CHAPTER - 1
INTRODUCTION

1.1 Indian Automotive Industry: Overview

The Indian automobile manufacturing sector is one of the largest employers because of its profound backward and forward chain integration with other industries. According to the report of the society of Indian automobile manufacture Indian automobile production has now taken 4th place globally reaching 4.02 million units in 2017, now India is the 7th biggest producer of commercial automobiles. A major impetus was provided by the liberalization of the Indian vehicle manufacturing in the year 1991, since then there has been the significant increase in the manufacturing facilities in terms of the number of players and size.

Over the past few years has shown excellent growth in terms of technology, regulation, customer buying preference and new product range.

India is also a major automobile exporter and has robust export growth prospects for years to come. Vehicle export has grown to 20.78 percent 3rd quarter of 2018. It is anticipated to grow at the compounded annual growth rate of 3 percent during 2016-2026. To fuel this growth numerous initiatives taken by the Government of India and the major vehicle manufacturer in India are likely to make India a frontrunner in the automobile manufacturing in the world by 2020.

Viewing the huge potential of the automotive sector, the Government of India jointly with the industry prepared ten-year strategic vision plan for the industry - the Automotive Mission Plan2006-16 (AMP 06-16) which was formally released in January 2007. The AMP 06-16 laid down a 10-year strategic plan for the locomotive industry covering every length and breadth of the industry ranging from the broad direction on fiscal policies, emissions, safety and globalization in terms of technical standards, enhancing competitiveness, skill development, testing and homologation, Research & Development, etc.

Foreign Direct Investment (FDI) worth USD 19.29 billion received by Indian automobile manufacture sector from the year 2000 to June 2018, as per the data released by Department of
Industrial Policy and Promotion (DIPP) is itself a testament to the fact that Indian automobile manufacturing sector is of paramount importance for the Indian economy.

Here are few glimpses of the recent/planned initiatives and expansions in the Indian automobile manufacturing sector:

- Honda Motors industry is preparing to set up its 3rd manufacturing unit in India for introducing hybrid and electric vehicles with the investment of Rs 9,200 crore, is its biggest investment in India till now.

- Ashok Leyland has scheduled investment of Rs 1,000 crore to introduce twenty to twenty-five fresh models in commercial vehicle range in 2018-19.

- Luxury car manufacturer Mercedes Benz has raised the production volume of its Chakan Plant to 20,000 vehicles per year, maximum for any luxury car producer in India.

- Korean car manufacturer Hyundai is planning to infuse US$ 1 billion in India by 2020 to gain more market share.

1.1.2 Current scenario

Vehicles supported under faster adoption and manufacturing of electric vehicles scheme has grown from 5,197 in June 2015 to 192,451 in March 2018 which is a significant increase. In period 2017-18, 185 four-wheelers, 2,202 three-wheelers  47,912 two-wheelers, 10 light commercial vehicles, and 2,202 three-wheelers were supported under FAME scheme.
1.1 Percent of Vehicles sales in Indian (2017-18)

As Figure 1.1 proves that Indian automobile sector is dominated by two wheels so it entails that Indian manufacturer must invest heavily in electric two wheelers and that earning can be further be implemented in other sectors of automobiles.

1.1.3 Growth of Indian Automobile Industry

Today, it is the largest manufacturer of tractors, the second largest manufacturer of two-wheelers, 5th largest manufacturer of commercial vehicles and the 4th largest passenger car market in Asia. Throughout 2011-12, India exported 2.9 million motor vehicles to more than 40 nations which included 0.5 million passenger cars and 1.94 million two-wheelers. Today, the automobile industry in India provides direct and indirect employment to 13.1 million people. The manufacturing of vehicles and exports is given in Table 1.1 & 1.2 below:
### Table 1.1: Production of Vehicles (in numbers)

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</thead>
<tbody>
<tr>
<td>Passenger Vehicles</td>
<td>31,46,069</td>
<td>32,31,058</td>
<td>30,87,973</td>
<td>32,21,419</td>
<td>34,65,045</td>
<td>37,91,540</td>
<td>3.92</td>
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<tr>
<td>Commercial Vehicles</td>
<td>9,29,136</td>
<td>8,32,649</td>
<td>6,99,035</td>
<td>6,98,298</td>
<td>7,86,692</td>
<td>8,10,286</td>
<td>-2.18</td>
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<tr>
<td>Two Wheelers</td>
<td>8,79,289</td>
<td>8,39,748</td>
<td>8,30,108</td>
<td>9,49,019</td>
<td>9,34,104</td>
<td>7,83,149</td>
<td>-1.81</td>
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<tr>
<td>Three Wheelers</td>
<td>1,54,27,532</td>
<td>1,57,44,156</td>
<td>1,68,83,049</td>
<td>1,84,89,311</td>
<td>1,88,30,227</td>
<td>1,99,29,485</td>
<td>5.30</td>
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<td>Grand Total</td>
<td>2,03,82,026</td>
<td>2,06,47,611</td>
<td>2,15,00,165</td>
<td>2,33,58,047</td>
<td>2,40,16,068</td>
<td>2,53,14,460</td>
<td>4.46</td>
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Source: Author calculation

The Industry registered 11 percent CAGR between FY 2009 to FY 2018. Two Wheeler Industry which is having about 80 percent segment share registered highest Compound annual growth of 11.7 percent, Passenger Vehicle (Private & Taxi) 8.7 percent, Commercial Vehicle 9.3 percent, and Three Wheeler segment registered around 6.9 per cent between FY 2009 to FY 2018. All segments of Indian Auto showed positive growth in FY 2018.

The vehicle manufacturing in India is likely to be the world's third largest by 2016, with the country currently being the world's second largest two-wheeler manufacturer. Two-wheeler production is projected to rise from 18.5 million in FY15 to Rs.34 million by FY20. Furthermore, passenger vehicle production is expected to increase to 10 million in FY20 from 3.2 million in FY15. Automobile exports grew at a CAGR of 14.65 per cent during 2010-15. Passenger Vehicles,

Commercial Vehicles, Three Wheelers and Two Wheelers grew by 6.89 per cent, 13.77 per cent, 18.69 per cent and 16.60 per cent respectively during 2010-15.
Figure: 1.2: Trends of Production of vehicles in India (2011-17)

Two wheelers accounted for the largest share of exports at 69.4 per cent in FY15. Passenger vehicles comprised a sizeable 16.7 per cent of overall exports. Exports of three wheeler vehicles registered around 11.1 per cent share in exports in FY15.

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<tbody>
<tr>
<td>Passenger Vehicles</td>
<td>26,29,839</td>
<td>26,65,015</td>
<td>25,03,509</td>
<td>26,01,236</td>
<td>27,89,208</td>
<td>30,46,727</td>
<td>3.13</td>
</tr>
<tr>
<td>Commercial Vehicles</td>
<td>8,09,499</td>
<td>7,93,211</td>
<td>6,32,851</td>
<td>6,14,948</td>
<td>6,85,704</td>
<td>7,14,232</td>
<td>-1.88</td>
</tr>
<tr>
<td>Two Wheelers</td>
<td>5,13,281</td>
<td>5,38,290</td>
<td>4,80,085</td>
<td>5,32,626</td>
<td>5,38,208</td>
<td>5,11,658</td>
<td>0.22</td>
</tr>
<tr>
<td>Three Wheelers</td>
<td>1,34,09,150</td>
<td>1,37,97,185</td>
<td>1,48,06,778</td>
<td>1,59,75,561</td>
<td>1,64,55,851</td>
<td>1,75,89,511</td>
<td>5.60</td>
</tr>
<tr>
<td>Grand Total</td>
<td>1,73,61,769</td>
<td>1,77,93,701</td>
<td>1,84,23,223</td>
<td>1,97,24,371</td>
<td>2,04,68,971</td>
<td>2,18,62,128</td>
<td>4.73</td>
</tr>
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</table>

Source: Author’s calculation
The sales of Passenger Vehicles grew by 3.90 percent in April-March 2015 over the same period last year. Within the Passenger Vehicles segment, Passenger Cars and Utility Vehicles grew by 4.99 percent and 5.30 percent respectively, while Vans declined by (-) 10.19 percent in April-March 2015 over the same period last year. The overall Commercial Vehicles segment registered a de-growth of (-) 2.83 percent in April-March 2015 as compared to same period last year. Medium & Heavy Commercial Vehicles (M&HCVs) grew by 16.02 percent and Light Commercial Vehicles declined by (-) 11.57 percent. Three Wheelers sales grew by 10.80 percent in April-March 2015 over the same period last year.

![Figure: 1.3: Trends of Sales of vehicles in India (2011-17)](image)

Passenger Carriers and Goods Carriers grew by 12.16 percent and 5.27 percent respectively in April-March 2015 over April-March 2014. Two Wheelers sales registered growth of 8.09 percent in April-March 2015 over April-March 2014. Within the Two Wheelers segment, Scooters, Motorcycles and Mopeds grew by 25.06 percent, 2.50 percent and 4.51 percent respectively in April-March 2015 over April-March 2014.

Exports
In April-March 2015, overall automobile exports grew by 14.89 percent over the same period last year. Passenger Vehicles, Commercial Vehicles, Three Wheelers and Two Wheelers grew by 4.42 percent, 11.33 percent, 15.44 percent and 17.93 percent respectively during April-March 2015 over the same period last year.

Table 1.3 - Export of Vehicles (in numbers)

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<tbody>
<tr>
<td>Passenger Vehicles</td>
<td>5,08,783</td>
<td>5,59,414</td>
<td>5,96,142</td>
<td>6,21,341</td>
<td>6,53,053</td>
<td>7,58,830</td>
<td>8.41</td>
</tr>
<tr>
<td>Commercial Vehicles</td>
<td>92,258</td>
<td>80,027</td>
<td>77,050</td>
<td>86,939</td>
<td>1,03,124</td>
<td>1,08,271</td>
<td>3.89</td>
</tr>
<tr>
<td>Two Wheelers</td>
<td>3,61,753</td>
<td>3,03,088</td>
<td>3,53,392</td>
<td>4,07,600</td>
<td>4,04,441</td>
<td>2,71,894</td>
<td>-3.57</td>
</tr>
<tr>
<td>Three Wheelers</td>
<td>19,75,111</td>
<td>19,56,378</td>
<td>20,84,000</td>
<td>24,57,466</td>
<td>24,82,876</td>
<td>23,39,273</td>
<td>3.75</td>
</tr>
<tr>
<td>Grand Total</td>
<td>29,37,905</td>
<td>28,98,907</td>
<td>31,10,584</td>
<td>35,73,346</td>
<td>36,43,494</td>
<td>34,78,268</td>
<td>3.66</td>
</tr>
</tbody>
</table>

Source: Author’s Calculation

In April-March 2017, overall automobile exports declined by (-) 4.50 percent. While Passenger Vehicles and Commercial Vehicles exports registered a growth of 16.20 percent and 4.99 percent respectively, exports of Three Wheelers and Two Wheelers declined by (-) 32.77 percent and (-) 5.78 percent respectively in April-March 2017 over April-March 2016.

1.2 Current Trends and Development in Automobiles sector

Luxury Cars:- The luxury car section has been considering high growth rates and lengthened at 38 percent Compounded annual growth rate between FY07-15. Sale of luxury cars clocked at 33,279 units in 2016. The luxury car market in India is likely to grow at 25 percent Compounded
annual growth rate till 2020 With the 12th largest population of high net worth individuals (HNIs), India still has huge room for this segment.

Electric Cars:- The Indian government has shifted its focus on electric cars in order to meet the emission reduction targets. It has aimed to sell only electric cars by 2030 under the National Electric Mobility Mission Plan which was launched in 2013.

New Product Launches

Ashok Leyland is planning to launch a couple of light commercial vehicle variants, in every quarter of FY18.

In March 2017, Maruti Suzuki launched Baleno RS, a high-performance hatchback car in the hatchback

SAIC motors are planning to enter the Indian market, the first Chinese automotive company to do so.

New Financing Options

Carmakers such as BMW, Audi, Toyota, Skoda, Volkswagen & Mercedes-Benz have started providing customized finance to customers through NBFCs

Major MNC & Indian corporate houses are moving towards taking cars on operating lease instead of buying them

1.2.1 Recent Strategies Adopted By Companies In Indian Automobiles Sector

Capacity Addition

Considering low cost of production, prominent auto companies are increasing their production capacity in order to capture a dominant share in Indian automobile industry.

Most of the vehicle corporation are viewing India as an outsourcing destination.

With the total investment of around US$ 163.7 million, Honda Motorcycle & Scooter India expanded its production of Active in three variants at Ahmadabad plant.
Catering Indian needs

Most of the firms including Ford & Volkswagen have adapted themselves to cater to the large Indian middle class by dropping their traditional structure and designs.

This allows them to compete directly with domestic firms making the sector highly competitive.

Launch of new models

Honda is scheduling to commence better & first-rate car models in 2017 to strengthen its sales share in the industry.

Fiat Chrysler Automobiles India, launched its new Jeep brand Compass in February 2017, which is going to be produced indigenously in Ranjangaon, Maharashtra. India will be the 4th manufacturing hub, globally, for the brand.

In March 2017, Tata Motors’ new sports car was unveiled, under its new sub brand – TAMO, at the Geneva International Motor Show. The show will have displayed niche segment models with advanced technologies.

In May 2017, Pune based Kinetic Green Energy and Power Solutions Ltd. has launched its 1st electric 3-wheeler “Kinetic Safar”, This 3-wheeler is equipped with an advanced lithium-ion battery.

1.2.2 Growth Drivers

Growing demand:-

- Rising income and a large young population.
- Greater availability of credit and financing options.
- Demand for commercial vehicles increasing due to high level of activity in infrastructure sector.

Policy Support
- Clear vision of Indian government to make India an auto manufacturing hub.
- Initiatives like ‘Make in India’, ‘Automotive Mission Plan 2026’, and NEMMP (National Electric Mobility Mission Plan) 2020 to give a huge boost to the sector.

Support infrastructure and high investments

- Improving road infrastructure.
- Established auto ancillary industry giving the required support to boost growth.

- 5 per cent of total FDI inflows to India went into the automobiles sector.

1.3 Opportunities

India is Fast Emerging as a Global R&D Hub

- Strong support from the government; setting up of NATRIP centres.
- Private players, such as Hyundai, Suzuki, GM, keen to set up an R&D base in India.
- Strong education base, large skilled English-speaking manpower.
- Comparative advantage in terms of cost.
- Firms both national and foreign are increasing their footprints with over 1,165 R&D centres.

Opportunities for Creating Sizeable Market Segments through Innovations

- Mahindra & Mahindra targeting on implementing digital technology in the business.
- M&M, Hero Honda & Bajaj Auto signed arrangement to mutually developing technology for 2-wheelers that are compact natural gas powered.
- Tata Motors to launch MiniCAT, a car running on compressed air,
- By 2018, Hyundai is planning to enter the hybrid vehicles segment, to explore alternative fuel technology & to avail the government incentives.

Small-Car Manufacturing Hub

- General Motors, Nissan & Toyota announced plans to make India their global hub for small cars.
- Passenger vehicle market is expected to touch 10 million units by 2020.
- Maruti Suzuki launched a facelift version of Alto 800, after the success of an earlier model
1.4 Government Policies and Initiatives

The government intervention in the form of policy decisions plays an instrumental role in initializing and sustaining the process of industrialization in. An industrial policy shapes the economic environment which ultimately changes the comparative advantages of an industry.

The economic environment can be influenced both positively as well as negatively by various state decisions. Changing policy decisions provide a more favorable treatment (in terms of fiscal and financial stimulus to some sectors of an economy as compared to other sectors, thereby developing a few targeted industries and discouraging the development of others.

However, the role of the state is not same at every stage of industrial development. As industry moves from factor driven stage to innovation driven stage, the government becomes indirect, reducing its role to a facilitator rather than a decision maker.

To look at these issues, policy changes may be viewed conveniently in terms of three phases:

a) Protective policy regime (1947 to 1980)

b) Internal liberalization (1981 to 1990)

c) The liberal policy regime (1991 onwards); each phase characterized typically by their respective priorities.

The division of whole period into three sub-periods is based on the intensity of regulation under three sets of policy regimes, as shown in Table

<table>
<thead>
<tr>
<th>Table 1.4 – Changing Nature of Regulation</th>
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<tr>
<td><strong>Protective policy regime (1947-1980)</strong></td>
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<tr>
<td>-Emphasis on the indigenization of automobile production.</td>
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<td>-Restricted capacity expansion and number of manufacturers through product</td>
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<td>-Specific licensing system.</td>
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<td>-Ban on import of complete vehicles (in 1949).</td>
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<td>-Rationalized foreign exchange.</td>
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<td>-Price regulation.</td>
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The table No.1.4 highlights the priorities of different policy regimes that the automobile industry has observed since independence. The policy instruments used in the first phase provided complete control to the government enabling it to develop the industrial sector according to the national priorities (A. Singh, 2009). The automobile industry was subject to strict regulation, requiring the automobile firms to get prior permission from the licensing authority not only for raising their production capacity but also for product diversification.

The state intervention through various policy measures indeed played a critical role in determining the initial structure, growth and performance of the automobile industry. This period was governed strictly by product-specific licensing system. Policy changes initiated in the early 1980s announced a number of relaxations and the restrictive licensing system observed a major overhaul for the automobile industry.
It was redefined and divided into two groups of different types of vehicles: (i) on road 4-wheelers and (ii) 2-wheelers. Once manufacturers got license for the broad category, they were not required to get any additional clearance for diversifying within their product group, provided the diversification would not require any new investment in machinery.

As compared to the product specific licensing system experienced till the mid-1980s, this scheme ensured a flexible use of the installed capacity. Further, the policy relaxations encouraged entry of new firms and provided incentives for export promotion.

The policy changes thus led to considerable flexibility in the functioning and also induced competition in the automobile industry. In line with 1980s’ policy changes, a comprehensive reform package was announced in early 1990s allowing entry of foreign firms along with the removal of restrictions on the import of raw material and technology. These relaxations were aimed at developing a modern and competitive automobile industry in India.

1.4.1 Support from the Indian government in the form of new policies

Setting up of R&D centres at a total cost of US$ 388.5 million to enable the industry to be on par with global standards.

- Nine R&D centres of excellence with focus on low-cost manufacturing & product development solutions.
- Department of Heavy Industries & Public Enterprises
- Worked towards reduction of excise duty on small cars and increase budgetary allocation for R&D
- Weighted increase in R&D expenditure to 200 per cent from 150 per cent (in-house) & 175 per cent from 125 per cent (outsourced).
- The Automotive Mission Plan 2016-26 (AMP 2026)
- AMP 2026 targets a 4-fold growth in the automobiles sector in India which includes the manufacturers of automobiles, auto components & tractor industry over the next 10 years.

FAME (Faster Adoption and Manufacturing of Electric Vehicles)
- Planning to implement Faster Adoption & Manufacturing of Electric Hybrid Vehicles (FAME) till 2020 which would cover all vehicle segments, all forms of hybrid & pure electric vehicles.

1.4.2 Long Term Outlook

The Indian automobile industry has emerged stronger from the recent global downturn, and sales across all segments have seen record breaking numbers in the recent past. While the Indian industry has much to look forward to, by way of steady growth in both domestic and export markets, there are some clear challenges accompanying the opportunities in greener vehicles and alternative mobility.

In order to capitalize on these opportunities, the industry needs to develop or acquire technologies and capabilities to produce vehicles that meet future market needs. The government for its part has much to do to ensure the growth trends are maintained, and encourage the development of greener vehicles, while also improving compliance to even existing environmental standards.

Demographically and economically, India’s automotive industry is well-positioned for growth, servicing both domestic demand and, increasingly, export opportunities. A predicted increase in India’s working-age population is likely to help stimulate the burgeoning market for private vehicles.

Rising prosperity, easier access to finance and increasing affordability is expected to see four-wheelers gaining volumes, although two wheelers will remain the primary choice for the majority of purchasers, buoyed by greater appetite from rural areas, the youth market and women.

Manufacturers are already planning for the future: early advocates of technological and distribution alliances have yielded generally positive results, enabling domestic OEMs to access global technology and experience, and permitting them to grow their ranges with fewer financial risks. This exciting outlook for the industry is set against a backdrop of two potentially game-changing transportation trends – the gradual legislative move towards greener, gas-based public
transport vehicles, and a greater requirement for urban mass mobility schemes to service rapidly-expanding cities.

Green Revolution: In a price-conscious economy such as India’s, the shift towards green vehicles will be slow unless spurred by government mandates. Although the major players are already equipped with the necessary capabilities to develop cleaner vehicles, they do not see much merit in commercializing these technologies until the green revolution gains momentum – most likely through changes in political legislation – and it achieves the market scale required for commercial viability.

Manufacturers are placing greater faith in dual-fuel technologies than in battery-powered alternatives because the necessary support infrastructure, such as recharge stations, is not yet in place for the widespread adoption of the latter. The launch of electric motorcycles could have a significant impact on the market, given that motorcycles account for the majority of two-wheeler sales in India. Manufacturers of four-wheelers and commercial vehicles in particular stress the importance of optimizing conventional combustion engines before experimenting too radically with costly new technologies.

Mobility Revolution: Use of public transport in India has waned as private vehicle ownership has boomed, but increasing strain on the road infrastructure in major cities means public investment is likely in Urban Mass Mobility Schemes such as metro systems and buses.

The automotive industry is unlikely to lose much of its customer base in the near-term, even as these schemes become more prevalent, because the socio-economic statement of car ownership will continue to make private vehicles desirable.

At present there is a lack of clarity in the automotive industry over the role it will play in any mobility revolution. Although some industry experts believe the impact of the mobility revolution will be minimal in the short-term, there may be opportunities for manufacturers to become involved with the public sector in areas such as improving links between different modes of transport.

Current low car penetration, rising prosperity and the increasing affordability of private vehicles offer a healthy prognosis for the Indian automotive industry. The companies benefiting most
from this evolving landscape will be those who forge judicious alliances and resource-sharing agreements, who prepare for the growing importance of green technologies, and who remain flexible enough to respond to the twin needs of private light transport and mass transport schemes.

In the context of the unique characteristics of the Indian automobile market, growth is expected to be driven by the following factors:

Affordability

The affordability of the car is seen by the price of car (Price of Volkswagen Golf 1.4 or similar) with the respect of per capita income in different countries.

![Figure 1.4: Comparative Affordability Of Car](image)

Fuel Economy

The volume leaders across two-wheelers and four-wheelers in India are companies which have been able to offer products with the globally acknowledged best-in-class fuel economy rates, as well as affordable total cost of ownership. For example, while the US is setting norms for cars to achieve 35 mpg on petrol, a majority of Indian cars already offer that much, while the leading
class bikes offer up to 200 mpg and more in some cases. This performance expectation will only increase in the future.

Alternative Fuels

Vehicles based on alternative fuels remain another area of interest for both consumers and companies. Reva, a pioneer in electric cars, remains an exception in the area of electric vehicles in India, although in two wheelers there are multiple offerings, none of which have as yet taken off in terms of volume.

Although both commercial vehicles and passenger vehicles running on CNG are gaining popularity among transport service providers and consumers due to their lower cost of operation, much more needs to be done to improve the fueling infrastructure before CNG vehicles become more main-stream. This report explores this theme in detail in the section on Green Revolution.

Niche Products

While India remains predominantly a cost conscious market, profitable niches are available for the products which address specific needs. One example is the growth in the sales of gearless scooters. Of these, most of the scooters are in the 75-125cc sub-segment, often targeted at young people and women in particular.

The growing population, a significant proportion of which will be of working age over the next decade, is another source of demand to most automobile companies. The luxury car segment has taken off substantially in the last three years and current data suggests that the demand will be sustained in the medium term. While the luxury car volumes are only about one percent of the total passenger vehicle sales in 2009-10, the cumulative annual growth rate (in volume) of nearly 40 percent over the last two years suggests that this share is bound to grow.

Rural Market

The automobile industry has yet to fully tap into demand from rural areas. Previously, consumers from these areas would need to go to automobile dealerships in towns and cities for their vehicle purchases. However, in recent years, market players have made overtures to rural consumers, with encouraging sales. There is a gradual but steady growth in demand for passenger vehicles
from rural areas, accompanying the growth of the overall segment. While the Indian automobile industry seeks to double total sales on the back of steady growth over the next decade, these relatively under-tapped demand segments (rural markets, youth, women and luxury cars) are expected to play a significant role.

1.5 The Need for Electric Mobility

Globally, automotive industry is passing through a paradigm shift. The past century has been the era of internal combustion engine (ICE) primarily on account of the ease of use, availability and low-cost of fossil fuels. The shift to electric mobility has become necessary on account of fast depletion of fossil fuels, rapid increase in energy costs, impact of transportation on the environment and concerns over climate change.

As per IEA report of 2009, fossil fuel based transportation is the second largest source of CO2 emissions globally. From 2006 to 2030, the global energy consumption is likely to rise by 53% and about three quarters of the projected increase in oil demand will come from transportation. World over these concerns are driving Governments and automotive industries alike to invest heavily towards developing vehicles based on alternate propulsion systems including electric mobility.

For emerging economies like India, the urgency to find viable alternatives for sustainable mobility is also accentuated by rapid economic development which is accelerating the demand for transportation. As a result of sustained high GDP growth, primary energy consumption is expected to increase by 70% in the next ten years.

The gap between domestic crude oil production and consumption is widening. This, coupled with hardening of the crude prices, is leading to increase in the trade deficit. This poses a serious challenge to environment. Therefore, all measures need to be taken to lessening the dependence on fossil fuels for energy requirements and the projected production and consumption of crude oil for India up to 2020.

The transportation sector alone accounts for about one-third of the total crude oil consumption and road transportation accounts for more than 80% of this consumption. Therefore, the Government will need to focus on this sector and partner with industry for investing in
sustainable mobility solutions for the future. Transportation energy use and its impact on the environment including greenhouse gas emissions are determined by a number of factors.

These can be broadly classified in four distinct yet interrelated set of factors that include

a) Vehicle Efficiency

b) Vehicle Use and Distance Travelled

c) The Type of Fuels or Energy Sources Used in Transportation

d) Overall System Efficiency of the Infrastructure.

Each one of these factors are important and the various interventions relating to them will need to be adopted as a part of a multi-pronged strategy for increasing transportation efficiency levels & mitigation of the adverse impact of transportation sector on the environment and climate change. Some of the interventions within this broad classification of factors include the following:

(a) Vehicle efficiency: This includes improvements in fuel efficiency of both “new vehicles” and “on road vehicles”. In addition to achieving higher efficiencies through improvements in traditional ICE vehicles by better designs for lowering rolling resistance, aerodynamic drag and light weighting etc., much higher gains can be made through greater adoption of EVs. Simultaneously, it is also essential to address the huge “on road vehicle”. population in India.

This will be possible through introduction of a vigorous pan India Inspection and Certification (I&C) regime. In addition, recent developmental testing results for retro fitment hybrid kits for cars in India by the industry indicate that fuel efficiency gains of 25-30% are possible. These solutions will also need to be supported and adopted.

(b) Vehicle use and distance travelled: Vehicle usage and distance travelled includes broad level interventions like better designed cities for minimizing the need for travel, development of mass public transportation for intra-city travel, shift to public transportation from private vehicle use, etc.
(c) Type of fuels or energy sources used in transportation: Interventions related to type of fuel are aimed at lowering dependence on fossil fuels and gradual shift to cleaner and low carbon energy sources such as advanced bio-fuels, a greater adoption of electric vehicles fed on renewable energy sources, etc.

(d) Overall system efficiency of the infrastructure: Overall system efficiency of the infrastructure: System efficiency improvements in infrastructure through better roads, traffic management and use of Intelligent Transport Systems (ITS), etc. are also important.

In India, a lot of work needs to be done in all these areas. In fact, the National Action Plan for Climate Change emphasizes the need for introduction of rapid mass transportation system for major cities and greater shift towards public transportation including Railways.

However, given the fact that the present level of vehicle penetration in India is amongst the lowest in the world, at 11 cars and 32 two wheelers per thousand persons, there is a very high head room for off take of personal vehicles. This coupled with the challenges of time and resources associated with rollout of comprehensive mass transport systems and given the aspirational aspects associated with owning vehicles, it is imperative that the National approach for energy security and for mitigation of the impact of mobility on environment and climate change also focuses strongly on the greater adoption of EVs (full range of electric vehicles from mild hybrids to pure electric vehicles). These vehicles can provide significant contribution in enhancing energy (fuel) security and sustainable mobility.

1.6 Past Efforts and Present Status of Electric Mobility in India

The first electric three wheelers - VIKRAM SAFA was developed by Scooters India Ltd, Lucknow in 1996 and approximately 400 vehicles were made & sold. These vehicles ran on a 72-volt lead acid battery system. In 2000, BHEL developed an 18 seated electric bus. Its power pack consisted of an AC induction Motor and a 96 Volt lead acid battery Pack.

Some 200 Electric vans were built and run in Delhi, with monetary support from MNES. The major concern with these vehicles was their poor consistency, low life and very high cost of the battery. Mahindra & Mahindra Ltd. launched its first electric 3 wheelers in 1999 and also
launched a new company, MEML, based in Coimbatore, in 2001, to make and sell electric vehicles named Bijlee.

In 2004, MEML was closed down due to lack of demand. Mahindra again started making electric vehicles at Haridwar plant in 2006 and continues to produce electric vehicles as per market demand. Bajaj Auto Ltd, Pune had also demonstrated their 3 Seated electric Rickshaw in 2001. The vehicle used advanced PMSM drive system. However, this product has not been commercially launched.

In 2001, REVA, Bangalore entered the EV sector in the Car category with a vehicle developed by an American company (Amerigon) and built with a state-of-the-art battery management system. Some 3200 cars have been sold worldwide including approx. 1500 cars that have been sold in India, mostly in Bangalore City.

Very recently, other manufacturers, including TATA motors, Maruti Suzuki India showcased their demonstration vehicles during Commonwealth Games held in 2010 at New Delhi. High battery cost and lack of charging infrastructure remains a major concern area for mass adoption. Recently, car manufactures in India including TATA motors, General Motors, Hero Moto Corp, and TVS have announced their EV rollouts and have also showcased their vehicles.

In the two wheeler segment, Hero cycles collaborated with UK based Ultra Motor to launch a series of bikes in 2007. Other companies such as Electro Therm India, TVS Motor, Hero Electric etc. are also manufacturing and selling electric two wheelers.

Some other players who have entered this space and launched e-bikes include Atlas, Avon Cycles and Chennai based TI Cycle. These bikes are usually charged at the domestic supply voltage and therefore, require no special adapter. Batteries, Motors and other electrical kits for these vehicles are imported from China and other countries whereas, mechanical design and assembly of these bikes is done here. However, despite an installed capacity close to half a million units; the high cost of electric two wheelers remains the major hurdle due to which the average capacity utilization in the industry remained quite low.

However, recently the off take of these vehicles has picked up on account of subsidy scheme launched by the Government of India and concessions given by some state governments. The
Government of India has been supporting electric mobility efforts in the country. The Department of Heavy Industry (DHI), being the nodal Department for the automotive sector, has been funding research, design, development and demonstration projects and also spearheading the electric mobility initiative in the country.

In the recent past (2010-12), Ministry of New and Renewable Energy (MNRE) has also incentivized the purchase of electric vehicles through its Alternate Fuels for Surface Transportation Program (AFSTP) scheme which had an outlay of Rs 95 cores. The incentive was provided to OEMs that gave at least one-year warranty and were setting up at least 15 service stations across India.

In addition, the Department of Science and Technology (DST), has a funding scheme for all industries, including automotive industry. The Council for Scientific and Industrial Research (CSIR) is also active and R&D on lithium-battery technology for EVs is on-going at the Central Electrochemical Research Institute, Karaikudi. Furthermore, certain state governments like the Delhi Govt. are also providing demand side subsidies in addition to VAT and road tax waiver. Owing to these various programs, EV 2 wheelers have reportedly witnessed growth of 20% and Reva recorded a three-fold rise in average monthly sales. However, these initiatives remain largely fragmented & short-term.

The various initiatives taken in the country to promote electric mobility could not yield the desired results mainly due to higher cost of EVs, challenges in battery technology, limited range of EVs, lack of infrastructure and consumer’s mind set. In addition, the past efforts also did not have the desired level of synergy, continued top level support & ownership both in the government and industry.

As such, most of the efforts undertaken fizzled out since they were isolated in nature, lacked collaborative approach and did not tackle all the issues holistically. In order to achieve the potential, a more systematic and collaborative approach is required with a clear long term roadmap. Funding scheme for all industries, including automotive industry. The Council for Scientific and Industrial Research (CSIR) is also active and R&D on lithium-battery technology for EVs is on-going at the Central Electrochemical Research Institute, Karaikudi.
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1.7 Action gap Analysis

Sluggish sales of electric vehicles so far in India mark a stark reality towards the actual scenario of BHVs and PHBVs and what Indian government is intended to do in the field of electric mobility.

The study emphasizes to understand and analyses major action gaps that are proving to be deterrent for buyers of electric vehicles.

GST rate of 12%: -an Electric vehicle with power train of electric motor at its heart is levied 12% GST tax. The upper ceiling is 28% under the GST tax regime. The government is of the opinion that establishing and adhering to well-built policy framework that allows industry to accelerate in a feasible and sustainable way is far more vital than giving tax holidays or subsidies.

The ministry of power and transport has intended to bring a very ambitious change from ICE (Internal combustion engine) to electric powertrain and has set a target of year 2030 to achieve this aim.

It was very contrary to the tax regime the other countries are following for gaining traction in the field of electric mobility. In India GST Council taxed Electric vehicles at 12% rate which is very high considering the subsidies given by various foreign countries. Indian Government could have easily chosen 5% tax slab for at least for 3-4 years,

Even a complete exemption from the tax to electric vehicles would have given much cheers to consumers and added one more feather to the cap of electric vehicles. It would have helped electric vehicles in building substantial Consumer base in the formative years. It would have created a synergic effect as observing more traction in the field of electric vehicles many manufacturers would have invested in better research and development; this will further help in
bringing better Technology for electric vehicles and in the end would have created a Win-Win situation for all.

Although, electric vehicles got some advantage over the hybrid and petrol cars. The absence of complete tax holiday will offer limited incentives for consumers. So there is a doubt whether consumer will be really attracted towards the electric vehicle given the current scenario of upfront cost of electric vehicles.

India named least green country for electric cars

The India’s total installed capacity for energy generation stands at 315,369.08 MW out of which Energy generated by renewable sources is 50,745 MW. India generates only 16% energy from the renewable sources out of its total energy generation.

Reliance for energy generation over coal is around 60%, which itself is a huge source of carbon emission. Hydropower accounts for 14.01%, with 44,189.43 MW, Nuclear power has a share of 5,780 MW amounting to 1.83 percent of the total energy generation.

Although the government is not completely oblivion to this view point and is considering a major restructuring in the energy generation. According to Draft National Electricity Plan 10-
year energy blueprint published by Indian government this week envisages that 57% of India’s total electricity generation will come from renewable sources by 2027. The Paris climate agreement target given to India was 40% that too by 2030 only.

Indian has achieved compound annual growth rate (CAGR) of about 20% YOY, in the capacity accumulation of renewable energy between 2002 and 2014.

Around $160 billion is required over the next seven years at yearly average of $23 billion to achieve the avowed goal and if one has to imagine how much it is then it is greater than 4 times the country’s total annual defense budget, and greater than 10 times the country’s yearly expenditure on health and education sector of India.

1.7.1 The impact of electrification on India’s automobile industry

Due to escalating urbanization come ecological challenges because of high levels of vehicle pollution. To contest this, governments globally declared convention on emissions and efficiency that are anticipated to become stern in times to come. For India, fossil fuels import account for a major segment of the current account deficit and also create reliance on certain global province to full fill it need for fuel.

With increasing electrification coming into sight, so it becomes the obvious area for future Research and development in the form of alternate fuel vehicle like battery-powered electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles could be avenues of exploration. According to NITI Aayog report, India can easily save 64 percent of energy demand for road transport and 37 percent of carbon emissions by 2030 by practicing and pushing a common, electric and connected transportation future.

The automotive industry is already feeling the effects of electrification or e-mobility, both globally and in India

The evolution to EVs could be very nippy in India. As already observed in developed countries like the US and Germany, around 30% to 45% of vehicle purchasers do consider electric vehicles as a choice while buying a car. By 2030, EVs could garner a sizeable share-which can go up to
50 percent in case of path breaking developments of commuter vehicle sales in key global territories.

This inclination could affect the automotive industry in numerous scenarios. This can result into overlapping of different verticals of value chain, majorly impact the cost structure and cause to be a few apparatuses superseded. For e.g., electric motor used in EV’s will eventually drive down demand for major components used in fossil fuel vehicles like engines and transmission system.

This will push original equipment manufacturer and part vendors to seek options outside their current work culture. Uncultivated areas like electric motors and powering solutions like battery services will surface as more pertinent and striking. Automobile corporations could profit from bearing in mind electrification as an opening to undertake leap of faith into newer horizons of value addition.

Electric mobility is coming and it is coming to stay and will have a deep impact over the world and India. One thing can be surely predicted that it is going to attract lots of new players in automobile sector and will hit the last nail in coffins of many existing players.

Emission Norms: -Indian government neither has stricture nor it implements the stricter emission norms. Strict government regulations on emission norms can be a major influencing factor for advent of electric vehicles in India and worldwide. The industry is now struggling to comply with lower CO₂ emission norms over the next decade, the only way out is through the use of alternate fuel powered vehicles.

Not denying the fact that EV diffusion will create reliance on import of new supplies and component from abroad, but under the make in India campaign more and more home grown suppliers with technological alliance with foreign companies can eventually provide necessary parts and technical know-how for cost effective production of EVs.

India Already bearing the brunt of huge current account deficit the below data corroborate the statement.
According to Aditi Nayar, principal economist at ICRA Ltd CAD for the third quarter of 2016-17 is above normal when we compare it to developing countries like chain, and this can be attributed to increasing levels of crude oil imports and rising prices due to marked difference in demand and supply.

Monetary Benefits are alone sufficient: - monetary inducement alone cannot gain the traction for EV. According to research done in West Virginia in the US, it offers the maximum monetary benefits for EVs, but has not shown the desired adoption rate for EV.

On the other hand, California, offers minimum monetary benefits, but has shown the huge growth rate in adoption of EV, kudos to the government for efforts put in terms of investing in providing strong EV charging infrastructure and loads of other benefits like free parking and priority lane at tolls etc.

1.7.2 An ecosystem for electric vehicles doesn’t exist

The government’s plan also spotlighting on establishing an ecosystem for EVs. Which will support the EV business - supporting all stakeholders to stay linked-putting a highly efficient Electric power driven public mobility system in place? For example, an electric bus heading for the last-mile coverage can indication to EV cab in the area about how many commuters will be offloading.

This ensures most favorable forward voyage options for disembarking passengers. Or EVs can communicate with refueling stations about battery requirements, so there is never any danger of being stranded. These associated vehicles are also a step towards the unavoidable succession to self-directed vehicles.

Additionally, a well-connected ecosystem helps build up efficient and real-time big data analysis for continuous integration and improvement. As states invest in Smart Cities, they must incorporate the infrastructure necessary to help make the EV vision a reality. A suitable network of recharging and exchange stations, and car parks and bus depots that provide charging points and batteries for swapping, will benefit the nation economically and environmentally.
The auto industry is flourishing and India is becoming an export hub for small and medium-sized cars. This ensures the business well-placed to go all out on electric, principally with policies that enable entrepreneurial surroundings. It’s time for the auto/EV industry to team up with tech-expertise and mobility solution providers and OEMs to gain from this potential and make the move to electric. In fact, I would say it is an imperative that the industry moves quickly to get ahead of this inevitable disruption and reap the rewards.

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At present, the financial case for a consumer to invest in EVs is weak. Achieving fuel saving by spending in well-organized ICEs, small hybrids, or 2W is the most likely reaction from the consumer if fuel prices rise.

Battery exchange stations: - If the battery is successively low, you go to the next-door battery exchange station and in about the same time (or less) it takes to refuel, someone swaps out your batteries and fits another one, fully juiced up.

You pay as long as you go and you continue on your way besides the smart batteries, the company plans to set up the infrastructure for charging and battery swap-stations (self-owned as well as through partnerships). It is also in conversations with energy providers to source renewable energy to keep this battery network juiced up.

This technology is going to be a cross-platform, which means it will work across two-wheelers, three-wheelers, cars and even buses. More importantly, it would be an open, modular platform that works across vehicle original equipment manufacturers (OEMs). Maini understands that this is parallel to how the smart phone market evolved and standardizing a key component like batteries could do the same for electric cars in India.

India’s Niti Aayog in its report ‘India Leaps Ahead – Transformative Mobility Solutions for All’ signified the importance of ‘smart swappable batteries’ for two and three wheelers but there are quite a few roadblocks to it, namely:
Standardized EV Lithium Ion Battery Packs: this is one thing which has not happened worldwide so far and its realization in India may be disputed with majority of the auto OEMs preferring to control their design strategies for battery packs as their core technology USP and important IP rights/patents.

Commercially Viable Business Models: While the government is eschewing subsidies, it is extremely important to have a very sound and commercially viable business model to ensure aggressive industry participation.

What will it take to bring clean cars to India?

Upfront cost of vehicles is a key barrier for consumers and manufacturers are keenly monitoring developments in energy storage that will help reduce this cost. In the absence of strong consumer demand, there is still an immediate need to reduce dependence on crude oil derivatives and to fulfill the transport sector vision outlined in NEMMP 2020. Government’s bodies will need to:

Ensure Perform, Achieve, and Trade (PAT) Scheme drives sector-wide energy efficiencies in second cycle

Initial reports suggest that the second cycle of PAT (commencing 2015) could include transport supply-side sectors (such as refineries, electric transmission companies, with thermal power already included in the first cycle) and transport demand-side sectors (such as railways, aviation and buses). If so, then for the first time, market mechanisms will be able to recognize and act on energy efficiency benefits across the whole transport supply chain. This will help incentivize electrification of road transport and ensure electric vehicles do not generate unintended environmental impacts.

Battery Technology Augmentation

EV technology could help lower the battery cost, charging duration and driving range, the cumulative effect of all these factors may lead to the faster espousal of EVs.
The largest constituent of the overall EV cost is high battery cost which ultimately impacts the final manufacturing and sales cost. In between 2011 and 2016, global battery prices have fallen drastically from around $800 per kWh to $227 per kWh. This will also lead to elevated BEV and PHEV sales, particularly in Europe and China who are the forerunner of this change.

1.8 Global Scenario

Various alternate powertrain technologies are available today – Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicle (PHEV), Extended-Range Electric Vehicle (ER-EV) and Battery Electric Vehicle (BEV). In the NEMMP 2020 document these are collectively referred to as EVs. HEVs have both internal combustion and electric drives, which work in tandem leading to higher fuel efficiency.

If the battery is used only when vehicle is started or stopped, for regenerative braking and limited electric motor assist, it is classified as mild hybrid. Whereas, full Hybrids have full electric launch assist and motor drive. PHEVs and Extended Range EVs (ER-EV) can run on batteries alone for a significant length and have ICE backup. BEVs run solely on batteries.

Across the world, Governments are playing a key role in facilitating greater adoption of electric mobility through use of the following five main levers of public policy to influence the early adoption of EVs (i) Demand incentives (ii) Supply side incentives for spurring manufacturing(iii) Power & Charging Infrastructure (iv)Research & Development incentives (v)imposition of stringent fuel efficiency norms.

Different nations have followed different strategies for promoting EVs. While US has been primarily focusing on both demand and supply side incentives, with Government directly subsidizing private initiatives, Japan and France have been focusing on supporting charging infrastructure of EVs with more limited support on demand and supply side in incentives. In contrast, China has a very comprehensive and large scale program for adoption for e-mobility ' and plans to spend tens of billions of dollars, primarily to support PHEVs (Plug-in Hybrid Vehicles) and EVs lately, there is talk for support to HEVs . Deeper analysis of the strategies adopted by different countries reveal that USA aims to have 1 million PHEVs by 2015 and has been focusing on both demand and supply side incentives and has also been directly subsidizing
private initiatives, which includes USD 2.5 Billion grant for battery development and USD 2.4 Billion loan to OEMs for EV production

China plans to have 5 million EVs by 2020 and has earmarked USD 15 billion over next three years for R&D on vehicles and components, USD 4.4 billion over next 10 years on pilot projects and USD 5 billion for half million public chargers.

Japan has targeted 2 million EVS by 2025 and has earmarked USD 250 million over next three years R&D on vehicles and components and USD 4 billion over next 10 years on pilot projects for vehicles and USD 2 billion public investments for recharging network of 1 million recharging points by 2015. Further the French companies and government also plan to buy 100,000 electric vehicles.

The entire global requirement for cars and two wheelers, which at present is 45 million and 43 million units, is likely to increase to 70 million and 76 million units correspondingly by 2020. Two wheeler sections already have a high diffusion level for electric variants, mainly in China. The demand for EV two wheelers is expected to remain high with majority of demand expected to come from Asia Pacific region (95%) with China likely to generate greatest demand.

The Global demand projection for four wheeler EVs has a high degree of uncertainty as demand and supply sides along with the EV technology are all quite immature. Furthermore, as the future technology and price evolution is not clear, precise forecasting is difficult. It is expected that penetration of EVs in the passenger 4 wheeler vehicle space will be significant. The detailed global EV demand forecasts are dealt within.

In view of the increasing focus on EV research, promising developments across all dimensions of EV powertrain have been seen. These include significant progress in the area of engine downsizing (HEV/PHEV), development of non-rare earth material motors and research in battery and battery management system around chemistry, stability, performance, smart charging, etc. In the area of controllers too, better cooling and power management techniques have been developed and a higher level of control integration is being envisaged. The cumulative efforts
have led to significant performance improvement and cost reduction in EVs. This is likely to continue and lead to a favourable cost evolution for EVs in the future.

At present Lithium-ion batteries are the preferred choice for usage in EVs. They have high energy density and low discharge rates, and hence are able to deliver sustained high performance. These batteries have low maintenance cost and a long lifespan. However, their high price continues to bathe main barrier to their widespread usage.

It is expected that technology innovation and scale of production will bathe important levers that will together impact almost 90% of the lithium-ion battery cost. From the technology standpoint, cost could be reduced by identifying cheaper raw materials and safe chemistries for automotive usage. Furthermore, manufacturing processes could be automated and streamlined to improve quality and yield. It is expected that favourable developments in these areas could bring down Lithium ion battery costs from the current levels of $500-800 / kWh to $ 325-430/kWh by 2020 .

In the BEV segment, this would tantamount to a 5% y-o-y decrease, while for HEV and PHEV, the decrease could be up to 7%. The favourable battery cost evolution would lead to significant global sales penetration of EVs. However, despite the reduction in price of Li ion batteries in the future, as far as India is concerned, it is expected that the Li ion battery costs are likely to remain higher than the customer expectations. This is borne out from a comparison of the expected willingness of the consumer to pay price premium for Li ion batteries with the expected cost evolution of these batteries up to 2020.

1.8.1 The Challenges

There have been major challenges that electric car developers have had to face through the years. The battery is the greatest challenge as it poses many issues such as quality, lifetime, price and safety. Other major challenges are charging time, infrastructure and range. The consumers pose a major challenge as they experience range anxiety, face high costs and the new technology has yet to convince them to switch from their comfort zone of fossil fuel vehicles.
1.8.2 Battery Problems

The battery technology has been developing fast and has gone through turbulent times. They have gone from catching on fire, having a short lifecycle, to a weakness for cold temperatures. The technology improved slowly but some say that it is not fast enough. Most electric vehicles that are currently being sold are equipped with lithium-ion batteries. The lithium-ion battery technology has become the most widespread and is considered the best option available today for electric vehicles due to its high energy density and charging possibilities.

The first rechargeable lithium-ion battery was commercialized by Sony in 1991. It quickly became the battery of choice for small electronic equipment (Sony Corporation). Shortly after that, electric car manufacturers started using lithium-ion batteries and the Toyota’s Vitz was the first electric vehicle that was put in mass production in 1998. Nissan’s work with the lithium-ion batteries with what they claim as the start of their Nissan Leaf development in 1996. Tesla used the first US and EU approved lithium-ion battery in 2004 it in their Roadster model. The Tesla Roadster was the first electric vehicle to travel more than 320 km on a single charge.

Apart from the higher energy density, there are other advantages to lithium-ion. It is a low maintenance battery which means that it has no memory and no scheduled cycling to prolong the lifetime of the battery. On the disadvantage side, the battery is fragile and in order to maintain safety, it requires a protection circuit. The protection circuit limits the peak voltage of each cell while charging and prevents the voltage from dropping too low on discharge. The cell temperature needs to be monitored to prevent the temperature from rising too high.

There is another disadvantage, which is the aging of the battery. This has been a great concern for producers and users. Some capacity deterioration has been noticeable after one year regardless if the battery has been used or not. There is a risk of the battery failing after a few years, however, they are also known for lasting up to 5 years.

A new version of a lithium-ion battery has recently emerged and promises more power, easy manufacturing and can tolerate high and low temperatures (-30 to 60°C). A123 system is the company behind this new battery and they believe that this is a breakthrough for the EV market.
as the cost is lower, the battery life is longer and it is lighter in weight. The new batteries may first find use in micro hybrids until further development.

It is agreed by researchers that the lithium-ion chemistry used today is reaching maturity and many are looking towards other possibilities such as lithium-sulphur and lithium-air (oxygen). Researchers believe that there is need for considerable improvement before EV’s can become more widespread. Lithium-sulphur battery prototypes show that the potential for energy storage is theoretically 5 times more than lithium-ion.

Researchers at Stanford University have been working with lithium-sulphur batteries by using an x-ray machine have yet found a way to expand the battery’s lifetime. However, this work could help scientists to develop this technology further so that it might be usable for electric vehicles in the future. The work that has been done so far with lithium-air batteries has shown a similar outcome with the short lifetime.

Now, researchers have found a way to expand the lifetime that allows a stable performance. Theoretically, the energy capacity of lithium-air is ten time more than the lithium-ion battery. The development of a new battery technology is good news for electric vehicle producers but it is still far away from being commercially ready.

1.8.3 High Price

Product pricing is one of the major challenges for electric vehicle producers today and the lithium-ion battery is the biggest cost driver. The cost for the lithium-ion batteries is high and it can count for 25-50% of the total production cost. The price of the batteries is calculated in kWh (kilowatts per hour) and right now the price is between $500-$600 USD per kWh. If the pricing of big brand EV’s Ford Focus Electric 2013 is considered, which has a 24kWh battery, an estimate can be made on the cost proportion.

According to Ford’s CEO, Alan Mulally, the battery cost for the Ford Electric is $12,000-$15,000. With a retail price of approx. $39,000 in the US, the battery cost is 30-38% of the total cost.
This high cost of the batteries might not such a major issue in the coming years, since most forecasts predict the prices to go down gradually with time. Since 2009, the price has gone down by 30% and in 2011, the prices dropped by 14% as the production capacity exceeded the demand. New Energy Finance is predicting an overcapacity that would bring prices down to $150 kWh by 2030.

Pike Research predicts prices to drop by a total of 33% by 2017 and that electric vehicles will continue to be a niche market in the global transportation industry until 2017 with a 1.4% market share (Pike Research, 2012). McKinsey predicts a price of $200 kWh by 2020 and $160 by 2025. IDC Energy Insight Forecast predicts a rise in manufacturing capacity of lithium-ion batteries of 390% by 2015 and a global demand increase by 447%. This would lead a significant price drop in lithium-ion batteries by 2015 according to IDC Energy Insight.

### 1.8.4 Range Anxiety

Range anxiety is a concern for electric car drivers and has been defined as a “fear of becoming stranded with a discharged battery in a limited range vehicle”. Range anxiety has been coined as a major hurdle against the adoption of electric vehicles and has been a great concern for auto manufacturers. Most manufacturers try to put a damp in range anxiety by providing longer range and more accuracy in measurements.

The thought of running out of power causes worry for many users, especially considering that the range can vary between different situations and weather conditions. A driver does typically not want to suffer from stress while commuting in their daily routine. The thought of being stranded with no source for power nearby is a terrifying idea to some people.

In addition to range extending development, there is another attempt being made to minimize range anxiety. Researchers have been developing a navigation technology that is described as an “eco-routing” system and it is said could add 10% to the range. It takes into account real-time traffic information, weather, road condition and the weight passengers and cargo of the car.
1.8.5 Charging and Infrastructure

The countries that have begun to use electric vehicles and plug-in hybrids are at various stages of the implementation of a charging infrastructure. Some governments are financially supporting the charging projects, while others have to rely on investors and financially viable business models. In some countries it is illegal to sell electricity if you are not a licensed retail power provider.

There are three types of charging, slow, fast and ultra-fast charging. The slow charging is what is used in household charging today and people use the regular electric plugs and it takes about 7-8 hours to fully charge a small sized electric car. The fast charge stations can give an 80% charge under 30 minutes. The ultra-fast solutions are being developed with the goal of a full charge in a few minutes. The charging networks that are not being financed by the government require a substantial investment and a return on this investment.

Many developers struggle to design the appropriate business models for the network and many are combining it with full service packages. The infrastructure for electric cars is one of the hurdles for the adoption rate as the customers are reluctant to purchase an electric car when there is no certainty for a supportive platform. There are cases where charging stations have been put up and sales of electric vehicles are less than expected. There are also cases of vehicles being sold at a fast rate with an undeveloped infrastructure. This has become a case of the egg and the chicken, which comes first and how to possibly predict the development.

1.9 Barriers to Adoption of Electric Mobility

Globally significant barriers to larger and faster adoption of electric mobility exist. These are mainly on account of higher cost of acquisition, challenges relating to batteries (these include issues relating to price, range, performance etc.), consumer acceptability, performance standards of EVs in comparison to traditional IC engine based vehicles (range, speed, acceleration etc.), lack of charging infrastructure etc.

These barriers can be clubbed into four broad areas which need to be overcome. As far as India is concerned, various issues in these areas include
a) Consumer Acceptability: this includes issues relating to low consumer awareness, current price performance gap etc.

b) Technology Development: the existing low level of R&D in this area in the country, limited current capabilities etc. are some of the concern areas.

c) Manufacturing Investments: It includes the limited domestic manufacturing capabilities and non-existent supply chain.

d) Lack of EV related Infrastructure.

In order to overcome these barriers, creation of market for EVs through greater consumer acceptability will have to be the starting point. This will need to be taken up in right earnest and includes addressing issues related to higher price of acquisition of electric vehicles and various other demand generation measures.

Demand incentives should be accompanied by measures for spurring localization of manufacturing and greater investment in R&D and technology acquisition. The efforts for addressing the infrastructure related issues will need to be addressed continuously from the very beginning of the road map.

1.10 Theories of consumer behavior

To study the behaviour of buyers of electric cars Pertinent theories of consumer decision making strategies plays a central role in each stage of consumer buying of electric cars (BEVs, PHEVs). The decisions of consumers are exhibited by these models, which is worth exploring.

Consumer buying behaviour is believed to be an indissoluble part of marketing and Kotler and Keller states that study of consumer buying behaviour deliberating into areas as to how a consumer spends his income on buying goods, services, ideas and experiences by the consumer in order to gratify their needs and wants.

There is a difference between the buyer and the actual consumer, the person who is mind the goods may not actually consume it what is buying for someone else so there is a significant
difference between the buying intentions as we human tend to differ in our behaviour when we are buying goods for our personal use or for someone else.

Consumer buying behaviour is a multifarious, vibrant issue which cannot be dealt with easily and casually. Consequently, the perception of consumer buying behaviour has been mentioned in diverse ways by poles apart researchers.

1.10.1 Cognitive Approach

Evaluating the basics of conventional behaviourism, the cognitive approach portrays experiential action to intrapersonal cognition. The consumer is viewed as an ‘information processor’. According to cognitive approach electric car buyer will process the Information supplied to him. He is not expected to believe blindly on whatever information provided to the buyer. Marketers must observe this behaviour of the electric car consumers and must provide the most exact and relevant information regarding the electric vehicles that may be related to its range capabilities or in terms of charging time required or the overall cost of ownership.

The cognitive approach has extracted its great part from behavioural psychology which can map out its foundation back to eminent philosophers such as Socrates who was keen observer of the human psychology and produced various original piece of knowledge. It was only in 21st century when cognitive psychology truly got the place what it deserved and raised as a mainstream and functional field of research.

A well thought out and carefully designed model of buyer behavior is known as the stimulus-response model, which is depicted in the diagram below:

Stimulus-Organism-Response Model of Consumer Decision Taking Process:- In marketing and other stimuli provided by the marketer go into the customer’s “black box” and generate certain reaction. the marketer must work hard in making sure that what enters in the minds of the consumer and it’s the GIGO approach garbage in garbage out.

As a shoddy marketing plan without proper marketing research won't be able to generate the kind of response especially electric vehicle segment demands as it doesn’t have the history of proven track record satisfying the customer in the most delighted way. There is no dearth of information
available to the consumer so any marketing gimmick will be caught in a jiffy and don't provide success in the long run. Today electric vehicle required stimulus which are credible and can win the faith of astute customers.

1.10.2 Marketing stimuli for electric vehicles

**Product and services:** - electric vehicles should be manufactured in such a way that they appear robust, reliable, and user-friendly and last but not the least a prized possession. The proof of credibility of electric vehicle could be like they must be made to compete with the traditional vehicles and prove their superiority for example Electric vehicles can be made to participate in Himalayan rally, Buddha circuit car racing.

Many companies are already doing that for example Tesla is making their cars to compete against the industry heavyweights like Bugatti, Ferrari and it's actually beating them in terms of acceleration, upfront cost, driving range and running cost.

**Price Place and Promotion:** - electric vehicles in India should be priced as low as possible considering the Indian consumer’s sensitivity towards price. Competition for electric vehicles absolutely clear and it is traditional vehicles with internal combustion engine under their hood.

So, to give initial impetus to electric vehicles price should be kept to lowest possible range. In terms of Place, yes India is a vast market so to make electric vehicles available in every nook and corner of India would be an uphill task. But, even more critical thing is to provide charging infrastructure at every place a consumer can go to nearby cities and towns to buy electric vehicle but he can't go every day to charge their vehicle. Promotion of electric vehicles should be done in the subtest way which includes both ATL and BTL activities which makes their presence felt in the minds of consumer

**Other Stimuli**

**Economic:** - Today India bears the brunt of import of crude oil over its current account deficit which is hovering around 1.5% of the total GDP of India and various other aspects as well. As India import more than 80% of its total crude oil requirement, there is a staggering number given
any parameter of a healthy economy. Electric vehicle could be proven as Panacea for the developing economy like India.

Technical: - with the advent of technologies like fuel cell which primarily used hydrogen to power the electric vehicles and emission fuel cell technology is only water vapors is hydrogen being available in abundance in the environment and water vapor does no harm to the environment it's far better technology to be adopted for electric vehicles.

Even now we are shifting from existing Acid-Lead base batteries to the Lithium ion batteries; this is given great push electric vehicles in terms of its driving range and reduction in charging time. These sort of technological developments Instill great confidence in consumer’s mind. Writing on the wall is very clear that future of electric vehicle is very bright.

Political: - Political will is always required to execute any change in the country. Indian government is hell bent upon implementing the production and usage of electric vehicle in Indian transportation system. Government wants to completely get rid of Internal Combustion Engines by the year 2030. Recent statements of made by the Indian political leaders like Mr Nitin Gadkari, our honorable minister for Road Transport &Highways, said“ diesel or petrol car Banane walo ka Baja Bajana Padega” Shows the clear intent of government for bringing electric vehicles as a main source of transportation in India.

Indian government recently ordered 10,000 electric cars to TATA motors to be used by government officials. So, Indian government is leading by the example and is very serious about the environmental concerns and economic betterment of the country.

Culture: -In India we have to develop the culture towards environmental sensitivity. As, then only will be able to build the society of people who show a positive intent towards the environmental friendly products. Norway is the world leader in electric vehicles usage as it uses highest percentage of electric vehicles in comparison to the total number of vehicles used in the country. Culturally, Indians are infamous for showing their apathy towards the environment saving.

We are more interested in saving money even if we have to compromise on the environmental damage caused by our vehicles. We have to understand that any new technology doesn't come at
a cheaper price and we have to shell out some extra money so is the case of electric vehicle. In India we have to develop that culture where people think that this extra money that they are paying is their contribution towards the saving the environment.

After all these stimulus things enter in to consumer’s black box which is influenced by consumers’ perception, learning, motivation, Memory Attitude. After that buying process starts.

1.11 Stages in the buying decision-making

Stage 1- Recognition of an unsatisfied need

At this stage of the process purchaser comprehend that they have an unmet need that is yet to be fulfilled. For example, for example, Traditional vehicles that we are currently using is definitely meeting our commuting needs but taking a heavy toll on the environment and as well as rising cost of oil putting extra pressure on our already leaking pockets.

So at this stage many consumers might recognize their unsatisfied need of buying an alternative fuel vehicle which is not hard on the pocket and it is a delight to the nature as well but Consumer is not able to determine how this need will be contented.

Stage 2- Information search

At this stage consumer is required to do information search. At this step consumer might fine information from both informal and/or formal sources. As conversed above, you may have recognized that an unfulfilled need for electric vehicle exists. But, as of now, consumer is not sure as to how this void will be filled.

A purchaser can acquire information from numerous sources:

Stage 3 - Informal Sources of information

Experiential sources: test driving or past memory of the electric cars.

Personal sources: close neighbors, family members, friends at office and home.

Stage 4 - Formal Sources of Information
Websites: - Zig-wheel, Carwale.com, Cardekho.com, YouTube etc. give lots of credible and accurate information about electric vehicles.

Other sources: point-of-sale displays, dealers, salespeople etc.

Public sources: newspapers, radio, television, consumer organizations, specialist magazines like Auto X, first issued in 2006, Auto car India, Overdrive etc.

The helpfulness and sway of these sources of information will differ according to product and buyer. According to research done by various researcher customers value informal sources of information like words of mouth more than formal sources as most of the formal sources of information are paid form of marketing.

Finding and concentrating on the most appropriate sources of information from which actual buyer of the electric vehicle obtain information while making their purchase decision is going to be a major challenge for the marketing team. As it is a developing sector and no one has much knowledge about the marketing of the electric cars making the situation even more complicated is that not much research has been done in the context of marketing of electric vehicle.

Stage 5 - Evaluation of the Alternatives

At this stage, the patron must choose between the alternative products, services and brands available in the market at his critical juncture information obtained from previous stage must be of great use.

1.11.1 How does the buyer use the obtained information?

An important deciding factor for the extent and intensity of evaluation is whether the purchaser sense "involved" in the product. The word involvement conveys the degree of professed relevance and personal importance be an adjunct to the choice.

When a purchase is of high involvement, the customer is likely to carry out a far-reaching evaluation. High-involvement purchases comprise those associated with heavy expenditure or huge personal risk, for example, purchasing a home, a car or making long term investments like investing in mutual funds with a lock-in period.
Electric vehicles come under the category of high involvement purchase as in India vehicle once bought is used for at least 3 to 5 years by the single owner so in terms of time for which a vehicle is kept it is a high involvement purchase. Even going by the current standards of electric vehicle prices the investment of 6 to 8 lakh rupees is not a small amount for average Indian consumer so according to the cost involved in buying an electric vehicle it is a high involvement purchase.

In India car is not only a utility product but also a status symbol for the owner so consumer put high personal value tag to it. So by no means buying an electric car is a low involvement purchase and a lot of deliberation goes into the evaluation of alternatives.

Why it is imperative for a marketer to understand the evaluation process of customers of electric vehicles? The answer lies in the kind of information that the marketing team needs to supply patrons in different buying circumstances.

In decisions concerning high-involvement, the marketer needs to provide the most credible information like data of testing done by some independent agency regarding the good consequences of buying. The sales department may need to stress upon the significant characteristics of the electric vehicles, the advantages offered by electric vehicles over its competition which are basically traditional cars only the best way to educate consumer at this stage will be to give them hands-on experience by encouraging them to take test drive of the product in the expectation of getting a sales done.

Actual purchase decision

A need has been recognized, research has been finished and the purchaser has made up his mind regarding make a purchase. However, this doesn’t mean assurance of buying the product. A purchaser could still be diverted towards the competitors. Marketing becomes even more important at this stage contrary to the belief of many marketers.

Marketing to this stage is uncomplicated just keep the bottlenecks away. Things we should keep in mind are check electric cars purchase process online. Is it complex? Are there too many hurdles? What is the load time of your website? Is your website mobile friendly or not? Ask these significant questions and make alterations wherever required.
Again I would like to mention Tesla an example to follow in India. you can book your electric car from their website only you just have to follow simple steps and you will be allotted booking number along with the time specified for the delivery of the car, loading time of the website is really quick, the graphic user interface of the website is really user friendly and the website can be operated from mobile phones as well. They have a single platform for the entire globe, you can select your region and then you can check the availability of different models within your region.

As we don't have a homegrown established player in the electric vehicle segment so as of now we have to emulate the best practices adopted by the foreign players. this will save time and energy and will cut short the learning curve for Indian electric vehicle manufacturers

Post-Purchase Evaluation

When a customer has bought the product, things don’t end here. In fact, real work starts from here, future revenues and customer fidelity can be lost easily. As a disgruntled customer is 6 times more likely to spread negative word of mouth about the product in the market then the delighted customer, so marketer of electric cars will have to make sure that buyers of electric vehicles feel not only satisfied but delighted after the purchase, they can do so by taking time to time feedbacks about the performance of the product and taking corrective measures if the need exists.

A manufacturer must invest in the product quality as they are selling electric vehicles which are of high involvement purchase, an unsatisfied customer might never come back in the future so you have to be right the very first time. Because of the augmentation of social media these days, it has become very easy to spread negative word of mouth and with the click of a button, the bad experience of a customer might propagate to the Millions of other prospective buyers.

Cognitive Dissonance:- It is quite universal for customers to experience apprehensions after making a purchase decision. This occurs from a concept recognized as "cognitive dissonance". It is but natural to come into the consumer’s mind that alternative product would have been the better choice as grass on the other side is always greener.
Marketers at this stage have one weapon at the disposal that is a comparative analysis of their product with the competitors but they should keep this in mind that this comparative analysis must be done by some accredited agency who have authority and experience and is well regarded as unbiased. In many markets such as Australia, electric cars have hit the dead end because of the sorry state of affairs that existed for electric vehicles there, low-quality product with compromised features list will not be a winning strategy in the long run.

Price divergence:-Here is a comparison of prices of few selected hybrid-electric vehicles models with their incremental price over the traditional gasoline engine version. It’s quite evident that an upfront price disparity is them because of primarily attributed to the high cost of the electric batteries. The increasing steadfastness and decreasing maintenance costs linked with electric vehicles reduce the total cost of ownership of electric vehicles in contrast to traditional fossil fuel powered vehicles. Rising prices of fossil fuels globally further lower the total cost of ownership of electric vehicles.

**Table 1.5: Hybrid-Electric Vehicles Incremental Price**

<table>
<thead>
<tr>
<th></th>
<th>Ford Focus ST</th>
<th>Ford Focus Electric</th>
<th>Mercedes S Class</th>
<th>Tesla Model S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sale price</td>
<td>$24,495</td>
<td>$39,995</td>
<td>$92,350</td>
<td>$87,400</td>
</tr>
<tr>
<td>Battery replacement</td>
<td>N/A</td>
<td>$13,500</td>
<td>N/A</td>
<td>$12,000</td>
</tr>
<tr>
<td>Major engine repair</td>
<td></td>
<td>$4,899</td>
<td>$18,470</td>
<td>N/A</td>
</tr>
<tr>
<td>(1/5 original sale price)</td>
<td>$4,899</td>
<td>N/A</td>
<td>$18,470</td>
<td>N/A</td>
</tr>
<tr>
<td>8-year fuel costs</td>
<td>$16,222</td>
<td>$5,067</td>
<td>$16,846</td>
<td>$5,262</td>
</tr>
<tr>
<td>(15,000 miles/year)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total costs</td>
<td>$45,616</td>
<td>$58,562</td>
<td>$127,666</td>
<td>$104,662</td>
</tr>
</tbody>
</table>

Range:-As per the report of the U.S. Bureau of Transportation Statistics, the typical American drives not more than 40 miles in one day. The range of EVs is now near twice from the initial versions of electric vehicles which are a significantly higher range, these days electric can travel
up to hundreds of kilometres in a single charge. In illustrations where this statistic doesn’t seem to be appropriate, novel technological development in the Eva Rena has presented answers.

There are numerous ways to deal with the daily feasibility anxieties stemming from the availability of sufficient charging infrastructure EVs. Innovative lithium-ion battery technology has amplified competence in power storage space, Permitting the usage of small batteries with increased power storage when compared to acid-led batteries of equal size. Electric vehicle charging infrastructure is becoming more accessible to common people; many govt. agencies in partnership with private businesses are putting in place electric vehicle charge stations for their customers, and improvements in fast charging technology have significantly deceased the time necessary to charge a battery of an electric vehicle.

Ultimately, the soul saviour could be the battery exchange programs which can increase the range and existence of EVs. Putting all of these qualities are working together to make electric vehicles more viable option compared to the traditional gasoline engines. Moreover, the stipulation of their producer, driving environment and driving approach also has huge bearing over the range of electric vehicles.

1.12 Allied Infrastructure

The most important support an electric vehicle needs is charging stations as it largely determines the consumer confidence in all battery-electric vehicles. EV charging station which is installed at their home; where he/she will be charging their cars maximum times. Even government is not far behind they are installing public charging stations at the site of their operations because electric vehicles have become higher-flying.

This gives additional advantage to the owners of electric vehicles as they can recharge their vehicle while they are outside for work, thereby further improving the electric vehicle’s driving range. The greater than before number of publicly available charging station have greatly increased the power of electric vehicles and now they can compete easily with traditional vehicles that have advantage of low refuel time and the widely availability infrastructure of fuelling stations.
A well trained workforce for servicing of electric vehicles is of paramount importance that includes: automobile engineers and mechanics skilled in electric vehicles maintenance and repair; electricians skilled in the right installation of different types of electric vehicles and primary responders educated to act in response in urgent situation pertaining to electric vehicles with high-power batteries. So Electric vehicle charging infrastructure is an essential constituent of the electric vehicles infrastructure, but no one can undermine the importance of trained workforce to help consumer stay worry free.

Dedicated teaching and training programs are being developed and promoted all of these areas through government and private partnerships, community colleges, universities and courses providing great impetus to the adoption of electric vehicles.

1.12.1 Vehicle Protection

Budding electric vehicles patrons may have apprehension for vehicle security with the company of a high-power electric battery. The uncertainties of what may occur if the vehicle break down, or concerns in case a collision, or how it will react to hostile weather conditions like extreme heat and cold, or what could occur in extreme rain conditions, every factors act as a deterrent to possible patrons.

In reply to these apprehensions, electric vehicles producers have installed the electric batteries in properly preserved enclosures that have surpassed all vehicle safety and testing standards, they have added protection by insulated all high-voltage lines. Furthermore, they have installed a security apparatus that disengage the electrical systems in case of disaster. As additional protection, producer provides model explicit directions for primary responders to educate them on how to react to crisis situations securely and neutralize the high-power systems to decrease risk of damage to the driver and the co-passengers.

1.13 Research Gap

The study on secondary data identified that there has been lot of work done on the concept of customer purchase behavior towards Hybrid and Electric Vehicles.
Many researchers have worked upon issues related to the practical & possible infrastructural aspects like travel distance, charging station, cheaper batteries, lower emissions and environmental safe, etc.

However, very few studies were conducted on the consumer perception, awareness, satisfaction, brand loyalty and government initiatives altogether. Also, no study specific to this paradigm was conducted for the buyers residing in NCR. The studies based on NCR’s buyers are with different paradigms.

The present study emphasizes upon the consumer perception, awareness, satisfaction, brand loyalty and government initiatives in Faridabad (National Capital Region). This is to boost up business related strategic action plan in this concrete area of business.

1.14 Research Objectives

- To study the government policies and recent development in hybrid and electronic vehicles industry in India.
- To examine the changes in consumer’s attitude in espousal towards the electronic vehicles.
- To Identify and analyze the factors considered by consumer in preferring hybrid and electronic vehicles.
- To suggest the strategies to bridge the action gap for electronic vehicle manufacturers.

1.15 Chapter Organization

This thesis has been organized into following chapters

Chapter.1 Introduction- In this chapter author have explored the current scenario of electric vehicles in India and analysed the research gap that paves the way for outline of the research and the structure of the thesis.

Chapter.2 Literature Review- this chapter provides background of the researches done in context of espousal towards electric vehicles. This has helper author to gain more clarity as to how further research should be conducted.
Chapter.3 Research Methodology- this chapter introduces the interdisciplinary research design and the methodology used in this thesis work.

Chapter.4 Data Analysis and Interpretations- this chapter presents the main interpretations from the analysis of data collected from respondents and discussion of these interpretations according to the four themes:

a) What is the profile of the users of private vehicle in Faridabad?
b) Are these consumers aware of and concerned about environmental issues?
c) Do these consumers have or think to adopt environmentally friendly behaviour?
d) Does the concern for and awareness of environmental issues impact on consumers “Hybrid/Electric vehicle purchase decisions?”

Chapter.5 Summary and Conclusions- this chapter concludes the work with a final discussion and recommendations based on the findings of previous chapter for espousal of electric vehicles.