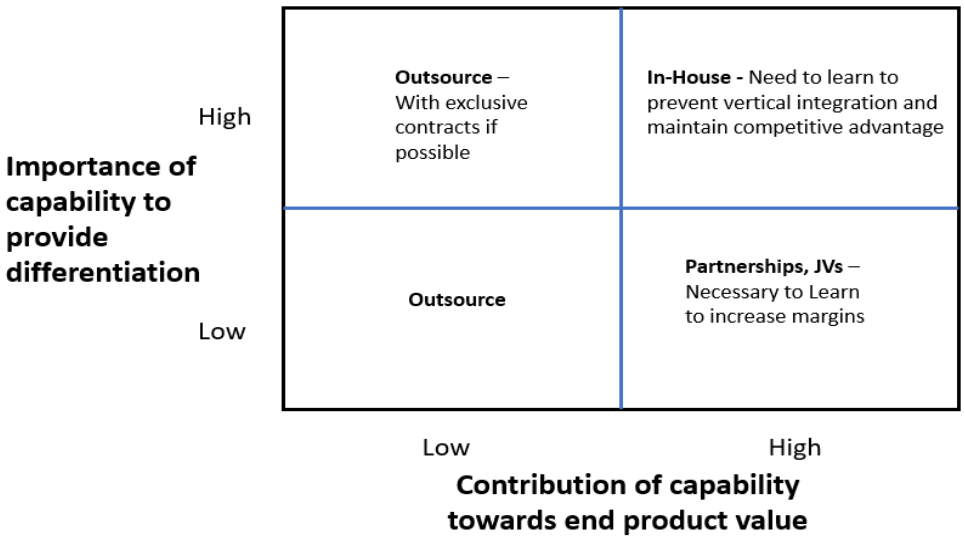


Figure 7. Framework to assess future growth strategies[37]

An executive of a major global battery cell manufacturer opined that in the first wave, Indian auto OEMs will form strategic alliances with battery manufacturers. The auto OEMs would bring the demand and the battery OEMs will bring the technical know-how. Later, when demand firms up, larger auto OEMs will have to master the battery cell manufacturing capability to gain the advantage of economies of scale and hold the margins to themselves preventing value appropriation.

4.5 Battery Standardisation and Swapping

Battery swapping has been suggested by NITI Aayog as a mechanism to hasten the adoption of electric vehicles by reducing the initial cost of ownership. Vehicle purchase without the batteries will halve the purchase price for the consumer. This mechanism will work only if the batteries are

[36] https://auto.ndtv.com/news/suzuki-jv-with-toshiba-denso-to-begin-rolling-out-lithium-ion-batteries-by-2020-1750344 (Retrieved on 21st March 2018)

[37] Developed by authors, based on various existing frameworks

standardized in which case OEMs lose their ability to differentiate and stand apart from their peers. To create an ecosystem where battery swapping is possible, the following needs to be determined.

- the battery rating
- battery packing dimensions

NITI Aayog has suggested a scenario in which the battery casing is modular and the battery packs are standardized across vehicles. The battery packs will vary in number according to the type of vehicle. An example will be a 2-wheeler fitted with 2 packs whereas a 3-wheeler will have 3~4 battery packs. For a commercial vehicle, depending on the load rating of the vehicle, 8~12 battery packs might be required. This approach has 3 main advantages:

- Brings down the initial cost of the vehicles as the battery is not privately owned. This is crucial since the high initial cost of ownership is one of the strongest barriers for adoption of EVs.
- Standardisation of battery specifications leads to economies of scale in manufacturing, distribution, servicing, and disposal. This will again bring down the battery cost
- Reduces the often-touted charging problems regarding time and place. Given a standard battery pack exists across all vehicles, investments made by OEMs in establishing the required charging infrastructure comes down drastically.

On the other side, from an OEM perspective, though they would like to have standardized batteries to enable scale of manufacture and distribution, it puts them in a tight spot as battery packs and battery management system might be the true differentiating factor when they compete in the EV market.

A plausible scenario which might play out soon: A person is returning from work, headed back home. Halfway through, the vehicle alerts the driver of low battery charge. Detecting the vehicle location with the help of GPS (Global Positioning System), it reroutes to the nearest battery replacement station, taking into consideration the destination, remaining charge left, vehicular traffic, queue at the battery station, etc. Once the driver arrives at the station, the vehicle is docked where a robot takes over the replacement process. Removing the old battery, replacing the new one, and billing are all automated and it is expected that it will take about 2 minutes to replace 1

battery pack. Thus, for a 4-wheeler vehicle, it might take around 8-10 minutes to fully replenish a standard car's range through this battery replacement technique.

4.6 Changing EV landscape and industry sentiments

Though companies are looking towards it, EV strategy is still in uncharted waters. For the past one-year Government of India has been trying to reduce the oil imports and achieve energy sustainability. On a long-term basis, NITI Aayog aims to have around 30-40% penetration of 4-wheeler EVs, and 100% penetration in 2-wheelers and buses.

There needs to be a clear direction in terms of policy and supporting subsidy mechanism. In the pre-GST (Goods and Services Tax) regime, there was a concession given in the excise duty for battery operated electric vehicles and hybrid vehicles which provided a cushion for buyers. This has changed with GST introduction where EVs are taxed at 12% whereas hybrids are charged at 28% (highest slab) + 15% additional cess, taking the effective total tax to 43%. This might have been done primarily to discourage adoption of hybrid vehicles as the Government does not see any benefit in moving to hybrids. Certain industry leaders feel that hybrids should not be discouraged as they do not require a drastic change in vehicle design and are not plagued by the absence of charging infrastructure while achieving gains of around 8~20% in fuel efficiency without compromising on the range.

From an industry insider's point of view, the two major hurdles for development of electric vehicles are:

1. **Lack of clear action-oriented policy**

A prominent auto executive echoed the views of the industry, posing some tough policy questions, answers of which would dictate the strategy of each OEM. Some of these questions are as below:

- What will happen to the cars sold before 2030 – relating to production and sales of spares, servicing of existing cars?
- What is the planned scrapping policy for the old cars? (an example of the NCR Diesel engine ban on cars powered by >2000cc diesel engines – short-sighted approach, no effective scrapping mechanism in place)

- What about alternate fuel development such as fuel cells, ethanol-based biofuels, etc., which the government was seen promoting a few years ago?
- The surge in demand for electric power can collapse the entire power grid during specific times of the day such as evenings when most of the professionals return from work. There need to be simultaneous reforms in power sector as well, these considerations and assumptions should be extensively simulated before embarking on a plan to fully electrify the vehicles on road. What is the roadmap for an inclusive energy policy?

2. **Issues regarding charging infrastructure:**
    - The lack of real estate space in urban areas puts a question mark on the number of charging stations that can be built up. Traditional fuel stations might not have sufficient space or infrastructure to accommodate vehicles even for an hour. Pricing will include the economic value of electricity plus the real estate costs increasing the TCO (Total cost of ownership) for EV owners
    - Current urban town planning does not support charging at homes and one can see a lot of the cars are parked in driveways and apartment parking lots which negates the charging at home argument

Answers for these are the need of the hour and the government should make a long-term commitment without wavering back and forth.

4.7 Competing strategies towards complete electrification

Much of the global majors have electrified their vehicle offerings – either partially or fully. This is done mainly to remove anxiety from consumer's mind regarding range and fuel (charge). Though many new technologies might be viable technically and fulfill the requirements, only a very few are commercially viable. It is a common opinion amongst the OEMs that it might not be commercially viable to have the entire fleet of IC engines replaced.

Players like Toyota have long argued for adopting hybrid vehicles over pure electric vehicles. In 2010, Toyota announced that it would manufacture a mass market EV called eQ but shelved the plans rather drastically in 2012, ahead of the Paris Motor Auto Show, citing that the market is not

yet ready to adopt EVs[38]. In 2014, the car developed jointly with Tesla, the Toyota RAV4 EV, did not gain much traction, with just a few hundred being sold[39]. Now recently, Toyota seemed to have changed gears and seems to be willing to adopt EVs. It has announced that all its current models will be produced in a pure electric format by 2025[40]. But it has not given up its hybrid vision. It still plans to continue development of hybrid vehicles based on fuel cells. These fuel cell-based cars need hydrogen filling stations to generate electricity and power the battery, the requirement on the number of stations will be very less as a tankful can theoretically provide a range of around 1000 km and these new hydrogen filling stations can be built on the city outskirts, solving the infrastructure piece of the problem

On the other hand, there are players like Mahindra who have been in the Indian EV space for a long time since it acquired the homegrown electric car brand Reva in 2010. Also, they have signaled their capabilities through the supply of EVs to EESL while bigger players such as Maruti Suzuki were clearly caught unawares in the EV evolution.

The strategies employed by the auto OEMs to lead the EV market space differ significantly. Some players want the progression to be gradual where they envision the co-existence of hybrids and EVs alongside IC engines by 2030 while some players want the transition to an EV fleet directly skipping the hybrid story. Figure 8 gives an indication of the two different strategies. In the stepwise transition, we hypothesize that OEMs will develop hybrids and when market demand materializes for EVs, they will launch full electric vehicles. Right now, even though they have the technology to manufacture hybrids, their vehicles are not affordable for the masses in emerging countries like India. These are OEMs who are already heavily invested in hybrids such as Toyota, Volvo, etc. (invested globally and can bring these cars to India).

On the other hand, we will have OEMs who are willing to bet on the unexplored potential of EVs and skip developing hybrids. Mostly, these will be the home-grown OEMs such as Maruti Suzuki, Mahindra, and Tata Motors. They will use this opportunity to signal their capabilities and

[38] https://www.digitaltrends.com/cars/toyota-eq/ (Retrieved on 21st March 2018)

[39] https://insideevs.com/will-toyota-cancel-the-rav4-ev/ (Retrieved on 21st March 2018)

[40] http://www.autonews.com/article/20171225/OEM/171229906/toyota-moves-from-the-shadows-on-evs (Retrieved on 21st March 2018)

understand the market and consumer mindset better. This will help them tweak their product portfolio to suit customer expectations.

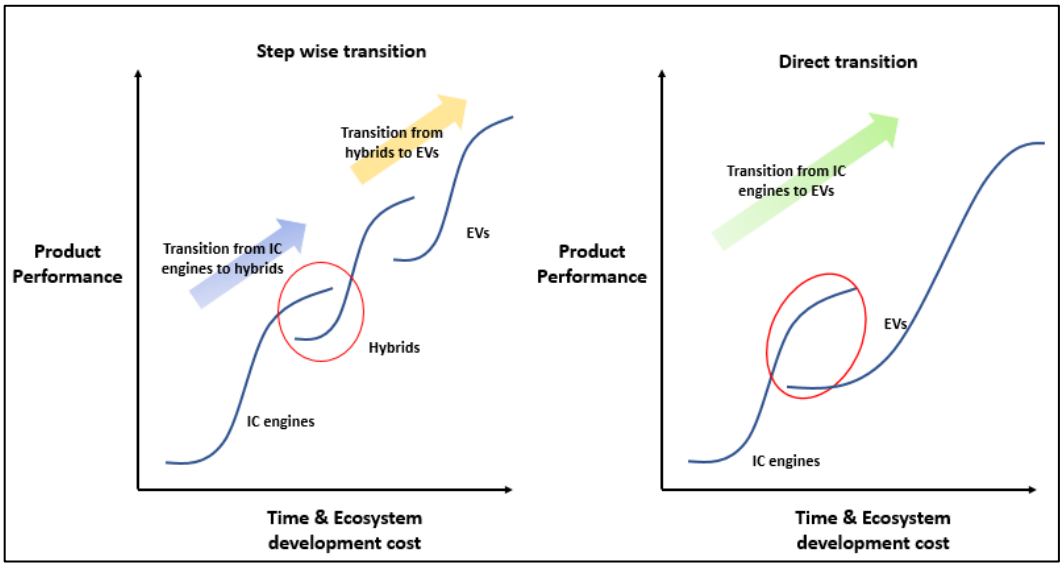


Figure 8. Possible transition strategies of auto OEMs

4.8 Real emissions from EVs

Though EVs are celebrated for their zero emissions from the tailpipe, one should consider the emissions from the source of generating electricity. Pollution from an automobile can be measured in 3 pathways[41]:

- Well to Tank (WTT)
- Tank to Wheel (TTW)
- Cradle to Gate (CTG)

Well to Tank (WTT) measures the pollution involved in the production of fuel be it gasoline or diesel for normal ICE cars, and electricity for EVs. Tank to Wheel (TTW) measures the tailpipe emissions. These two together constitute the pollution pathway called Well to Wheel which provides a holistic view of total pollution caused by driving the vehicles. To power an EV,

[41] https://www.thehindubusinessline.com/opinion/are-electric-vehicles-really-green/article22826789.ece (Retrieved on 21st March 2018)

electricity is needed and a closer look at the source of power generation is warranted. In India, 66.20% of the installed power is from thermal, with a majority coming from coal-powered thermal reactors[42]. With a majority of coal plants polluting much above the prescribed norms, it is a real question if a complete EV policy would make economic sense, particularly considering the long-term costs associated with healthcare and environmental degradation. Table 2 below shows that India depends majorly on thermal power sources to generate electricity.

Fuel	**MW**	**% of Total**
Total Thermal	2,18,960	**66.20%**
Coal	1,92,972	58.30%
Gas	25,150	7.60%
Oil	838	0.30%
Hydro (Renewable)	44,963	**13.60%**
Nuclear	6,780	**2.00%**
RES* (MNRE)	60,158	**18.20%**
Total	**3,30,861**	
* Installed capacity in respect of RES as on 30.09.2017.		
* RES (Renewable Energy Sources) include Small Hydro Project, Biomass Gasifier, Biomass Power, Urban & Industrial Waste Power, Solar and Wind Energy [43]		

Table 2. Split of Power generation sources - India

[42] https://powermin.nic.in/en/content/power-sector-glance-all-india (Retrieved on 21st March 2018)

[43] https://powermin.nic.in/en/content/power-sector-glance-all-india (Retrieved on 21st March 2018)

A study estimates that total emissions from EV production lie in the range of 87-95 grams carbon dioxide equivalent per kilometre (CO_2 eq./km) whereas an ICEV (Internal Combustion Engine Vehicle) production emits only 43 grams carbon dioxide equivalent per kilometer. The study concludes by stating that EVs are not beneficial in all cases and should not be promoted when there is a heavy reliance on coal for power[44]. Using EVs might shift the pollution from localized urban mobile centers – ICEVs to a centralized location in form of power plants. The auto industry should recognize this and press the government to draft an inclusive energy policy aiming to alter the power mix towards greener sources such as solar, wind and nuclear which can deliver better benefits due to lesser emissions.

4.9 Policy proposal

Having studied the existing and proposed actions on part of auto manufacturers and the government, we believe that a future policy should be such that it may favour cleaner vehicles rather than make it mandatory. Thus, the emission norms and regulations need to work with proposed tax incentives. In parallel, to actually control air pollution, it is also necessary to keep the source of power generation green: the government's efforts in increasing the contribution of solar, wind and nuclear power is in the right direction.

We recommend that the government should propose to move towards cleaner vehicles, and not necessarily mandate electric vehicles. The tax structure described earlier gives a good carrot in that direction. By not providing differential treatment unless a car is completely electric, the government is providing the right incentives. On the emission norms, we believe that the government should have an additional standard beyond the one for the vehicle: one for the manufacturer. The vehicle norms will continue to monitor each vehicle's emission levels and standards in the pipeline such as BS VI and BS VII should follow their timeline. This is considering the urgency levels of the government to reduce vehicular pollution and the industry's ability to

[44] Comparative Environmental Life Cycle Assessment of Conventional and Electric Vehicles
Authors - Troy R. Hawkins, Bhawna Singh, Guillaume Majeau-Bettez

research and develop cleaner vehicles. In addition to the vehicle standards, there must be an emission target for the manufacturer as a single entity.

A pollution index needs to be developed. This pollution index should consider the various parameters that are part of the vehicle emission norms. Thus, corresponding to BS VI, a composite index leading to 100 should be developed which reflects the quantum of CO, NO_X, HC, PM allowed. This mix would be different between petrol and diesel cars. So at the time of homologation, each car model will be assigned a pollution index which would be less than or equal to 100. Thus, every car model of the manufacturer has an assigned pollution index. Care should be taken to identify this pollution index appropriately such that a car would need to qualify under a sufficiently lower number to take benefits of lower GST tax (as mentioned earlier electric cars have significantly lower tax).

Subsequently an emission standard needs to be set for the manufacturer. This pollution index for the manufacturer would be weighted average of the pollution index of all the cars sold by the manufacturer in that year.

Thus, pollution index for the manufacturer would thus be = $\frac{\sum_{i=1}^{n} Pi*Ni}{\sum_{i=1}^{n} Ni}$

Where Pi = Pollution index for model i, an example would be Maruti Suzuki's Alto.

Ni = Number of vehicles sold in this model; i will be from 1 to n, where n is the total no. of models manufactured by a manufacturer.

This weighted average pollution index figure will give an overall rating for the OEM. We propose that this overall figure be a certain percentage less than the individual vehicle norms. Some guiding numbers are outlined in Table 3 below (these are to be taken as indicative only). A techno-emission-commercial committee with representations from the government (regulators and tax authorities), testing authorities, auto industry representatives and bridge agencies should be formed to arrive at such indices. Combined with the tax incentives for electric cars, this would represent an appropriate carrot-and-stick policy towards emission control. Non-compliance of such manufacturer pollution index norms should be penalized heavily. To further such a move, trading

of credits (arrived at by looking at the manufacturer pollution index) should be allowed between manufacturers.

In this way, automotive companies would be allowed to strategize their own mix of diesel, gasoline, hybrid, electric, and fuel cell vehicles. Depending on the achieved reduction in percentage points below the threshold level, the manufacturer should be given credit points. So, if a manufacturer has only electric vehicles in its portfolio, it would gain large credit points since its 'manufacturer weighted average rating' will be 100% less than the emission standard. This is unlike the California ZEV (zero emission vehicles) action plan which provides credits only for the manufacture of green vehicles[45]. The proposed manufacturer-level emission norms leave the government tech-neutral and give freedom to the manufacturers to decide the technology they wish to adopt. In this way, the governments will also achieve their target of reducing vehicular emission.

Standards	**Vehicle Standard**	**Manufacturer Standard – Weighted Average**
April 2020 -> BS VI	100	98 (2% less than vehicle std.)
April 2022		5% reduction
April 2024		8% reduction
April 2026		10% reduction
BS VII	X	x % less than vehicle std., but less than last prevalent manufacturer pollution index

Table 3. Proposed Manufacturer Standard for one pollutant - Suggestive Figures (Needs expert research)

[45] https://www.gov.ca.gov/wp-content/uploads/2017/09/2016_ZEV_Action_Plan.pdf (Retrieved on 21st March 2018)

5 Industry 4.0 (Smart Factories)

Industrial IoT (Internet of Things) occupies the central portion of Industry 4.0. Industry 4.0 has been touted as the next big thing for improving productivity and enhancing the efficiency of manufacturing plants. It has been making waves in the European and US markets for its ability to not only increase efficiency but also act as a substitute for labour whose costs are increasing rapidly.

Companies in countries like Germany, where Industry 4.0 originated, are rapidly adopting the concept. Bosch GmbH, for example, has started the process of converting all its 250 global factories including those in India into smart factories[46]. In the USA, Ford is using collaborative robots to fit shock absorbers in their Fiesta models[47].

Indian automotive manufacturers (OEMs) are also warming up to the concept of smart digital factories, but they don't see enough benefits from it yet. This was seconded by almost all the industry leaders whom we interviewed. Currently, the focus is on improving specific gaps in the supply chain and getting the suppliers up to speed with the changing regulatory environment. In the immediate future, End of Line (EOL) testing through computer vision and quality checks of sub-assemblies are use cases that have been planned. With the mandated implementation of ABS, airbags, etc. the focus on product liability and traceability will encourage firms to adopt more IoT technology in their factories.

A consultant from a leading firm who has worked extensively with Bosch previously, opined that the Industry 4.0 adoption in India will be led by the multinational OEMs. Companies like Ford, Toyota, Hyundai, VW, etc., will bring Industry 4.0 based production lines specific to their European models instead of upgrading the entire factory. These models will be built from ground-up with the Industry 4.0 architecture which would eventually be transferred to their Indian counterparts. In this way Indian manufacturing plants will have 4-5 lines of Industry 4.0 compliant

[46] https://yourstory.com/2016/05/industrial-iot-smart-factory-india/ (Retrieved on 21st March 2018)

[47] https://www.engineering.com/AdvancedManufacturing/ArticleID/12657/Ford-Gets-Swept-Up-in-Industry-40-Collaborative-Robot-Craze.aspx (Retrieved on 21st March 2018)

machinery, while the rest of the plant would be the legacy systems. Specialized budgets have been allocated by the companies towards research on increased automation within the factories. The Government of India has also been encouraging the industry to move from low margin products to high margin products to increase the export value. With the government's thrust to exports, more models are expected to be manufactured in India and exported to countries all over the globe. This will lead to faster adoption of Industry 4.0 standards where machines can communicate with each other through a combination of Intranet and Internet.

Making his observations about Industry 4.0, a multi-national tier 1 supplier executive commented that though there has been a separate push by the company's Industry 4.0 business division, the automotive manufacturers have been very skeptical in adopting them. The major challenges in adoption of Industry 4.0 has been the high up-front investments to be made, and the returns are not convincing enough to make the transition. Though labour issues are an area of concern, Indian OEMs still believe that the labour costs are far cheaper when compared to automation. This contrasts with the improvements in Europe and the USA, where labour rates have increased in contrast to the cost of using robots which has decreased in tandem, leading to greater adoption of Industry 4.0 applications.

A Managing Director of a consulting firm, who works alongside both OEMs and start-ups brought to light one of the other challenges in mass adoption of Industry 4.0. Many of the OEMs have a mix of old and new machines. While many of the new machines have sensor capabilities to generate data which can be used in further data analytics, many of the older machines do not have the capability to generate data in usable format. He also suggested that individual projects based on Industry 4.0 will be executed in the next 3 to 5 years. But these will not be the ultimate digital connected factories, as they would take off only after the next 8-10 years, by which time vehicle architectures would have changed to accommodate market-driven competitive actions and newer manufacturing processes.

Industry 4.0 will not be one of the opportunities pursued aggressively by Indian OEMs. The underlying truth remains that the Indian labour market will continue to remain cheaper in the near future, unlike Europe and US markets. Unless it makes economic sense for OEMs, opportunities

like Industry 4.0 are going to be looked aside. However Industry 4.0 solution suppliers like Bosch, Siemens etc. will try to adapt, downsize and customise their solutions to suit the Indian market.

6 Autonomous cars

The lack of road discipline is the major hindrance in the adoption of autonomous cars in India. Even though world-class road infrastructure can be created, lane keeping and responsible overtaking is a must for autonomous cars to work. Also, a separate legislation needs to develop providing clarity on issues such as product liability in case of accidents or other misfortune. Autonomous cars being developed with current technology still need some amount of manual intervention, particularly in tight spots. Hence, auto OEMs are not very bullish on developing autonomous driving technology in the near future.

Volvo is already developing autonomous vehicles in Europe with its proprietary technology called 'DrivePilot'[48]. There are five levels of autonomous vehicles - starting from Level 1 which has basic features such as cruise control, pedestrian detection, etc, and going to Level 5 which is truly autonomous driving, where there is no need for a driver to intervene. Currently Volvo is experimenting with Level 4 autonomous cars in Europe.

- Level 0 – Completely manual
- Level 1 – Driver Assistance
- Level 2 – Partial Automation → Industry's expectation of Indian market
- Level 3 – Conditional Automation
- Level 4 – High Automation → OEMs experimental technology
- Level 5 – Full Automation

In India, some OEMs look forward to introducing Level 2 or Level 3 automation possibly by 2022, considering the road infrastructure, driving behaviour, buyer's price sensitivity and political scenario. There are 2 dimensions to change, **Passenger centric changes** (Passenger immersive

[48] http://autoweek.com/article/autonomous-cars/five-levels-driving-autonomy-autoweek-explains (Retrieved on 21st March 2018)

experience, safety features. Ease of travel, Affordability) and **Vehicle centric changes** (In-Vehicle network, cameras & sensors, electrification of drivetrain, autonomous driving, etc.). The technologies will come to fruition when the market pull meets the technology push. The regulatory push acts as a catalyst to accelerate the change. In Europe, mixed autonomy is already in development and might be rolled out by 2020-21, where in certain stretches the car can drive by itself. Regulatory oversight and product liability laws need to be developed in close collaboration with the industry. Some OEMs expect the Indian market to adapt Level 2 (Partial Automation) by 2023. Though progress has been made in passenger vehicles with respect to autonomous driving, the technology is yet to take off in commercial vehicles. In developing markets, the size of the buses is increasing i.e., attached/elongated buses, double-decker buses placing a constraint on the development of autonomous driving systems for commercial vehicles such as trucks and busses. Some companies believe that it will be long while before the Indian market is ready to accept this technology in public transport systems.

The first autonomous cars would be developed for closed zones such as zoos, tech park campuses, factories, etc., Then the concept could get extended to include more open areas such as designated areas of highways, etc. In India, autonomous cars might not see the light of the day until 2025 when roads become safer and the technology is mature.

7 Connected vehicles

A leading commercial vehicle (CV) manufacturer segment believes that connected vehicles make more sense to the commercial market than the passenger segment. The CV market can be broadly segmented into two as follows:

- Single fleet owners: Single fleet owners own 1 or 2 trucks and they usually drive themselves. They make up 65-70% of the Indian market.
- Large fleet owners: Large fleet owners own on an average 25-30 trucks.

Volvo is a CV manufacturer that mainly targets the fleet owners. Accordingly, every Volvo truck comes with a telematics unit. All the truck related information such as location, driver's performance – acceleration, braking, idling, fuel efficiency, etc. is sent to the fleet owner in the

form of reports. Single fleet owners do not need sophistication such as IoT, connected fleet, etc. Their sole focus is to cut down operating costs. Even among the fleet owners, higher interest in connected vehicles is being shown by second generation owners (children of the original fleet owners are more tech-savvy and are taking over the business). They see connectivity as a differentiated offering to the customer as well.

The unorganized logistics market is becoming more organized and the connected fleet technology is expected to gain traction by 2025. With only a few players working seriously on connected cars, the immediate challenge before the auto industry is make the technology affordable to the masses. Some companies believe that connected cars seem to be an idea which might not find takers amongst the general public. This follows from the concept of expected value of perfect information – there is a steep decreasing marginal value attached to every additional piece of information which is more than required/ deemed sufficient. Too much information might lead to 'analysis paralysis' situation where one might be confused with what to do with so much information. Manufacturers need to provide data analytics as a service with tangible insights and action points which reduces the operating cost and increases life of vehicles.

With the current taxation levels, the price of a connected car will be steep, thus putting a question on its adoption. More studies need to be done to gauge the interest levels regarding connected cars – one from the private vehicle owner's point of view, and another from fleet owner's point of view. Thus, connectivity will be an additional opportunity for auto makers, who will incrementally innovate to make it a valuable proposition to its customers.

8 New Players in the Eco-System

The new opportunities mentioned in the previous sections have opened up the traditional auto supply chain, bringing in a number of new players into the ecosystem. Electrification has brought in battery manufacturers and a suit of other suppliers who will provide auxiliary components such as charging infrastructure, dc-dc converters, high-efficiency transmissions, electric air conditioning, etc. Prof. Ashok Jhujhunwla, who was appointed an advisor to the Ministry of Power

to help in designing the framework for the Govt.'s electrification program, valued the new supply chain at over $ 175 billion[49].

Connected Cars and Industry 4.0, both technologies that are dependent on Sensors, Analytics and Software have given rise to a slew of start-ups. Imagine, Intellicar, Waypals, Carnott technologies, News etc. are some examples.

Mobility as a service has given birth to platform players like Ola, Uber, and Zoomcar, etc. who can potentially change the way people travel.

8.1 Bridge maker

An interesting player that has come up in this automotive eco-system is an entity called 'Bridge Maker'. These are big consulting and technology firms who have positioned themselves in between start-ups and big established companies. Accenture, a renowned management consultancy and professional services company has been a pioneer in this area. Identifying an opportunity in the open innovation space, they act as a conduit between the demand side and supply side; demand side being their big Fortune 2000 clients and supply side being start-ups, R&D centers, universities, and entrepreneurs.

8.2 Win-Win-Win Collaboration

If OEMs need the bridge makers for identifying innovation pockets, start-ups need them for a different reason. They gain access to the bridgemaker's clientele which gives them an opportunity to showcase their technology and get possible orders. This audience and connect with DMUs (decision-making units) of established companies is one of the most important reasons start-ups sign up to service the requests of the bridge makers. Though start-ups are good at developing proof of concepts (POC), many of them falter when it comes to scaling their innovation across multiple

[49] https://www.youtube.com/watch?v=FpMbA14-Kso (Retrieved on 21st March 2018)

business units, geographies; Guidance from an established bridge maker helps them scale their organization.

For the bridge maker, who is generally a big consulting firm, this collaboration allows it to provide value creating solutions to its clients. Start-ups also help in building the bridge maker's internal capabilities. On top of this, if the start-up performs well, its valuation increases which gives a financial benefit to the bridge maker in case they have invested in the start-up. Thus, a win-win-win situation is established for all the three players, creating a virtuous cycle.

Conclusion

The study shows that the Indian auto companies are aware of the new opportunities but not embracing them proactively for various reasons. Government directives have proven to be the main driver for adoption. In the immediate future years, up until 2020, BS VI implementation will be the main focus of all Indian OEMs. Following this, the next priority for OEMs would be the electrification drive, which incidentally is what our proposal is all about. Other than a few pro-active players, most other OEMs still seem skeptical about the electrification opportunity. But for the fear of not being left behind, all companies are forming teams to work on electrification. There seem to be a number of unanswered questions which need to be resolved to direct the electric car strategy of the auto OEMs.

Connected cars take the third priority driven by the CV market. It will take more time for costs to reduce and penetrate the mid-level segment of cars. On the commercial vehicle side, connectivity and telematics will take big significance with both OEMs and start-ups offering solutions. So, commercial vehicle makers might find connectivity more lucrative than electrification and thus it could take immediate precedence over it.

Connectivity inside factories using Industrial IoT will only begin when companies are convinced with their cost-benefit analysis and take a long-term view. Here also, there will be pockets within the factory which will be equipped with sensors and analytics capability in a stand-alone fashion and none of the players showed significant interest in upgrading an entire factory.

Autonomous cars are still moon shots for the Indian auto industry. Systems like ADAS (Advanced Driver Assist System), auto parking etc., are features that might get more prominent in the luxury car segment but will more or less remain as gimmicks. There seems to be no roadmap laid by the OEMs to work on autonomous vehicles. Executives seemed least enthusiastic about self-driving cars, a feeling shared by most of the Indian drivers as well.