Enablers and Barriers for the adoption of E-Cars in Delhi-The Consumer Perspective

A Thesis submitted to the
University of Petroleum and Energy

For the award of
Doctor of Philosophy
in Management

By Gaurav Gupta

December, 2019

SUPERVISOR(s)

Dr. Rajesh Gupta

Dr. S. Selvam

UPES
UNIVERSITY WITH A PURPOSE

Department of Management
School of Business
University of Petroleum & Energy Studies
Dehradun-248007: Uttarakhand

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DECLARATION

I declare that the thesis entitled **"Enablers and Barriers for the adoption of E cars in Delhi-The Consumer Perspective"** has been prepared by me under the guidance of Dr. Rajesh Gupta, Senior Associate Professor of CCE, UPES. No part of this thesis has formed the basis for the award of any degree or fellowship previously.

Gaurav Gupta 21/08/2020

Gaurav Gupta

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Date: 21/08/2020

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CERTIFICATE

I certify that **Gaurav Gupta** has prepared his thesis entitled **"ENABLERS AND BARRIERS FOR THE ADOPTION OF E-CARS IN DELHI - THE CONSUMER PERSPECTIVE"**, for the award of Ph.D. degree of the University of Petroleum and Energy Studies, under my guidance. He has carried out the work at the Department of CCE, University of Petroleum and Energy Studies.

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स्वहित एवं राष्ट्रहित में ऊर्जा बचाएं

स्वच्छ भारत
एक कदम स्वच्छता की ओर

एनपीटीआई के साथ पावर सेक्टर का सुनिश्चित सम्पूर्ण विकास

Abstract

India has become home to the world's one of the largest automobile Industry and thus there is a phenomenal growth in the number of vehicles specially in two wheelers and cars. India currently contributes a major proportion of global car sales. With this exponential growth there are two major implications - energy security and pollution and both are critical.

India heavily depends on imported crude oil & petroleum products to meet the numerous energy demand. As per the data there is a huge gap between the demand and supply of oil and this gap is increasing year by year. In India the Transport sector is the largest consumer of crude oil & petroleum products. Within transport sector Road transport is one of the major consumers of crude oil & petroleum product. As world is already facing the challenge of oil scarcity there is a huge need of energy efficient road transport vehicles specially in country like India where oil import is too high.

Road transport is one of the major contributors of pollution too. It is mainly because of increased number of vehicles however other sources of pollution are also exist. Pollution due to road transport is very harmful for the health? It is one the major cause of various disease like cardio, lungs, brain & cancer. It has been found that cities with high car-ownership levels have PM10 concentrations above the standards set by the World Health Organization (WHO). Delhi has been declared the most polluted city of the world and it also has maximum number of cars in India. So, there is a huge need of zero emission vehicles to control the pollution level.

Electric - Car being energy efficient & zero pollutant may become one of the most commendable solution to this problem but unfortunately the adoption of e - car in Delhi is almost nil. Even Government is heavily investing but still haven't reached at potential. There have been various initiatives by the Government of India to promote electric vehicles in India but it is ineffective.

So, this research is an attempt to explore the enablers, barriers & measures for the adoption of e car in Delhi to combat with energy security and pollution -health.

To conduct the research the research methodology used by researcher was mixed method i.e. both qualitative and quantitative. The researcher has decided to opt Exploratory sequential mixed method. In the exploratory sequential research approach, the researcher first begins with the qualitative research phase and explores the view of participants, then data then analyzed and information is used to build into a second quantitative phase. Within qualitative research methods coding methods and Grounded theory was used and within quantitative research methods factor analysis and correlation was used.

The qualitative study used semi structured interview (questions based on parameters collected from literature review) method to collect the data from various stakeholders like govt. agency, Private agency, semi govt. agency, dealers, manufactures etc. and then coding methods and Grounded theory is used to accomplish the first objective as data is coded to identify emerging categories and then to generate substantive theory.

The quantitative study used questionnaire method for collecting the data from real consumers i.e. e car users. The questionnaire was prepared from the result obtained from objective 1. Necessary quantitative research methods were applied on the collected data from e car users for the quantitative analysis purpose.

Finally, researcher concluded about the enablers, barriers and measures and also developed a model for the same.

Acknowledgments

I would like to thank several people who have been of great help during my PhD journey. First of all, I would like to thank my former Internal guide Dr. Ashish Tripathi and Co -guide Dr. Anil Kumar who were very supporting and painstaking in guiding me in the start of the journey.

The most important contribution came from my Internal guide, Dr. Rajesh Gupta (Senior Associate Professor-UPES). I am indeed fortunate to have had him as my guide and then the privilege of his insightful supervision for this work. This thesis would not have been possible without him, who guided my efforts and encouraged me throughout the years.

Then I would like to thank my external guide Dr. S. Selvam (Director National Power Training Institute (Southern Region, Neyveli). The trust, support and ‘the freedom to create’ that he has provided throughout the project is very much appreciated.

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Last but not the least I owe a debt of gratitude to my wife Geeta, my son Pradhumna and my father. They have been there to support and encourage me with great patience and understanding during my PhD. They made sure that I had best of everything at home, which is so critical to put in long hours in research.

I am grateful to all the people who I am not able to list but have helped and supported me over the past five years.

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Chapter 1

Introduction

India has attained new statures and rising at a fast rate in the automobile sector day by day. The vehicular industry of India is one of the major industries in the world and has an annual production of 23.96 million vehicles in FY 2015-16. It also contributes around 7% for the country's Gross Domestic Product (GDP). (*Source: Karunakar, April 2017)* The growth of Indian auto Industry is noteworthy from its inception. There is an extraordinary development in the number of vehicles specially in two wheelers and cars.

Along with the necessity car has become a status symbol too in India. Depending on the income level people even have two or three cars. As income level rise people tend to buy second or third. It has been found that level of car proprietorship grows by 1.7 per cent when per capita income grows by one per cent, the (*POLICY BRIEF June 2014* TERI).

It has been found that the car-ownership levels in the USA, Japan, and Europe is above 450 cars per 1,000 persons while in India car ownership is 13 cars per 1,000 population and currently the number of cars is about 15 million cars, so it can be seen that India may also go in the same direction. . As far as Delhi is concerned the ownership level of Delhi is about 157 cars per 1,000 people. Many estimations have projected that by 2025 the increase in the number of cars will be around 35 cars per 1,000 population in India. This may lead to around 45–60 million cars in Indian roads while in some cities the count may be around 300 cars per 1,000 population. This may have a considerable increase in the total number of cars in Delhi from 2 million in 2011 to about 10 million by 2025 i.e. about 380 cars per 1,000 population in Delhi. The exponential expansion in the number of cars will have solemn consequences for energy security and air pollution. *(Source: Proliferation of Cars in Indian Cities, TERI policy brief, Issue 12 June 2014)*

With this exponential growth there are two major implications - energy security and pollution - health and both are critical.

In India, Delhi is one of the main impacted cities in term of energy security and Pollution - health. A city of about 20 million has almost about 10 million vehicles. As per the economic survey(2017-18) every second person in Delhi owns a vehicle which leads to 556 vehicles per one thousand people.(Source :auto economics times) .More than one crore vehicles have been registered in Delhi i.e. 1,05,67,7129 till May 2017*(Source: Transport department)* and cars have a significant number. The total number of registered cars in Delhi are 31,72,842(*Source: Transport Department)* till may 25 2017.

As per a new study by Centre for Science and Environment (CSE) it has been found that in the current scenario the total number of cars entering daily in Delhi are more than that got registered in the city in one year - 2014-15. Break-up confirms that 55% were cars out of all the vehicles entering the city. As per the data the total number of cars enter the city from various entrance were around 4 lacs i.e. almost double to the total number of 1.65 lakh cars registered in Delhi in the year 14-15 *(Source:* https://www.downtoearth.org.in/news)

Against a high of 9.9% in 2015-16, the overall growth of vehicles at 5.8 % in 2017-18 is the lowest since 2013-14. Compared with a growth rate of 5.5% in 2016-17 however cars saw 2.9 % rise in 2017-18(Times of India, Feb 24,2019)

Thus, cars play an important role in the road transport in Delhi. As the car ownership increases the oil demand grows rapidly and pollution too.

First Implication-Energy Security:

Our country heavily depends on imported crude oil & petroleum products to meet the numerous energy demand. Demand and supply data of oil shows huge gap which is increasing with time. *(Source: U.S. energy information administration 2014)*. It has been found that 55% of total available petroleum products is consumed by transport sector that is the largest amount of petroleum products consumed by any sector. It has been seen that 98% fuel for the transport sector comprises of petroleum products while only remaining 2 % is fulfilled by electricity (*TERI 2012).* According to the information by MOPNG in 2014, 99.6 % of Petrol and 70% of Diesel is used by Transport sector. *(Ministry of Petroleum & Natural Gas,2014).* Within transport sector Road transport is one of the major consumers of crude oil & petroleum product. *(Source: Petroleum Conservation Research Association).* More than 90 % of the energy is consumed by road transport among this the 65% used by road passenger transport and 35% by road freight transport. *(Source: Proliferation of Cars in Indian Cities,2014 TERI).* Within road transport**,** cars consumed 34.33 %

of Petrol and 13.15% of Diesel**.** *(Ministry of Petroleum & NaturalGas,2014).* As world is already facing the challenge of oil scarcity *(Source: BP research)* there is a huge need of energy efficient road transport vehicles specially in country like India where oil import is too high *(Source: U.S. energy information administration 2014)*. In India the number of vehicles is maximum in Delhi *(Source: data.gov.in)* thus a huge demand for oil too.

<u>Second Implication-Pollution & Health:</u>

Road transport is one of the major contributors of pollution *(Source: System of Air Quality and Weather Forecasting and Research (SAFAR))* it is mainly because of increased number of vehicles however other sources of pollution are also exist. The flaming of fossil fuel such as, oil & petroleum product yields chemical pollutants like CO, CO2, SO2 in to the atmosphere. Which are very harmful for the health? Chemical pollution is one the major cause of various disease like cardio, lungs, brain & cancer.

The increase in the number of personal vehicles also result in growth of vehicular pollution in cities. There is a standard set by the World Health Organization (WHO) to find out the PM10 concentration and it has been seen that this standard has been violated by cities with high car ownership. *(Source: Proliferation of Cars in Indian Cities, TERI policy brief, Issue 12 June 2014)*

Delhi has been declared the most polluted city of the world *(Source: WHO report, live mint*). In spite of using CNG & Metro the pollution level is much above the standard. So, there is a huge need of zero emission vehicles to control the pollution level.

Electric - Car being energy efficient & zero pollutant may become one of the most commendable solution to this problem but unfortunately the adoption of e - car in Delhi is almost nil.

Even after heavily spending by government it still hasn’t touched at potential.

Various initiative has been taken by the government to promote electric vehicles in India but it is ineffective.

So, this research is an effort to explore the enablers, barriers & measures for the adoption of e car in Delhi to combat with energy security and pollution -health.

Worldwide automobile production since 2000:

Due to internationalization of the worldwide production places, the market share of each country has been changing strongly in the world automobile production.

The graph represent a continuous growth of the worldwide motor vehicle production with exception of the economic crises 2001 and 2008/2009, affecting the total industrial production.

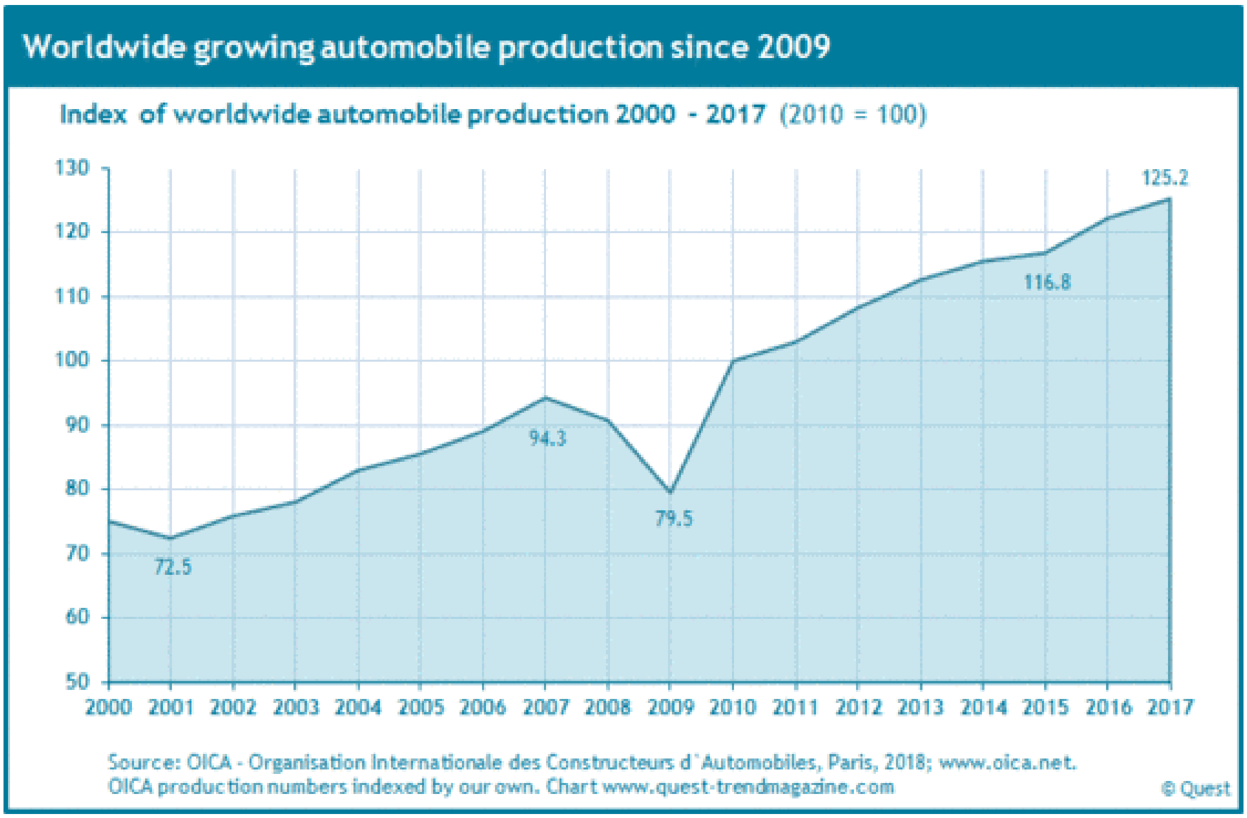


Figure 1.1: Worldwide growing automobile production since 2009

Source:http://www.quest-trendmagazine.com/en/automobile-industry/internationalization/internationalization-of-automobile-production.html

The Ranking & market share of ten largest automobile countries from 2000 to 2017

Ranking and market shares of the 10 strongest automobile countries 2017 and 2000	Ranking		Market shares	
	2017	2000	2017	2000
China	1	8	29.8%	3.5%
USA	2	1	11.5%	21.9%
Japan	3	2	10.0%	17.4%
Germany	4	3	5.8%	9.5%
India	5	15	4.9%	1.4%
South Korea	6	5	4.2%	5.3%
Mexico	7	9	4.2%	3.3%
Spain	8	6	2.9%	5.2%
Brazil	9	12	2.8%	2.9%
Canada	10	7	2.3%	5.1%
Market shares 10 countries			78.4%	75.5%
Source: OICA - Organisation Internationale des Constructeurs d' Automobiles, Paris, 2018; www.oica.net. Market shares consist of cars, LCV, HCV and buses. Own calculations.				

Table 1.1: Ranking & market share of ten largest automobile countries from 2000 to 2017

India jumps from fifteenth position to fifth position in seventeen years in worldwide automobile production while china jumps from eighth position to the first position and produces more vehicles than USA, JAPAN & Germany altogether. Almost every third vehicle produce in the world is manufactured in china.

Source: http://www.quest-trendmagazine.com/en/automobile- industry/internationalization /internationalization-of-automobile-production.html

Worldwide auto production relocated to developing countries

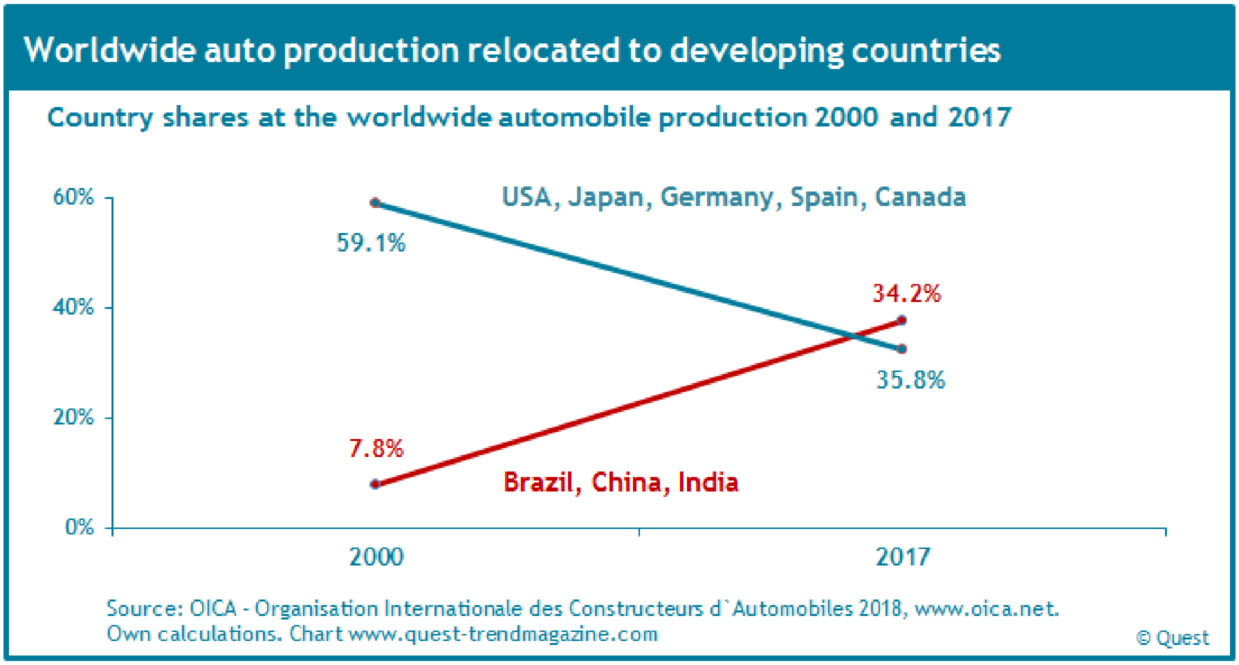


Figure 1.2: Worldwide auto production relocated to developing countries

It has been seen from the graph that almost 60% of world-wide motor vehicle production was done by the five countries USA, Japan, Germany, Spain and Canada in year 2000. This world market share has been almost cut in half to 35.8 % after seventeen years.

In year 2017 the worldwide automobile production share from the three countries Brazil, China and India have increased to more than quadrupled to 34.2% while in 2000 scarcely it was 8%.

Source:http://www.quest-trendmagazine.com/en/automobile- industry/internationalization /internationalization-of-automobile-production.html

ICE Car growth worldwide:

This statistic signifies the number of cars sold worldwide from 1990 through 2018.

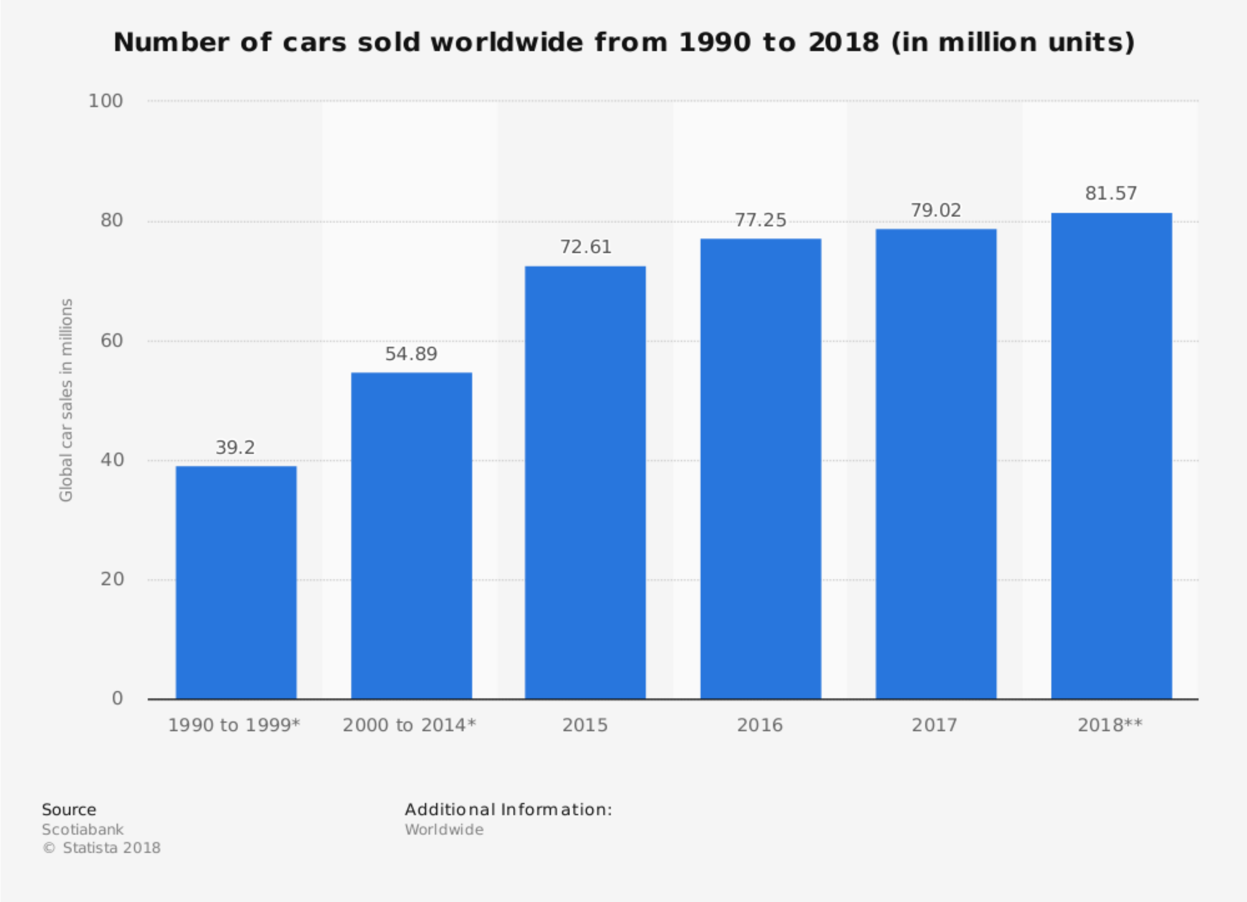


Figure 1.3: Numbers of cars sold worldwide from 1990 to 2018(in million units)

Source: https://www.statista.com/statistics/200002/international-car-sales-since-1990/

Worldwide Car production from 2000 to 2017 (in million)

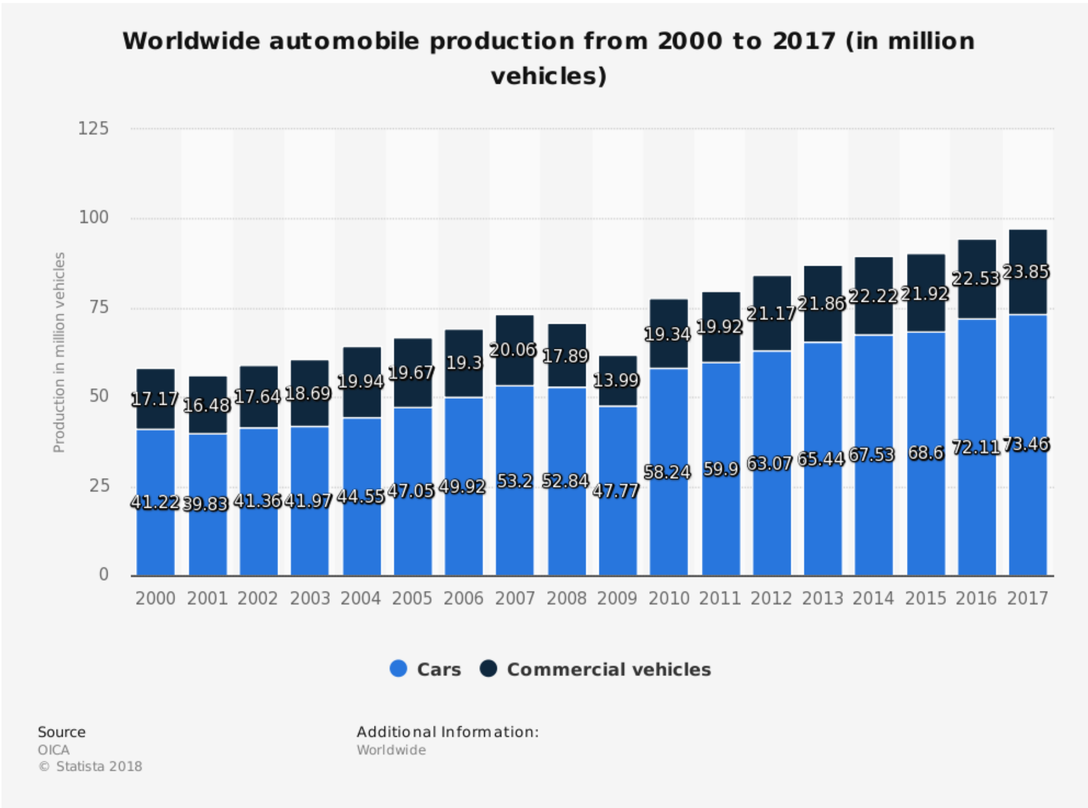


Figure 1.4: **Worldwide Car production from 2000 to 2017 (in million)**

In 2017 out of **the total motor vehicle** annual production in the world cars make up around **74%.** The largest producers of passenger vehicles were China, Japan, Germany, and India in 2017.

Approximate more than 70 million passenger cars were produced first time in a single year in 2016. China produce every third cars in the world**.** World's first largest car market is China which is almost 34 percent of the world's passenger vehicle production.

Source:https://www.statista.com/statistics/262747/worldwide-automobile-production-since-2000

Year	Cars produced in the world
2016	72,105,435
2015	68,539,516
2014	67,782,035
2013	65,745,403
2012	63,081,024
2011	59,897,273
2010	58,264,852
2009	47,772,598
2008	52,726,117
2007	53,201,346
2006	49,918,578
2005	46,862,978
2004	44,554,268
2003	41,968,666
2002	41,358,394

Table 1.2: Cars produced in the world

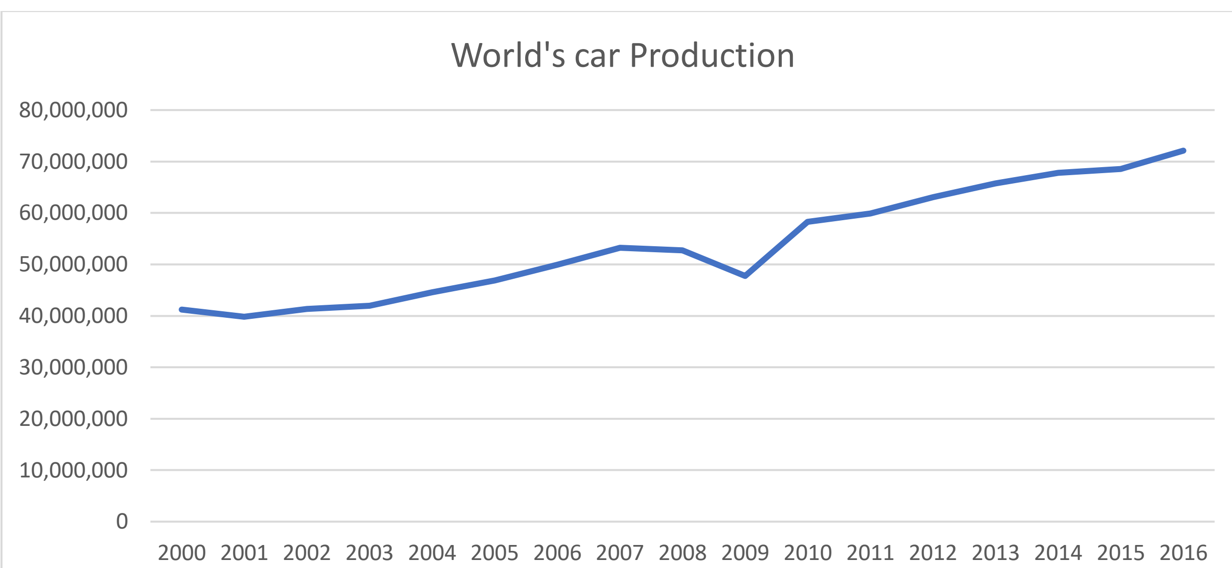


Figure 1.5: World’s car production

Global car production by country in 2016

Rank	Country	Cars produced	% of total world production
1	China	24,420,744	33.9%
2	Japan	7,873,886	10.9%
3	Germany	5,746,808	8.0%
4	USA	3,934,357	5.5%
5	South Korea	3,859,991	5.4%
6	India	3,677,605	5.1%
7	Spain	2,354,117	3.3%
8	Mexico	1,993,168	2.8%
9	Brazil	1,778,464	2.5%
10	UK	1,722,698	2.4%
11	France	1,626,000	2.3%

Table 1.3: global car production by country in 2016

<u>Global car production by country in 2016:</u>

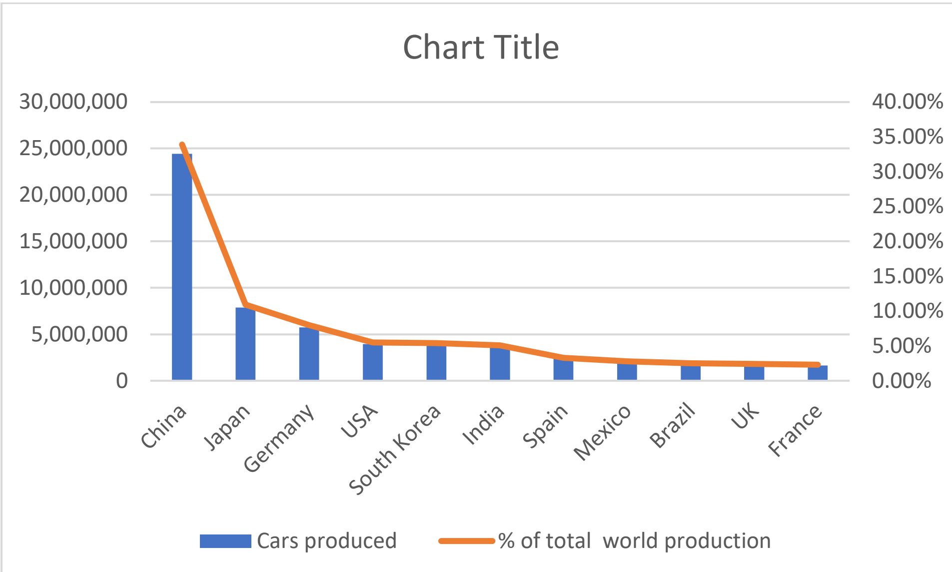


Figure 1.6: Global car production by country in 2016:

Source: http://www.worldometers.info/cars/

Projected passenger car production by countries in 2018

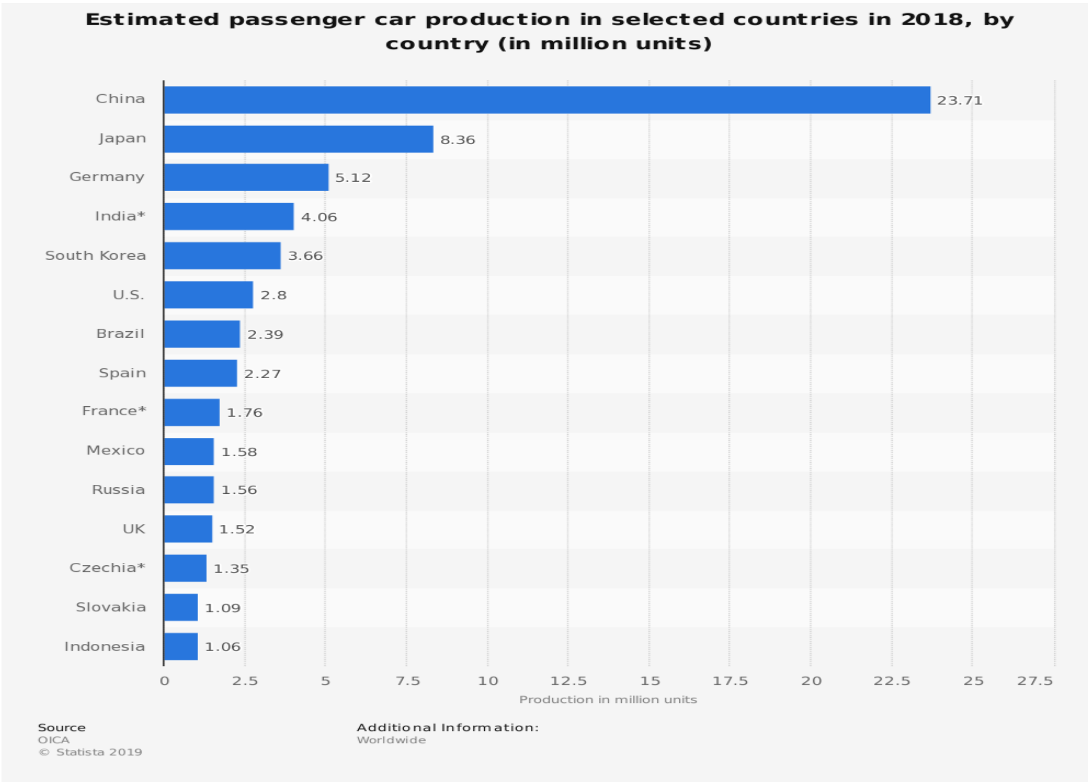


Figure 1.7: Projected passenger car production in selected countries in 2018, by country

India is on the edge of becoming a major producer of passenger vehicles: The quantity of Passenger vehicles produced in India is about 4 million units in 2018.

Source: https://www.statista.com/statistics/226032/light-vehicle-producing-countries/

<u>Automobile production trend in India</u>

Category	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Passenger Vehicles	32,31,058	30,87,973	32,21,419	34,65,045	38,01,670	4010373
Commercial Vehicles	8,32,649	6,99,035	6,98,298	7,86,692	8,10,253	894551
Three Wheelers	8,39,748	8,30,108	9,49,019	9,34,104	7,83,721	1021911
Two Wheelers	1,57,44,156	1,68,83,049	1,84,89,311	1,88,30,227	1,99,33,739	23147057
Grand Total	**2,06,47,611**	**2,15,00,165**	**2,33,58,047**	**2,40,16,068**	**2,53,29,383**	**2,90,73,892**

Table 1.4: Automobile production trend in India

Source: SIAM

Domestic sales trend in India

Category	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Passenger Vehicles	26,65,015	25,03,509	26,01,236	27,89,208	30,47,582	32,87,965
Commercial Vehicles	7,93,211	6,32,851	6,14,948	6,85,704	7,14,082	8,56,453
Three Wheelers	5,38,290	4,80,085	5,32,626	5,38,208	5,11,879	6,35,698
Two Wheelers	1,37,97,185	1,48,06,778	1,59,75,561	1,64,55,851	1,75,89,738	2,01,92,672
Grand Total	**1,77,93,701**	**1,84,23,223**	**1,97,24,371**	**2,04,68,971**	**2,18,62,128**	**2,49,72,788**

Table 1.5: Domestic sales trend in India

Source: SIAM

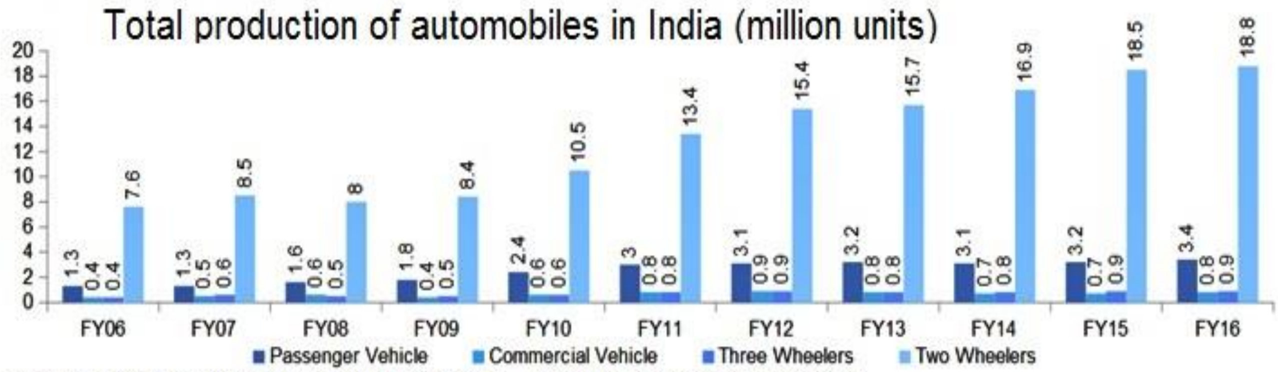
Automobile Exports Trends

Category	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
Passenger Vehicles	5,59,414	5,96,142	6,21,341	6,53,053	7,58,727	7,47,287
Commercial Vehicles	80,027	77,050	86,939	1,03,124	1,08,271	96,867
Three Wheelers	3,03,088	3,53,392	4,07,600	4,04,441	2,71,894	3,81,002
Two Wheelers	19,56,378	20,84,000	24,57,466	24,82,876	23,40,277	28,15,016
Grand Total	**28,98,907**	**31,10,584**	**35,73,346**	**36,43,494**	**34,79,169**	**40,40,172**

Table 1.6: Automobile Exports Trends

Source: http://www.siamindia.com/statistics.aspx?mpgid=8&pgidtrail=15

Production of automobiles increased at a CAGR of 9.4 per cent over FY06-16.During FY06-16, passenger vehicle segment witnessed the fastest growth, at a CAGR of 10.09 per cent, followed by two wheeler segment, which grew at a CAGR of 9.48 per cent during the same time period.



Source: SIAM, TechSci Research; Note: CAGR – Compound Annual Growth Rate

Figure 1.8: Total production of automobiles in India (million units)

Source: https://www.ibef.org/industry/india-automobiles/infographi

ICE Car growth in India:

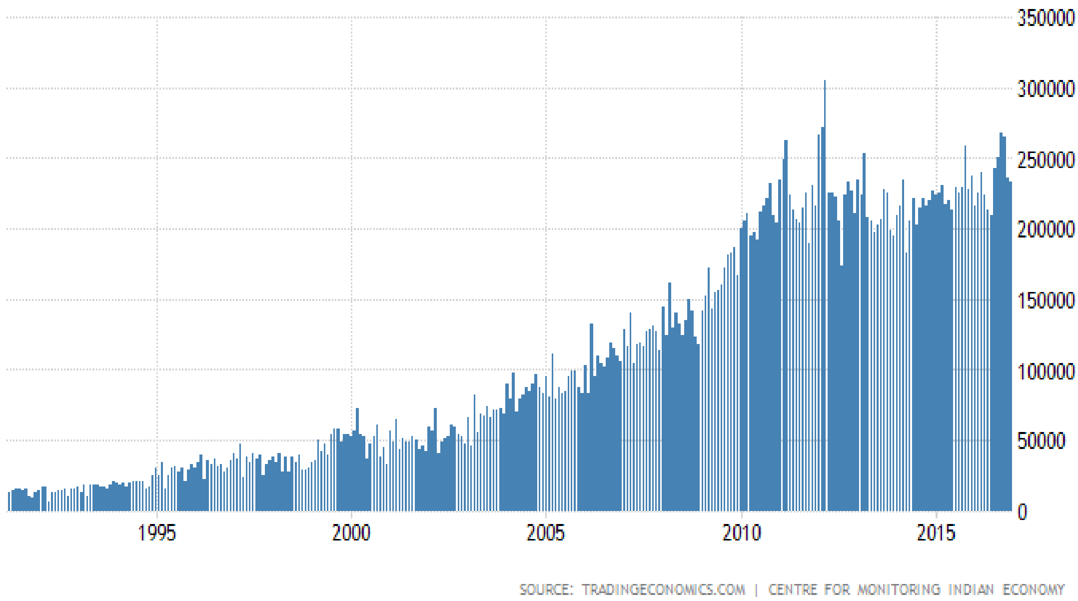


Figure 1.9: ICE Car growth in India

Source: Tradingeconomics.com

Production of Passenger 2001-2014-15

The 500301 Passenger cars were manufactured in 2001-02 and have grown to 2590917 in 2014-15. In percentage term the annual growth rate was be 32.14%.

Table 1.7: Production of Passenger 2001-201

	2001	**2014-15**	**Absolute growth**	**% Total Growth**	**Annual growth rate**
Passenger car	500301	2590917	2090616	417.87%	32.14%

Source: https://data.gov.in

Top Ten Towns with Highest Nos. of Car Ownership:

Figure 1.10: Top Ten Towns with Highest Nos. of Car Ownership

Source: https://www.mapsofindia.com/top-ten-cities-of-india/top-ten-highest-no-of-car-ownership.html

Rank	Major Cities of India	in numbers
1	Delhi	2172069
2	Bengaluru	800866
3	Chennai	653270
4	Greater Mumbai	617556
5	Hyderabad	558081
6	Pune	332293
7	Chandigarh	286584
8	Ahmedabad	239558
9	Jaipur	235310
10	Kolkata	222069

Table 1.8: India’s Top Ten Towns with Highest Nos. of Car Ownership

Source: https://data.gov.in/catalog/registered-motor-vehicles-million-plus-cities Last Updated on: March 16, 2016

Number of Vehicles/Cars in leading urban cities

City	31st March 2015
Delhi	88.27 lakh (24.9 lakh cars &53.56 two wheelers
Bengaluru	55.59 lakh (49.29 lakh two wheelers & car)
Chennai	44 lakhs
Mumbai	25 lakhs

Table 1.9: Number of Vehicles/Cars in leading urban cities

Source: http://timesofindia.indiatimes.com/city/bengaluru/At-55-lakh-Bengaluru-has-most-vehicles-plying-after-Delhi/articleshow/48260423.cms

Number of Vehicles/Cars in Delhi:

More than one crore vehicles have been registered in Delhi till May 2017.

More than one crore vehicles have been registered in Delhi till May 2017 The total number of registered vehicles were 1,05,67,712 till May 25 ,2017 as per the data recovered from the transport department -Delhi. Out of these the total number of registered cars are 31,72,842 and the major portion of the registered vehicles - 66,48,730 are scoters and motor cycles.

Source Vehicle numbers cross one crore mark in Delhi: PTI | Jun 4, 2017, 11:38 IST https://timesofindia.indiatimes.com/auto/miscellaneous/vehicle-numbers-cross-one-crore-mark-in-delhi/articleshow/58983958.cms

The Road Ahead

1-After being one of the largest auto industries in the world the contribution of the Indian auto Industry to GDP is around 7.1 %. It is expected that industry may rise at about 10-15 per cent to reach US$ 16.5 billion by 2021 from around US$ 7 billion in 2016. It may create 65 million extra jobs, contribute over 12 per cent to India's GDP and also has the possibility to make up to US$ 300 billion in annual revenue by 2026. Exchange Rate Used: INR 1 = US$ 0.015 as of March 1, 2018.

Source: https://www.ibef.org/industry/india-automobiles.aspx

2- It is said by the Maruti Suzuki India Ltd, India's largest car maker that by 2020 the home-grown car market may touch 5 million units in annual sales which in turn help the country to become the fourth-largest market in the world. Maruti Suzuki chairman Mr. R.C. Bhargava discussed about the same in an auto parts conference. Source: https://www.livemint.com/Industry/AAc3ZjIMCk4CrVsnuTUBdI/India-to-be-a-five-million-car-market-by-2020-Maruti-Suzuki.html

The Need of Electric Mobility

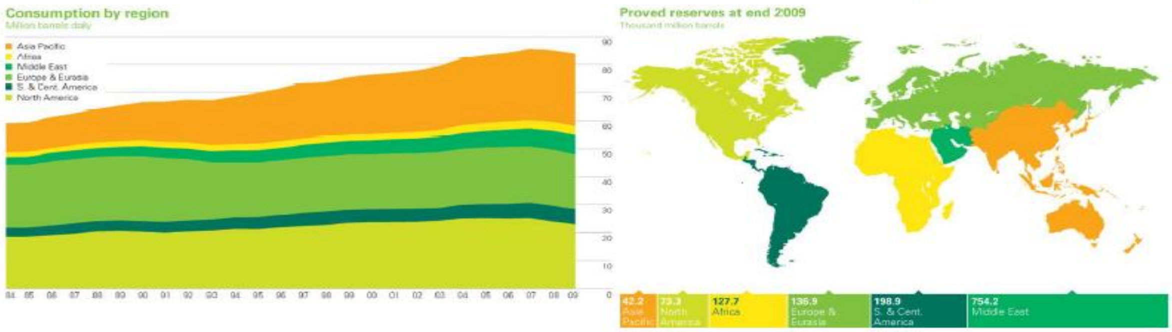
Problems with ICE Car Growth:

1-Fuel Security

2-Pollution & Health

Fuel Security:

Earth has oil for at most 43 years



Oil reserve now(mn Barrels)	1333200
Daily oil consumption now - (2009 end) mn Barrels	85
We can survive (days)	15685
Yrs we can live on the Proved - Yrs	43

**Assumption: Oil consumption will remain at present level.

*Source: BP research

Figure 1.11: Earth has oil for at most 43 years

As per the research it has been found that Global oil reserves increased by 15 billion barrels (0.9%) in 2016, which would be enough to meet 50.6 years of global production at 2016 levels.

Source: https://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy/oil/oil-reserves.html

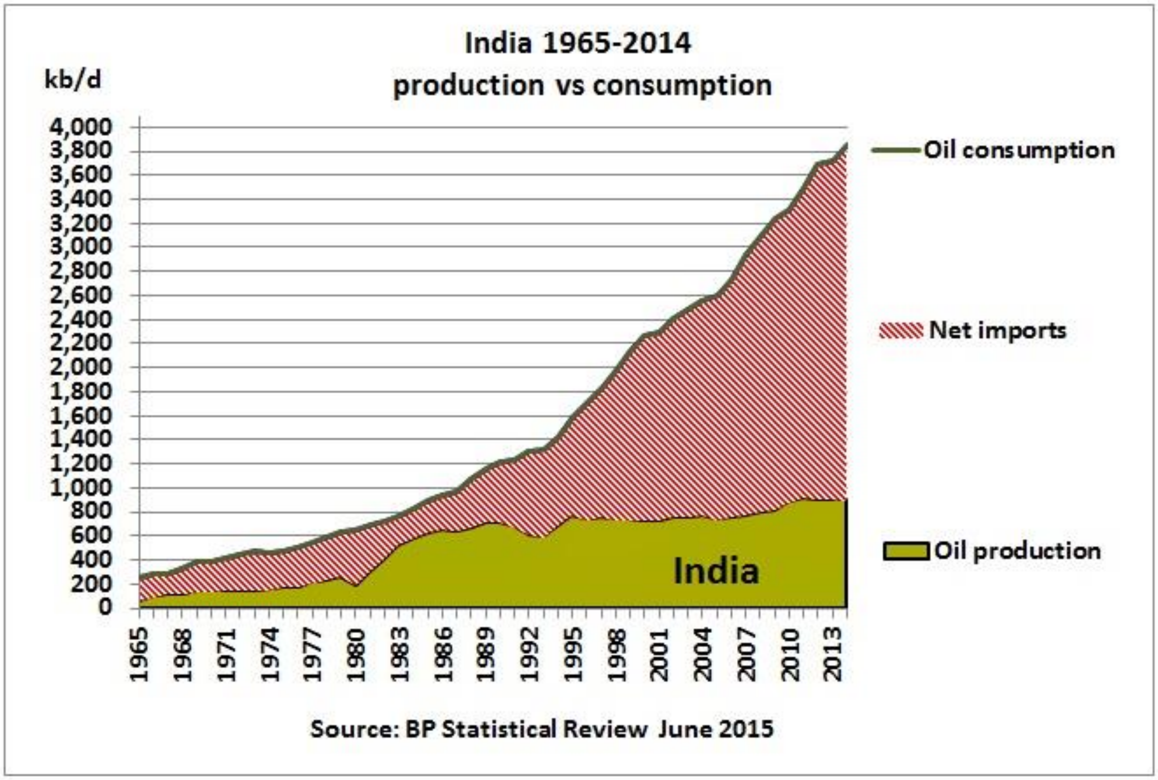


Figure 1.12: India 1965-2014 production VS consumption

http://www.resilience.org/stories/2015-06-23/asia-s-oil-consumption-at-record-high-while-production-peaked-in-2010/

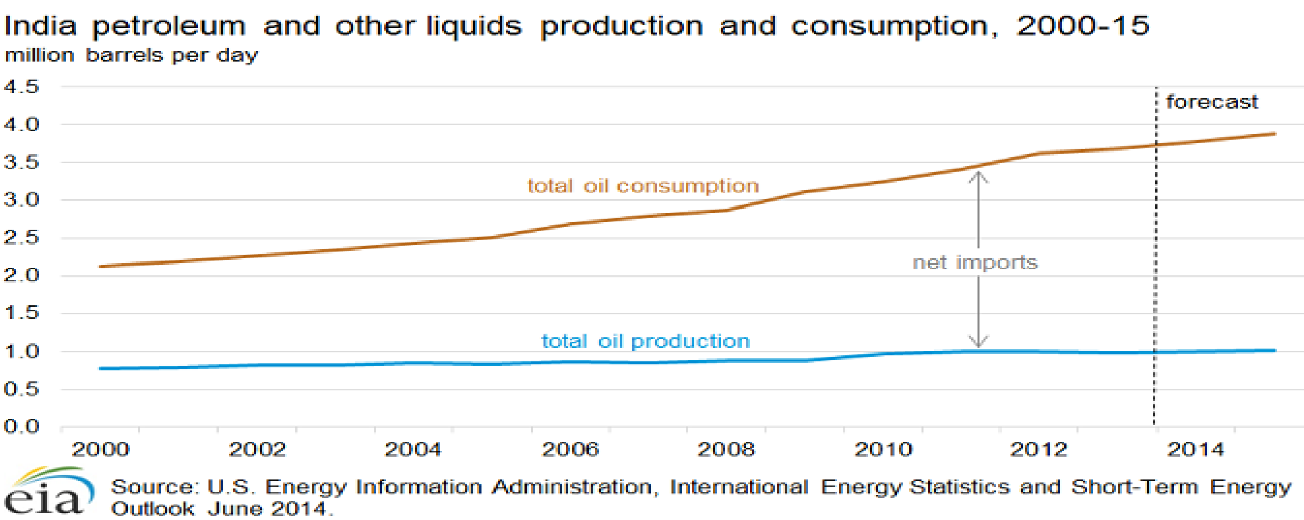


Figure 1.13: India petroleum and other liquids production and consumption, 2000-2015

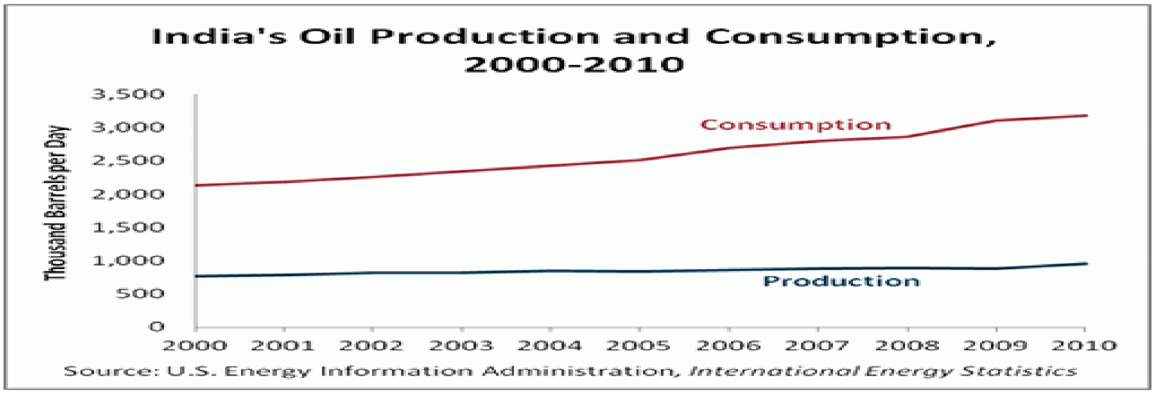


Figure 1.14: India’s oil production and consumption, 2000-2010

India’s ranked fourth as the major consumer and importer of crude oil and petroleum products in the world in year 2013. The other countries who are ahead of India in the consumption and import of oil are the China, United States, and Japan. India’s dependency on imported crude oil are immense specially from the Middle East.

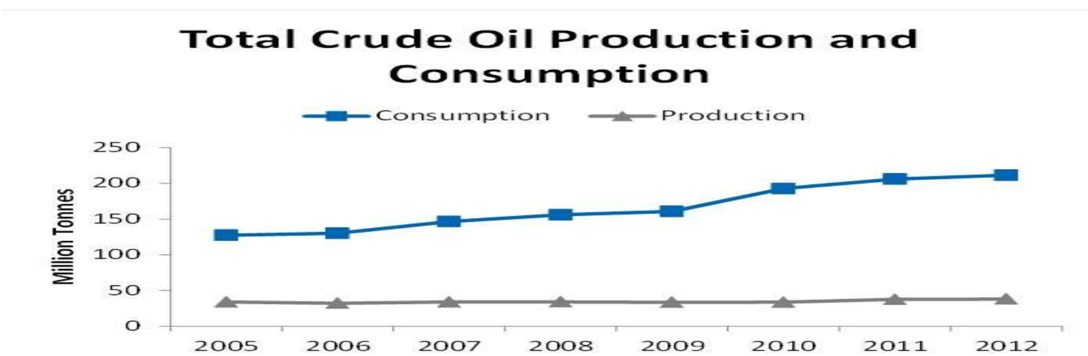


Figure 1.15: Total crude oil production and consumption

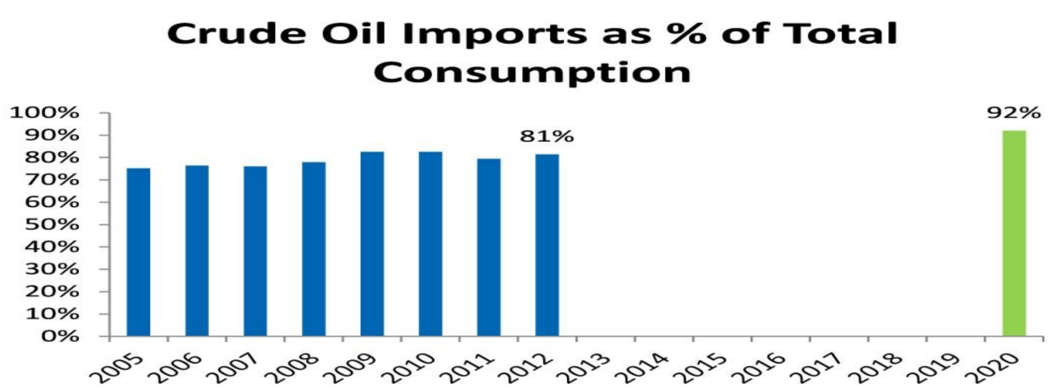


Figure:1.16: Crude oil imports as % of total consumption

Transport sector consumes around one-third of the total crude oil and more than 80% of this is consumed by the road transportation.

Crude oil consumption in India boundlessly exceeds the demand. By the year 2020 it is expected that the import of the crude oil will be reaching to 92% of all consumed crude oil. So, to reduce the crude oil demand Electric transport is considered as a controlling measure to diminish the crude demand. Source: Sustainability outlook forum http://www.sustainabilityoutlook.in/content/market-analysis-case-electric-and-hybrid-vehicles-india

2016 Status:

As per the data, India continuously maintained the third-largest energy consumer in 2016 in the world. Annual consumption raised at 4.33 million barrels per day (MBPD) of oil. It is expected that energy demand of country from 723.9 Mtoe in 2016 to be double to 1,516 Mtoe by 2035. (The tonne of oil equivalent (toe) is a unit of energy defined as the amount of energy released by burning one tonne of crude oil. megatoe (**Mtoe**, one million toe)

https://www.ibef.org/industry/indian-oil-and-gas-industry-analysis-presentation

The Road Ahead:

The import of oil is increasing on faster pace every year in India. In October 2017 it has raised by 27.89 per cent to US$ 9.29 billion. In the year 2016 the consumption increased to 212.7 million tonnes. The consumption grows 8.3 % year on year as compare to the global growth of 1.5 per cent thus making it the third-largest oil consuming nation in the world.

It has been estimated that by 2040 with a CAGR of 3.6 per cent the India’s oil demand may grow to 458 Million Tonnes of Oil Equivalent (MTOE). It is also projected that by 2021-22 the demand for petroleum product may reach to 244,960 MT which was 186,209 MT in 2016.

https://www.ibef.org/industry/oil-gas-india.aspxby

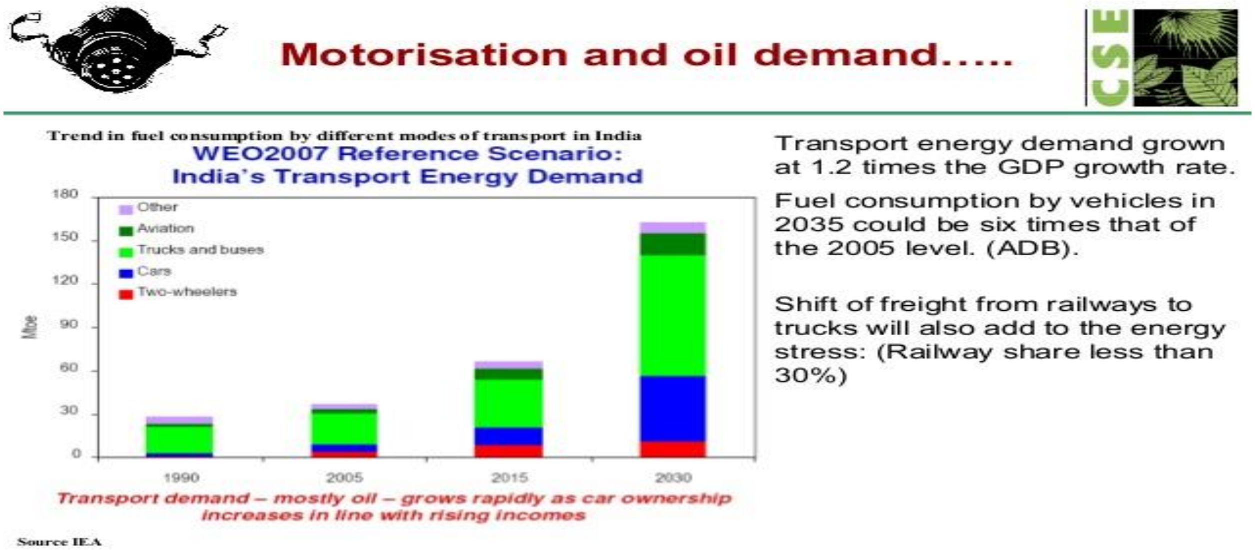


Figure 1.17: Motorization and oil demand

Source: https://www.slideshare.net/EMBARQNetwork/transport-and-air-pollution-delhi-story

Figure 1.18: Delhi's fuel consumption (2016-17)

In the year 2016-17 the quantity of oil consumed in Delhi was .91 million tonnes of petrol and 1.26 million tonnes of diesel. In Delhi 200,000 liters of petrol and diesel are being sold daily by approximate 2,600 fuel retail outlets.

Source: https://www.business-standard.com/article/economy-policy/imposing-clean-fuel-bs-vi-fuel-to-cost-more-117112300064_1.html

Therefore, there is an urgent need to look for a sustainable mobility solution in future.

Pollution & Health:

The presence of unwanted particles in the environment is referred as pollution. It is the outcome of human action. Substances which pollutes air, water or land are called pollutants. Environment is badly affected by the Pollution. When pollution crosses the safety limits it harmfully affects humans, plants and all other living beings.

Chemical Pollution: Chemical pollution can be referred to as the substances in the environment which are harmful to our health. When fossil fuel like coal, oil and natural gas are burnt the environment is polluted by as the burning of these fossil fuel releases the chemical pollution in the air. ICE vehicles use oil to operate as we burn the oil some kind of chemical gases are releases in the environment and this is called Green House Gases. One of this kind is carbon dioxide which absorb infrared radiation and trap heat.

When we burn the coal, Sulphur dioxide is released in the environment which contributes to acid rain, which is the phenomenon by which impurities combine with water vapor and fall to the earth.

Transport Pollution: Use of ICE vehicles is the main reason of transport pollution. Gases like CO_2, SO_2 and CO are released in the environment due to burning of fuel which drive ICE vehicles.

The amount of pollution is also dependent upon

1- The level of urbanization
2- Number of vehicles

It is difficult to survive in the urban area without transportation. As the urbanization increases the number of vehicles increases. Cities with more population recorded more pollution due to more vehicles.

According to the IEA -2009, worldwide the second largest source of CO_2 production are the fossil fuel-based transportation It has been found that the worldwide energy utilization will grow up by 53% and about 3/4th of predicted rise in oil demand will be expected from transportation sector between 2006 to 2030

.

Particulate matter (PM)

Definition and principal sources

PM (Particulate matter) is a mixture of solids and liquid droplets floating in the air. More people are affected by this pollutant than any other pollutant. Sulfate, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water are the major constitutes of PM. PM10 is referred to as particles with a diameter of 10 microns or less ($\leq PM_{10}$) and can enter and get fixed deep inside the lungs. PM 2.5 is the more health-damaging particles with a diameter of 2.5 microns or less, ($\leq PM_{2.5}$). $PM_{2.5}$ can pierce the lung barrier and enter the blood system. Diseases such as cardiovascular, respiratory system diseases, and lung cancer can be caused due to long term exposure to these particles.

Daily or annual mean concentrations of PM_{10} particles per cubic meter of air volume (m^3) are used to measure air quality. PM concentrations in terms of micrograms per cubic meter ($\mu g/m^3$) are used for routine air quality measurements. Concentrations of fine particles ($PM_{2.5}$ or smaller), can also be measured when adequately delicate measurement tools are accessible.

The standard limit set by the WHO for air quality are to decrease the air pollution to annual mean values of 20 $\mu g/m^3$ (for PM_{10}) and 10 $\mu g/m^3$ (for PM_{25}).

Source: WHO

Pollution in the world:

In various areas of the world the air pollution levels persist hazardously high and the polluted air is being breathed by every 9 out of 10 people worldwide.

According to WHO due to interaction to polluted air 7 million people die every year.

In the year 2016 around 3.8 million death were caused due to household air pollution from cooking with polluting fuels and 4.2 million death were caused due to ambient air pollution alone.

Low- and middle-income countries mainly in Asia and Africa constitute more than 90% of air pollution-related deaths.

Source: https://www.who.int/news-room/air-pollution

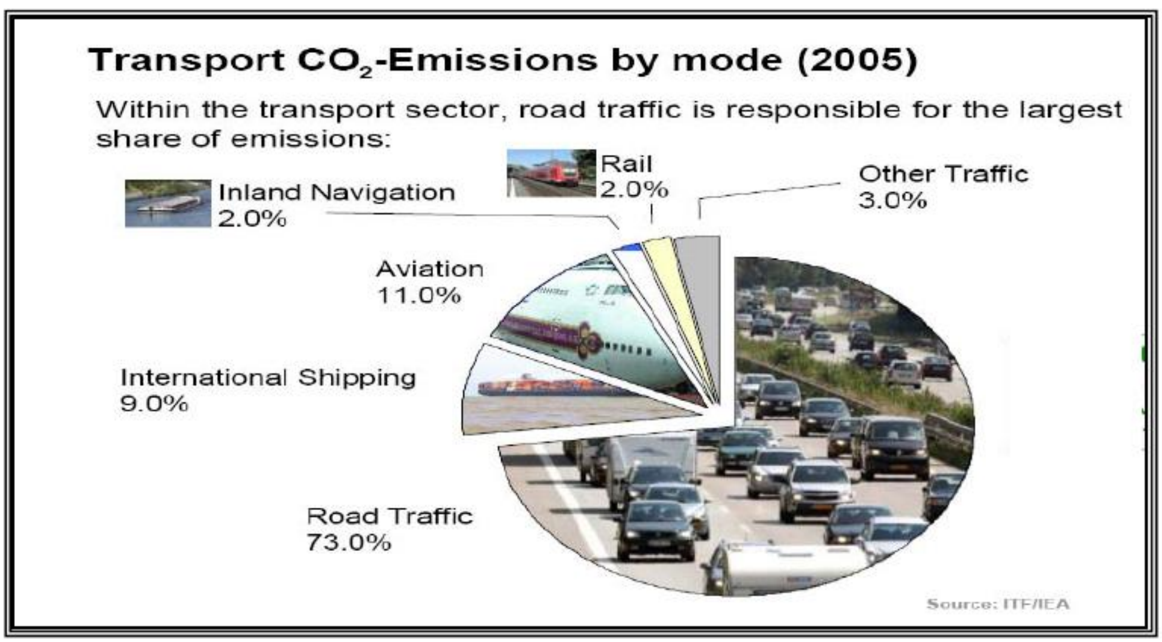


Figure 3.2 : Global GHG's emissions from Transport sector (Mode-Wise)

Figure 1.19: Transport CO2 emissions by mode (2005)

Pollution in India

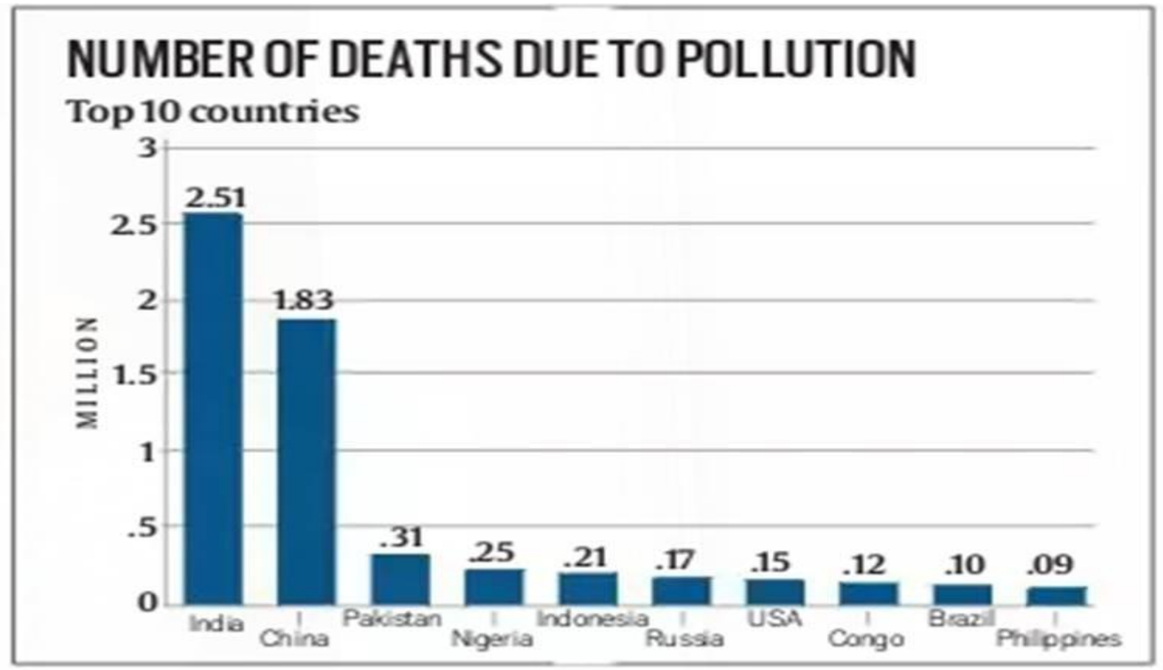


Figure 1.20: Number of deaths due to pollution

As per the study published in the reputed medical journal, The Lancet, Due to pollution 2.51 million people died prematurely in the country in the year 2015 and India has been ranked one with pollution-related deaths that year. The cause was various diseases related to air, water and other forms of pollution.

Globally, pollution has been declared the biggest environmental cause of disease and death today which is three times more those from HIV-AIDS, TB and malaria put together as concluded by The Lancet.

Source: http://indianexpress.com/article/india/at-2-5-million-india-tops-list-of-pollution-linked-deaths-study-4898337/

In 2017, Air Pollution is the cause of 10 lakh death in India, Study Shows

In 2017, Outdoor particulate matter air pollution causes 6.7 lakh deaths while household air pollution causes 4.8 lakh deaths as per the study by Lancet Planetary Health journal. As per the study if the air pollution in India would be within control limit than the average life expectancy would have been 1.7 years advanced.

Source: https://www.ndtv.com/india-news/study-shows-poor-air-quality-cut-life-expectancy-in-delhi-by-1-5-years-1958887

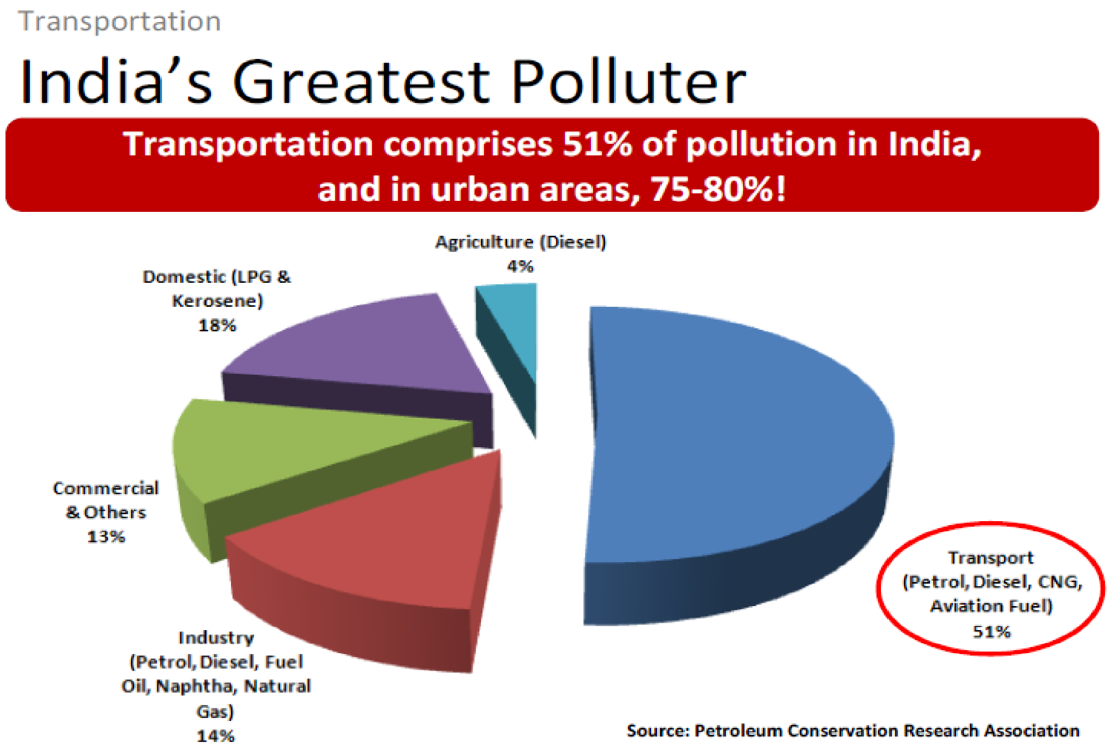


Figure 1.21: Transportation India's greatest polluter

Fuel consumption in India

Since the birth of automotives in the 19th century, diesel and gasoline are used as the primary source of energy for the vehicles. As per information available with CIA's World Factbook , 2008, India is one of the top ten oil consuming country in the world. With the oil consumption of 2,438,000 barrels per day, India stands 6th amongst top ten oil consuming countries of the world. Further as per PCRA (Pollution Conservation Research Association) , an average consumption pattern of petroleum products in India is as follows:

Table 4.7: Consumption Pattern of Petroleum products in India

S.no	Sector	Consumption (%)
1	Transport (Petrol, Diesel, CNG, Aviation fuel)	51
2	Industry (Petrol, Diesel, Fuel oil, Naphtha, Natural Gas)	14
3	Commercial & other	13
4	Domestic (LPG & Kerosene)	18
5	Agriculture (Diesel)	4

The transport sector alone consumes more than 50% of the total oil consumption in the country. Fuel consumption pattern in nine metro cities of the country during 2000-01 is described in **figure-4. 2**

Table 1.10: Fuel consumption in India

Source: Pollution Conservation Research Association

Fuel consumption pattern in nine metro cities of the country.

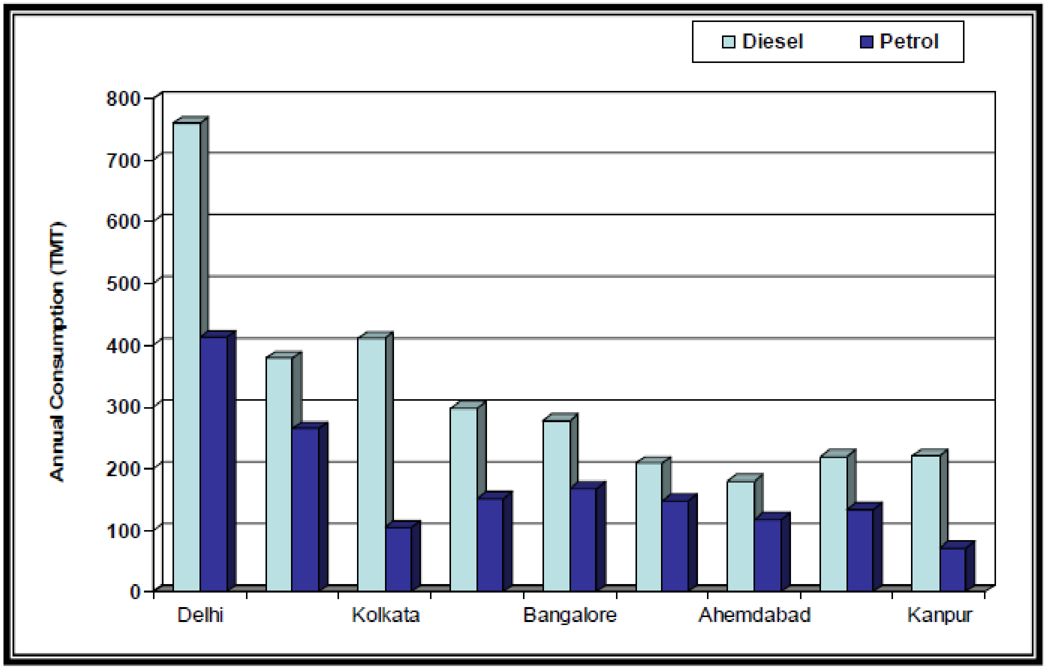


Figure 1.22: Fuel consumption pattern in nine metro cities of the country

Source: Pollution Conservation Research Association

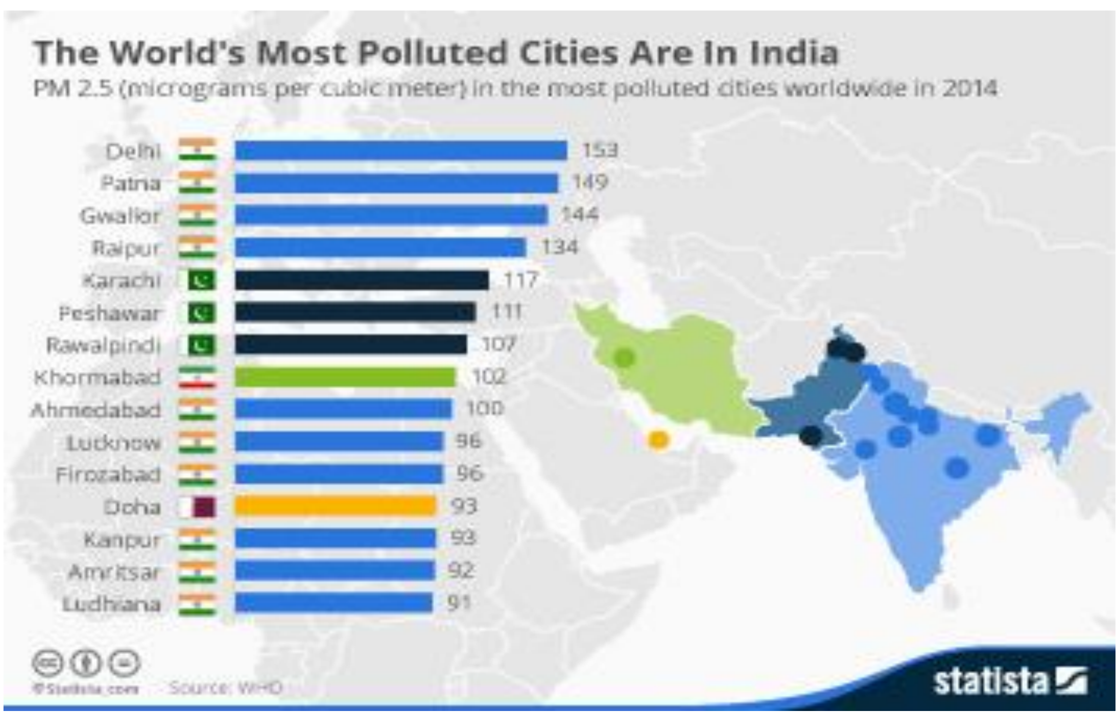


Figure 1.23: The most polluted cities of the worlds are in India

Pollution in Delhi:

Delhi Has the Worst Air Quality in The World

As per the WHO report released on May 2,2018 , Delhi was found to have a substantial existence of PM10 particular matter - 292 micrograms per cubic meter while the annual harmless limit fix by the WHO is 60. Thus, the air quality of Delhi has been declared the worst in the world. While out of 20 most polluted cities globally 13 cities are from India. The below diagram shows a comparison of Delhi to other major polluted cities worldwide.

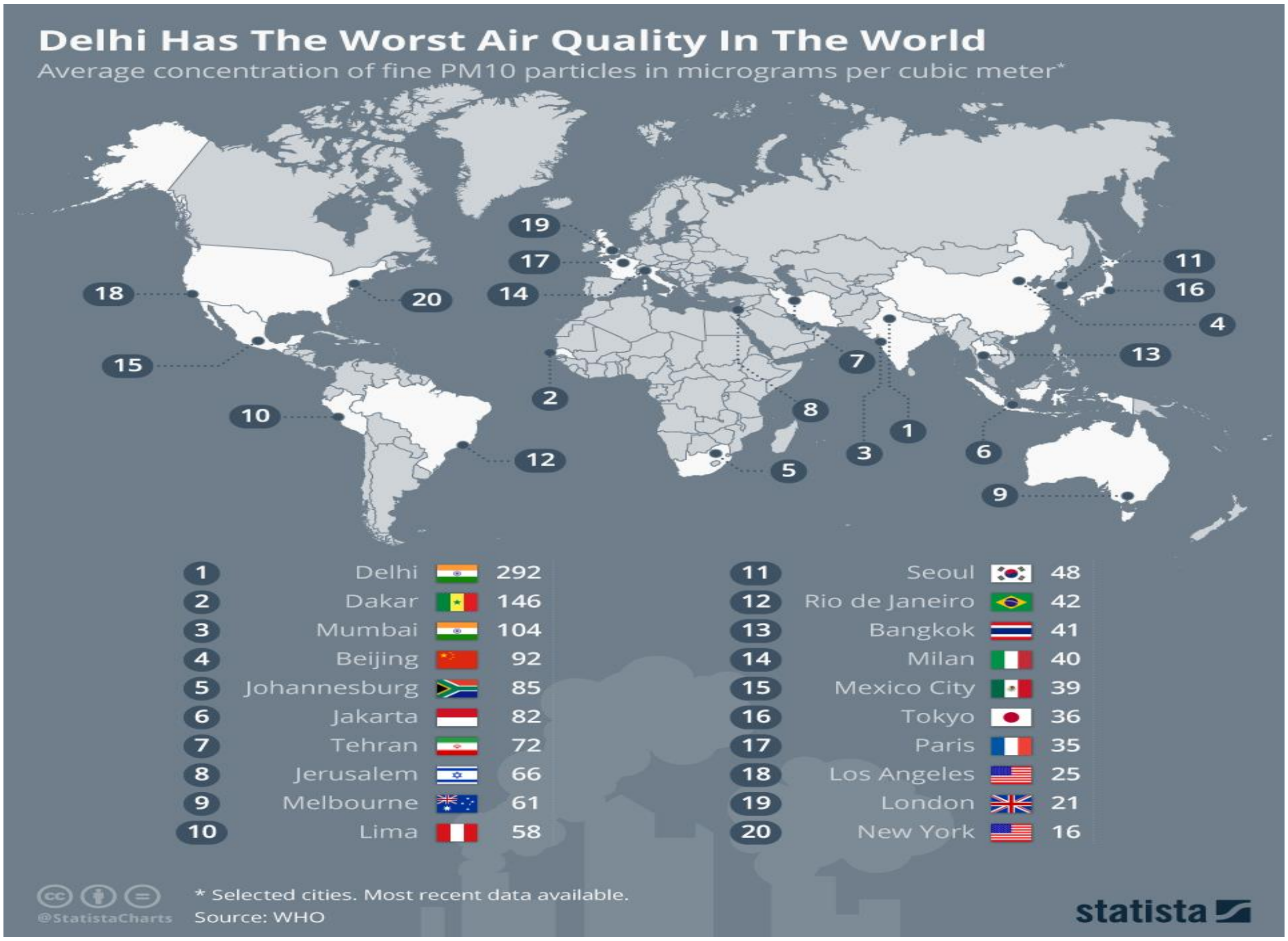


Figure 1.24: Delhi has the worst air quality in the world

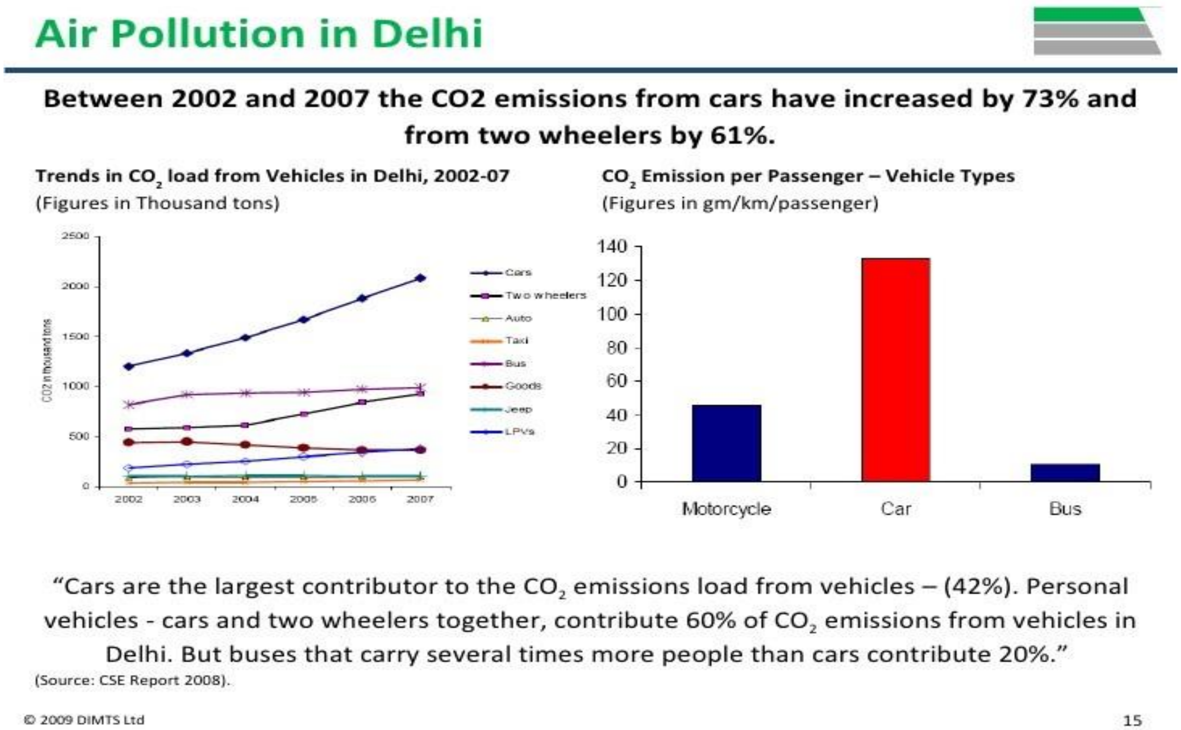


Figure 1.25: Air pollution in Delhi

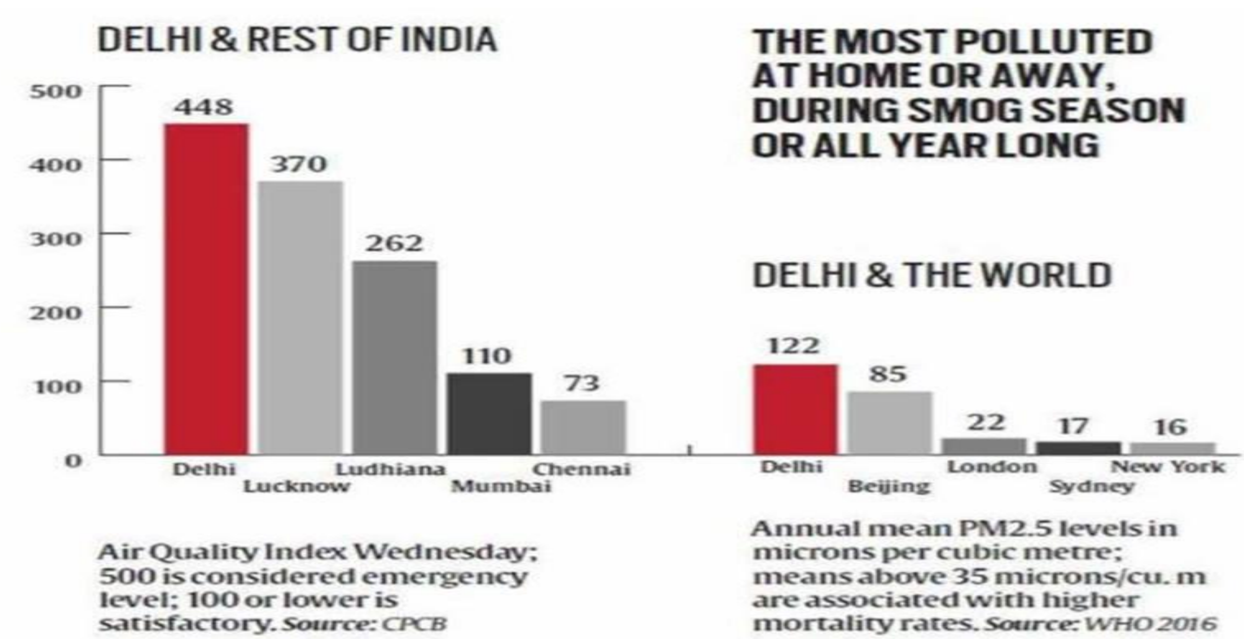


Figure 1.26: Delhi and Rest of India

Source: https://www.google.com/search?biw=1366&bih=613&tbm=isch&sa=1&ei=23YRW5-fGIGurQGiyLfQCw&q=air+pollution+in+delhi+statistics&oq=pollution+stat+in+delhi&gs_l=img.1.0.0i8i7i3

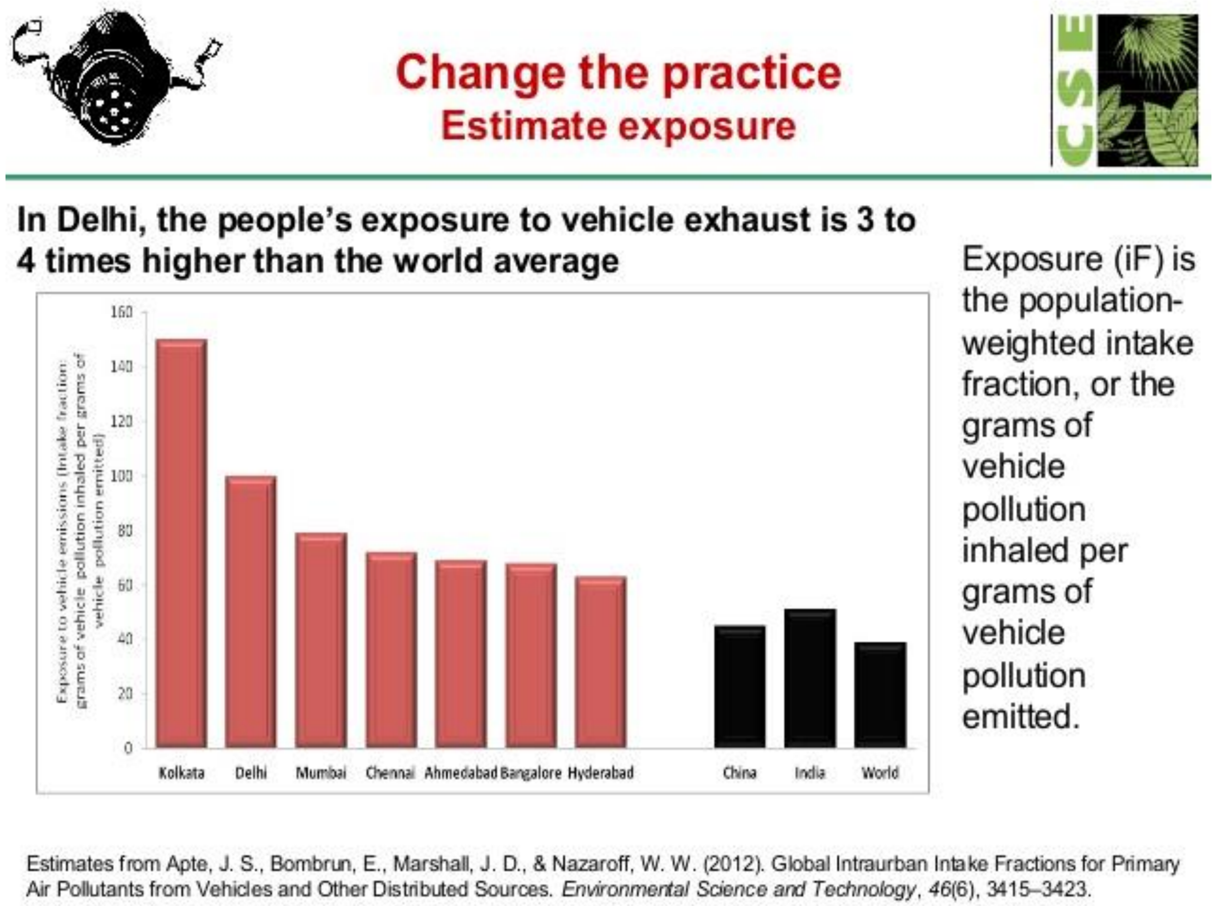


Figure 1.27: Change the practice estimate exposure

Source:https://www.slideshare.net/EMBARQNetwork/transport-and-air- pollution-Delhi-story

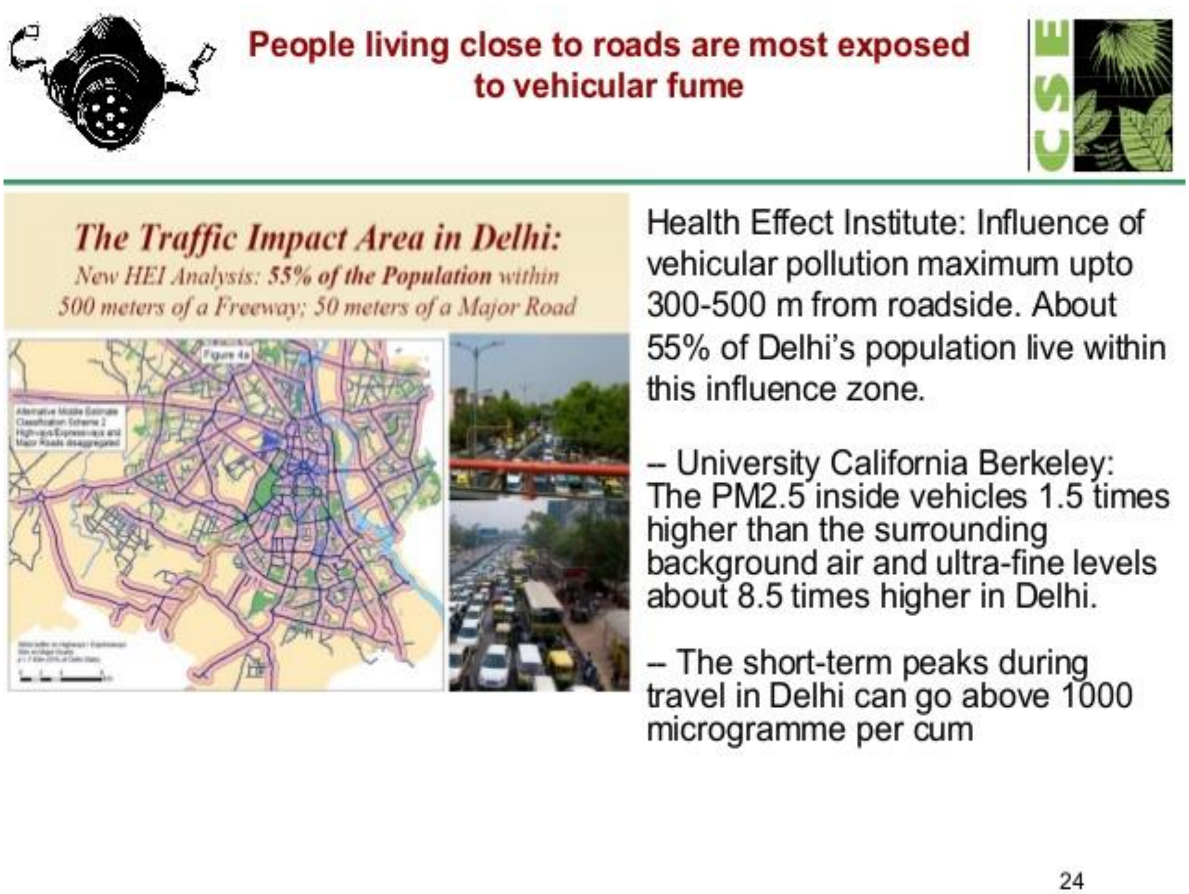


Figure 1.28: People living close to roads are most exposed to vehicular fume

Source:https://www.slideshare.net/EMBARQNetwork/transport-and-air-pollution-delhi-story

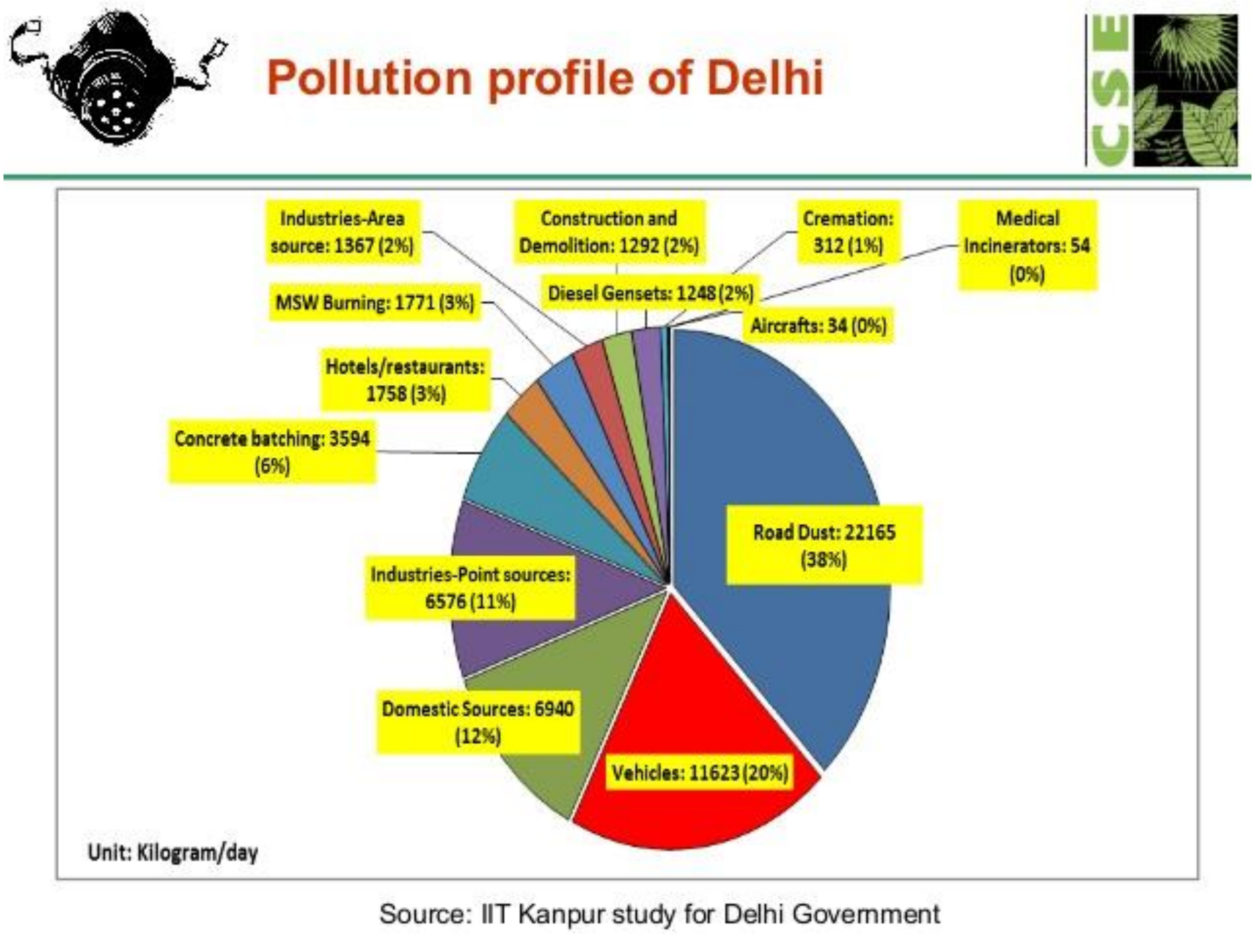


Figure 1.29: Pollution profile on Delhi

Source: https://www.slideshare.net/EMBARQNetwork/transport-and-air-pollution-delhi-story

Delhi-NCR ranks worst in vehicular pollution: Study

In spite of many better parameters like average trip length and shared public transport as compare to other mega cities Delhi has been considered the worst in overall toxic emission and energy consumption. It has been found that the main reason behind the worst ranking in vehicular pollution is because of increasing number of vehicles and increasing population as compare to other cities. Centre for Science and Environment (CSE) — a Delhi-based research organization conducted a study from urban commuting to evaluate transport related release.

Source:https://www.hindustantimes.com/delhi-news/delhi-ncr-ranks-worst-in-vehicular-pollution-study/story-v867fE0olPQprku1s5ZrEI.html

SAFAR Study:

Transport sector contributes 41 % of the total pollution in Delhi. The second major contributor after transport sector is ‘wind-blown dust’ with 21.5 per cent and then “Industry” at 18.6 per cent while “Power” and “Residential” are the minor contributors about 4.9 and 3 per cent respectively. Remaining contributes about 11 per cent according to the study by SAFAR (System of Air Quality and Weather Forecasting and Research under Ministry of Earth Sciences, Government of India

Heavy Commercial Vehicles (HCVs), commercial and privately-owned four-wheeler (4W) segment are found to be the major polluting sources in Delhi as per the study.

The major health damaging pollutant to the residents of the city are Particulate Matter (PM) 2.5 and PM.

The major PM2.5 emission sources are the transport sector and industrial sector and the emission from these sectors have gone up by 40% and 48% respectively.

It will be interesting to know that between 2010 and 2018 the pollution from windblown dust which is often blamed for pollution has reduced by 26%.

(Source: https://www.hindustantimes.com, https://www.dailypioneer.com)

DELHI POLLUTION DEATHS UP BY 100% SINCE 1991

By **Neetu Chandra Sharma** in New Delhi

THE health of Delhiites has been hit hard by air pollution, with the number of deaths and cardiovascular and respiratory diseases linked to the menace shooting up in recent years.

A World Health Organisation (WHO) study ranked New Delhi as the world's worst city for air pollution, with an annual average of 153 micrograms of small particulates, known as PM 2.5 per cubic metre. Released on Wednesday, the study conducted in 1,600 cities found that air pollution has worsened since a smaller survey in 2011, putting Delhi residents at higher risk of cancer and heart disease.

A similar study done by Indian Institute of Technology (IIT)-Roorkee in association with the University of Minnesota and University of Colorado at Denver has revealed a marked rise in deaths due to cardiovascular and respiratory diseases and hospital admissions for "chronic obstructive pulmonary diseases" (COPD) linked to pollution.

"As many as 8,945 cases of total mortality, 3,413 cases of cardiovascular mortality, 1,302 cases of respiratory mortality and over 12,809 hospital admission of COPD were recorded in Delhi in 1991. With 100 per cent growth, these figures in 2010 became 18,229 cases of total mortality, 6,374 cases of cardiovascular mortality, 2,701 cases of respiratory mortality and 26,525 hospital admission," the study done by Professor Bhola Ram Gurjar of IIT-Roorkee said.

In 2000, about "11,394 cases of total mortality, 3,912 cases of cardiovascular mortality, 1,697 cases of respiratory mortality and 16,253 cases of hospital admission of COPD" were recorded for Delhi, reported the study titled '*Human health risks in national capital territory of Delhi due to air pollution*'.

The study, recently published in *Atmospheric Pollution Research* journal, adopted WHO guideline concentrations for assessing air pollutants like sulphur dioxide (SO2), nitrogen dioxide (NO2) and total suspended particles (TSP). The study also assessed the risk to people from these pollutants. It found that higher ambient concentrations of suspended particulate matter (SPM) and nitrogen oxides (NOx) are responsible for excess number of deaths and illnesses in Delhi.

The study covered the areas of North-West, South, West, North-East, South-West, East, North, Central and New Delhi districts during 1991-2010. They calculated the health risks using ambient air pollution concentration data of nine districts. Concentration data of monitoring stations in each district was used for calculating district-wise health risk estimates.

The results found dissimilar trends in terms of deaths, diseases and hospital admissions. From 2002, the North-West district was at the top for the highest excess number of cases of hospital admission of COPD until 2010, while from 2002 to 2010, the North West district topped the chart with the excess number of cases of deaths due to cardiovascular diseases.

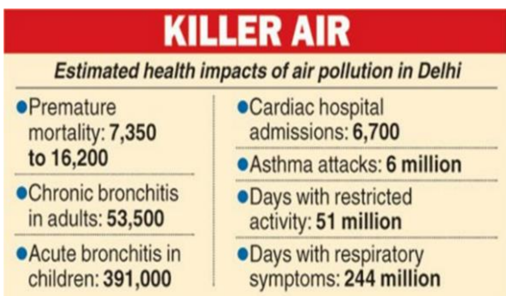
Doctors see rise in respiratory diseases

Doctors have been witnessing an increased number of cases of respiratory disease which they attribute to air pollution. "There is an increase in cases of respiratory diseases, especially in children. Air pollution is contributing to respiratory diseases while there is also a possibility of malformation of organs in new born babies as mothers are exposed to pollution for prolonged periods," said Dr. Dinesh Kapil, consultant pediatrician at Red Cross Hospital.

It is not just Delhi. Twenty-five other Indian cities — including Dehradun, Pune and Jammu — have higher air pollution levels. The levels of particulate matter with diameter of 2.5 micrometres recorded in the three cities are higher than in Beijing.

Figure 1.30: Delhi pollution deaths up by 100% since 1991

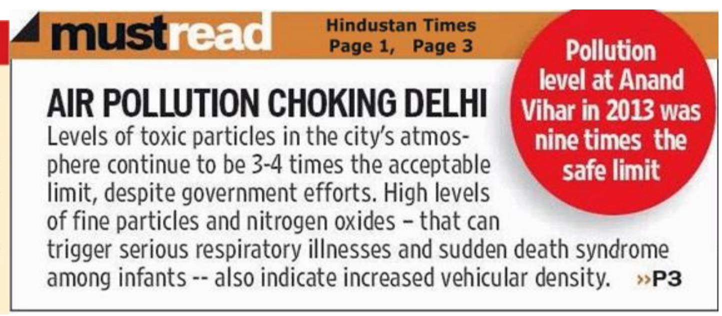
Source: http://urbanemissions.blogspot.in/2014/05/delhi-air-pollution-related-deaths-up.html



KILLER AIR

Estimated health impacts of air pollution in Delhi

• Premature mortality: **7,350 to 16,200**	• Cardiac hospital admissions: **6,700**
	• Asthma attacks: **6 million**
• Chronic bronchitis in adults: **53,500**	• Days with restricted activity: **51 million**
• Acute bronchitis in children: **391,000**	• Days with respiratory symptoms: **244 million**



mustread Hindustan Times Page 1, Page 3

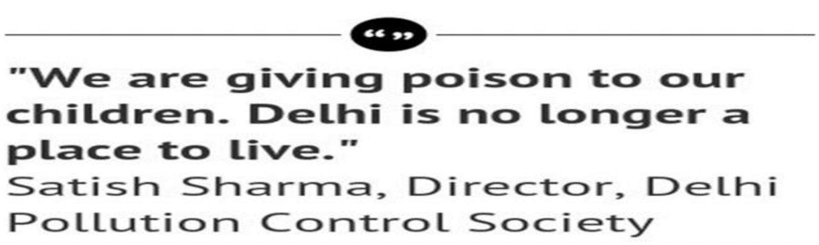
AIR POLLUTION CHOKING DELHI

Levels of toxic particles in the city's atmosphere continue to be 3-4 times the acceptable limit, despite government efforts. High levels of fine particles and nitrogen oxides – that can trigger serious respiratory illnesses and sudden death syndrome among infants -- also indicate increased vehicular density. »P3

Pollution level at Anand Vihar in 2013 was nine times the safe limit

Figure 1.31: Killer Air

Figure 1.32: Air Pollution Choking Delhi



"We are giving poison to our children. Delhi is no longer a place to live."

Satish Sharma, Director, Delhi Pollution Control Society

Source:http://www.theepochtimes.com/n3/1159184-new-delhi-pollution-getting-worse-in-winter/?utm_expid=.5zxdwnfjSHaLe_IPrO6c5w.0&utm_referrer=https%3A%2F%2Fwww.google.co.in%2

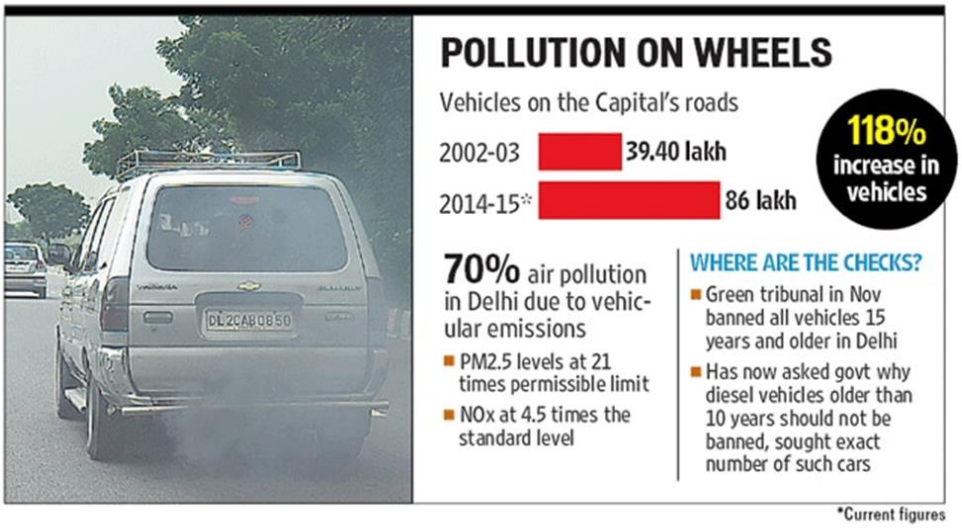
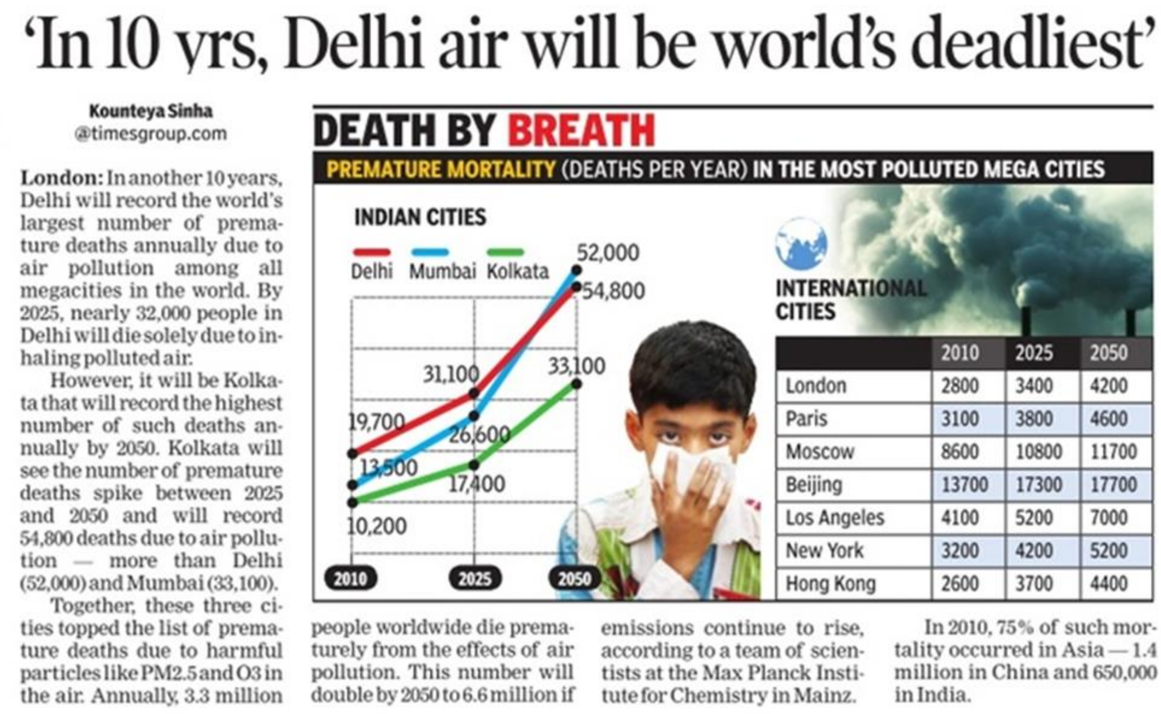


Figure 1.33: Pollution on wheels

Source: www.hindustantimes.com/delhi/pollutioncontrol-capital-has-nobody-to-check-vehicular-emission/story



'In 10 yrs, Delhi air will be world's deadliest'

Kounteya Sinha
@timesgroup.com

London: In another 10 years, Delhi will record the world's largest number of premature deaths annually due to air pollution among all megacities in the world. By 2025, nearly 32,000 people in Delhi will die solely due to inhaling polluted air.

However, it will be Kolkata that will record the highest number of such deaths annually by 2050. Kolkata will see the number of premature deaths spike between 2025 and 2050 and will record 54,800 deaths due to air pollution — more than Delhi (52,000) and Mumbai (33,100).

Together, these three cities topped the list of premature deaths due to harmful particles like PM2.5 and O3 in the air. Annually, 3.3 million people worldwide die prematurely from the effects of air pollution. This number will double by 2050 to 6.6 million if emissions continue to rise, according to a team of scientists at the Max Planck Institute for Chemistry in Mainz.

In 2010, 75% of such mortality occurred in Asia — 1.4 million in China and 650,000 in India.

DEATH BY BREATH

PREMATURE MORTALITY (DEATHS PER YEAR) IN THE MOST POLLUTED MEGA CITIES

INTERNATIONAL CITIES

	2010	2025	2050
London	2800	3400	4200
Paris	3100	3800	4600
Moscow	8600	10800	11700
Beijing	13700	17300	17700
Los Angeles	4100	5200	7000
New York	3200	4200	5200
Hong Kong	2600	3700	4400

Figure 1.34: In 10 years, Delhi's air will be world's deadliest

Every day 80 people die in Delhi due to Air pollution, says study:

A new study has exposed that approximately 10,000 to 30,000 annual deaths in Delhi is caused by air pollution which signifies that everyday 80 people die in Delhi due to pollution from PM2.5. Source: https://www.downtoearth.org.in/news/delhi-loses-80-lives-to-air-pollution-every-day-says-study-50222 Dec-10 2018

Global action on diesel cars

London: Pre Euro VI cars not to be allowed inside the ultra low emissions zone in Central London.

France: Euro VI diesel cars not to be included in the new category 1 colour coding scheme that classifies vehicles according to how much they pollute. French government to "progressively" ban diesel vehicles. **Paris**: To phase out pre-2011 diesel cars by the end of the decade.

Madrid: To ban polluting diesel cars from the city centre from 2020.

Netherlands: In 1998 the Third National Environment Policy targeted to reduce diesel chare to only 5% in 2010. Dutch registration and circulation taxes for diesel cars are close to prohibitive. Kept share of diesel cars in Netherland lower than EU average.

Brazil Sales of diesel passenger cars and commercial vehicles below 1,000 kg are banned since the 1970s

Beijing has banned diesel cars as a pollution control measure. China has the lowest diesel car penetration at less than 1%. China taxes do not differentiate between petrol and diesel fuel.

Sri Lanka has imposed several times higher duties for diesel cars compared to petrol cars and have reduced diesel car sales.

Figure 1.35: Global action on diesel cars

Source: https://www.slideshare.net/EMBARQNetwork/transport-and-air-pollution-delhi-story

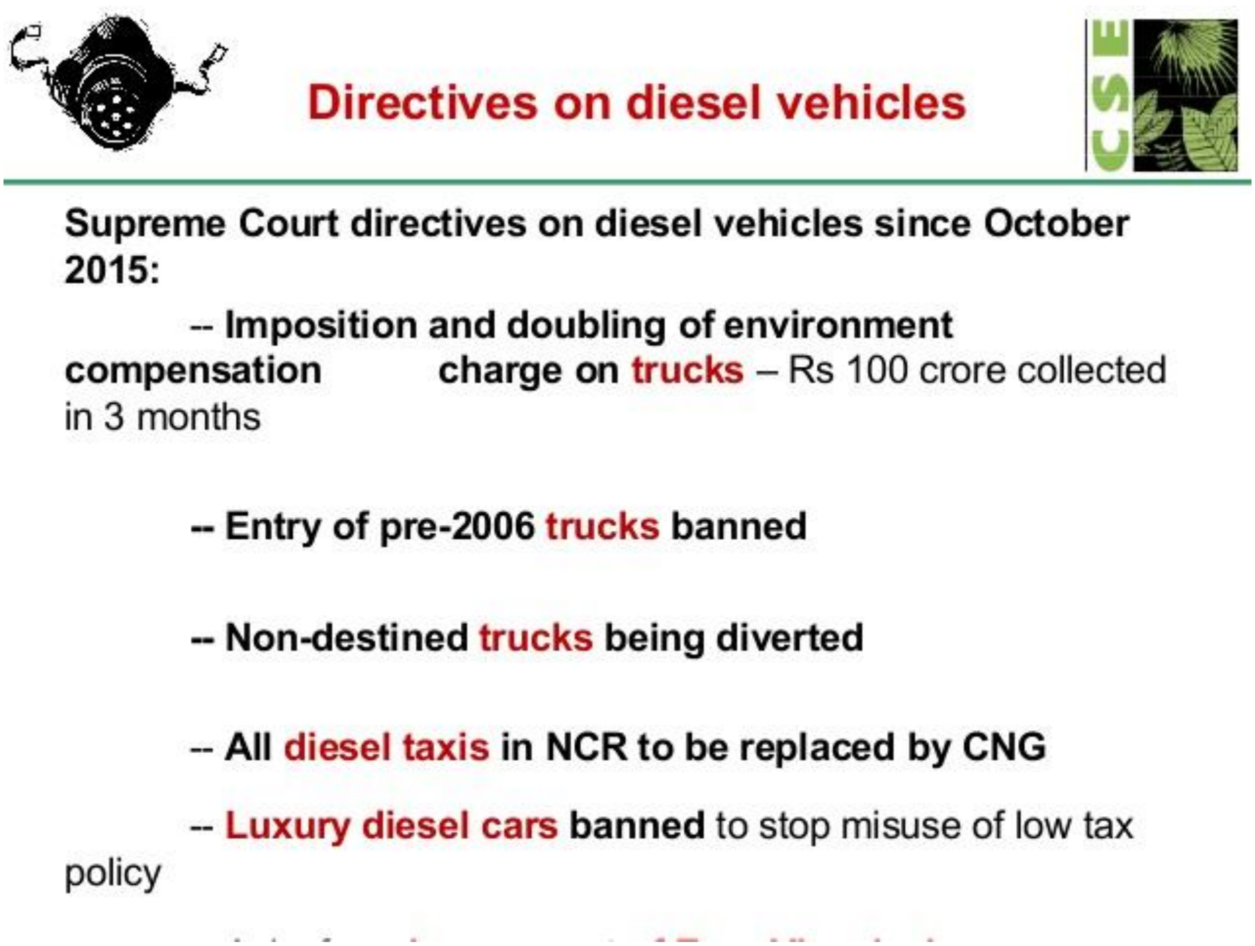


Figure 1.36: Directives on diesel vehicles

Government action since October 2015

Delhi Government programmes and budget:

-- Odd and Even scheme

-- Augmentation of bus numbers, infrastructure and service

-- Infrastructure for walking and cycling on PWD roads

-- Elevated BRT

-- Municipal bodies revising parking fees

Central government programmes and budget

Issued draft notification on Euro VI in 2020

Differentiated infra tax on diesel and petrol cars

AMRUT and smart city policies etc

Figure 1.37: Government actions since October 2015

Pollution emergency action in Delhi

Delhi enforces Odd and even scheme as pollution emergency action during January 2016

Pollution context based on AQI:

November and December 2015 -- higher number of days in severe category-four times the safe standard –the worst category according to the National Air Quality Index.

November 2015 had 73% cent of days in severe category against 53% in November, 2014.

December 2015 had 67% of days in severe category as against 65% in December 2014.

December 2014 at least had 3% of days in good and satisfactory category but December 2015 had none.

42

Source: CSE analysis based on DPCC data

Figure 1.38: Pollution emergency action in Delhi

CARBON EMISSION COMPARISON

Fuel Type	CO2 Emission (Kg per Km)
Petrol	0.23251
Diesel	0.273[1]
Electric Car	0.1032

Table 1.11: CARBON EMISSION COMPARISON

1 kg of CO2 is emitted when 1 kWh of energy is generated in coal power plant. In the table above, approximately the mileage of the petrol/diesel car in cities is taken as 10 km while an e car run 10 km with 1 kwh of electricity. The CO2 emission of petrol and diesel car is double as compare to that of e car even if charging of EV is done using the electricity produced over fossil fuel. It should be notifying that electricity used for charging the EVs is generated in power plants located many hundred kilometers from cities which are facing issues of air pollution. Even more important point is that the emission from EVs can be made nil by charging them through renewable energy sources.

Source:http://paryavaranmitra.in/Carpooling%20project%20report%20for%20CEE.pdf *http://cea.nic.in/reports/others/thermal/tpece/cdm_co2/user_guide_ver10.pdf*Document Number: ISGF – 2015 Version 1.0 Dated December 2015

Effect of Pollution on GDP

Economic toll of air pollution may have cost India 8.5 % of GDP: World Bank Report More than $560-billion loss to country in wellbeing and industry output.

Source:http://www.business-standard.com/article/economy-policy/economic-toll-of-air-pollution-may-have-cost-india-8-5-of-gdp-world-bank-report- 116090900235_1.html

Pollution costs India $80 bn a year: World Bank

Source: http://www.business-standard.com/article/economy-policy/pollution-costs-india-80-bn-a-year-world-bank-113071800035_1.html

81000 deaths due to air pollution in Delhi & Mumbai, cost Rs 70,000 crore in 2015

Source:http://economictimes.indiatimes.com/articleshow/56658488.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

Chapter 2

Introduction of E car

From the very starting of automobile's antiquity, competition existed between two types of technologies i.e. electric vehicle technology and internal combustion engine (ICE) technology respectively. Thus, E Cars are not new they have already come in existence in 1900 around 100 years ago but they couldn't have performed and closed in around 1920. The main cause of their failure was poor quality of motor and battery.

The first prototype of electric vehicle was invented in 1832-1839 by Robert Anderson who was a Scottish inventor. The first Electric Car was practically developed in the year 1835 by an American Inventor Thomas Davenport.

In1886 the first ICE car was developed in Germany by Benz and Daimler. There was huge competition between the two types but due to the advantage of low initial cost and flexibility Henry Ford, decided to select the ICE Vehicle for the first mass production of a car in history in 1908.

The first electric automobile starter was invented by Charles Kettering's in 1912 for ICE vehicles due to this invention the unwieldy used crank shaft was abolished and made ICE autos more attractive to customers which in turn cause dying of electric car.

There were many reasons for the downfall and dying of electric car during the 1920s. The electric car was not appropriate due to lack of power, lack of range and the easy availability fuel for ICE vehicles. Thus, BEV is replacing by ICEV but this was one of the major mistakes in the history of technology. ICEs vehicle became one of the major causes of urban air pollution due to fast growth and limited application of emission control technique.

Now the time has changed, and new battery has emerged which are sufficient enough to do their job efficiently. Similarly, because of better technology the motor has become very advanced and capable of providing enough torque, power and It is light in weight. These benefits make electric cars more practical as compare to ICE car.

Source: The Andhra Journal of Industrial News

Types of E cars:

There are three types of E-Car

1-AEVs (All Electric Vehicles): These vehicles use electric motor and battery instead of internal combustion engine and oil. . The battery is used to store electric energy and is charged by plugging into the grid. No emission is released as they do not consume petroleum-based fuel. AEVs include Fuel Cell Electric Vehicles (FCEVs) and Battery Electric Vehicles (BEVs).

1.1-BEVs A battery electric vehicle (BEV) runs entirely using an electric motor and battery, and its battery is recharged by electricity by plugging into some outside source. It also uses a phenomenon called regenerative braking to recharge its battery like all electric vehicles. In regenerative braking the vehicle's electric motor assist in slowing the vehicle, and during this some of the energy which normally converted to heat by brakes is recovered.

Pros:

- No emissions
- No oil or gas changes
- Capability to conveniently charge at home
- Smooth and fast acceleration
- Lower operating cost

Cons

- Gasoline vehicles range are more than BEVs, although many customer drives with the current range of BEV and may opt for the longer range a hybrid one.
- Gasoline vehicles are somewhat cheaper than BEVs equivalent although the difference in the fuel price is enough big to recover the cost difference in typically 2-3 years.

1.2 FCEVs: **Fuel cell** vehicles also run by an electric motor however they use hydrogen gas to power the electric motor. Fuel cell vehicles uses a mix of hydrogen and oxygen to produce electricity, which runs a motor. Like all BEVs, FCEVs also do not use oil or gasoline

2-HEVs. Hybrid Electric Vehicles (HEVs) consist of two technologies: one is ICE technology which uses a gasoline engine and another one is electric motor technology which uses a battery. The battery of HEVs cannot be directly charged with the grid but it is charged through regenerative breaking and from the energy which comes from gasoline. The electric motor and gasoline engine both can turn the transmission simultaneously. At low speed electric motor operates the car in mostly cases while for the longer distance's combustion engine runs the car at a high speed. The HEV's, advantage is the more range than EV. The difference between EV and HEVs is that EV cannot drive when the batteries are not recharged but a HEV can drive even if the batteries are not charged.

Pros:

- More range as compare to BEV
- Lesser oil consumption as compare to ICE vehicle
- Less emissions as compare to ICE vehicle

Cons:

- Emissions are not nil
- System is complex – Electric + Gasoline
- Less expensive to operate than ICE Vehicles but more expensive to operate than BEV
- Not capable to charge conveniently at home.

3-PHEVs: PHEV is different from HEV in the way that along with the gasoline engine it also has a larger battery as compare to HEV. In Plug-in hybrids (PHEVs) unlike HEVs battery can also be recharged by plugging in to some outside source of electricity however like HEVs the battery can be recharged by combustion engine too. In case when the battery is low combustion engine may replace the electric motor. PHEVs saves more fuels as compare to HEVs because PHEVs use electricity from power grid.

As compare to HEVs, more distance is covered by PHEV on pure electric, more like a BEV, but it also has a benefit of "range extender" in the form of a combustion engine.

Pros:

- More range as compare to BEV
- Less oil consumption as compare to ICE vehicle
- Lesser emissions
- Simple system, Chances are few to go wrong.

Cons:

- Generates Emissions
- Required oil changes
- Less expensive than traditional hybrid vehicle (HEV) but more expensive to operate than Battery Electric Vehicle (BEV)
  Source:(https://pluginbc.ca/wp/wp-content/uploads/2014/07/EV-Beginners-Guide_Final_Sept2_2014.pdf)

Inside an Electric Car

At the heart of an electric car lies the combination of:

- An electric motor
- The motor's controller
- The Batteries

Power is being delivered to the motor by a controller according to the potentiometer device (potentiometers sends the signal to the controller regarding the quantity of power that controller supposed to deliver). When driver floors the accelerator pedal the controller can deliver the full power when car is not running the controller can deliver no power and any power in between.

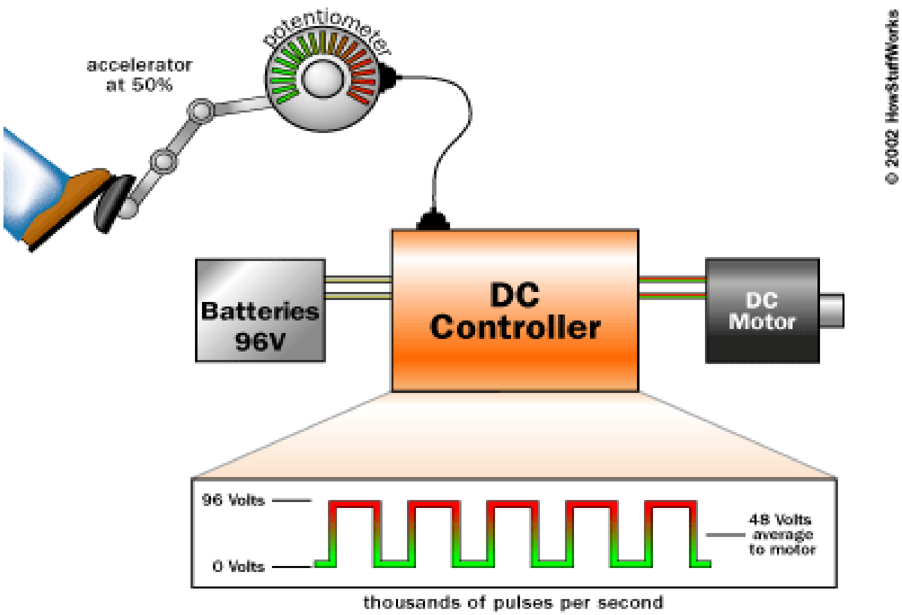


Figure 2.1: Inside an electric car

Batteries are connected to a simple DC controller and the DC controller is connected to motor. In the above given figure, a 96-volt battery is connected to a simple DC controller and the DC controller to a DC motor as mentioned above. If the accelerator pedal is fully pressed full 96 volt of power is supplied to the motor by the controller whereas if the accelerator pedal is not pressed or left idle no power is supplied to the motor. If the driver presses the pedal and keep it in between the controller create an average voltage somewhere between 0 and 96 volts.

Electric-car Motors and Batteries

Electric cars can use AC or DC motors:

- A DC motor can run on any voltage between 96 to 192 volts If the motor is a DC motor**.**
- If it is an AC motor, then it probably is a three-phase AC motor running at 240 volts AC with a 300-volt battery pack.

DC installations are simpler and cheaper. A regular motor has a range of 20000-watt -30000 watt while a regular controller has a range of 40,000 -60,000 watt. (for example, Maximum around 400-600 amps will be supplied by a 96-volt controller). A special feature of DC motor is that they can be overdrive for short duration of time. That is, 100,000 watts will be accepted by a 20,000-watt motor for a short period of time and deliver 5 times its rated horsepower. This is good for short bursts of acceleration. Too much overdriving heats up the motor and it self-destructs this is the only limitation.

One can use any three phase AC motor in AC installations and thus it makes easy to find a motor with a specific power rating, shape and specific size. It also has regeneration feature as during breaking motor deliver power back to batteries by turning itself into generator.

Source: https://auto.howstuffworks.com/electric-car.htm

Benefits of E- Car

Oil saving potential- Energy Security:

One does not need to buy gas and oil as a fuel in case of BEVs as these are entirely charged by the electricity.

Zero emissions- Green Car:

BEVs are entirely run on electricity and thus are 100 percent ecofriendly compared to any average IEC car which releases over 350 grams of CO2 per mile whereas BEVs do not produce any emission. Hybrids also produces emission thus BEVs are even better than hybrid cars. Fresh air means very few diseases that in turn fewer strain on hospitals, public health and so on. For instance, less greenhouse emission reduces carbon footprint and saves the ozone layer.

Efficiency – ICE cars are capable of converting only 20% of the energy stored in oil while electric motors are capable of converting 75% of the chemical energy from the batteries to power the wheels.

Low running cost:

The fuel for BEVS are very cheap as compare to ICE. These vehicles start to payoff for them self soon after they have been bought due to low running cost and thus significant saving potential.

Require less maintenance:

They have less maintenance cost and also require less maintenance as compared to ICE vehicle as the number of moving parts in E car is less than that of ICE cars .According to a paper by Idaho National Laboratory on the difference between ICE and EV states that E car consist of controller, charger and electric motor the controller and charger are electronic devices with no moving parts, and require little or no maintenance. Electric motor consists of one moving part called shaft which is very reliable and require little or no maintenance.

Electric cars are safer:

The same safety and the crash test are required to be pass by all passenger vehicles however there are some more safety features in e car making them safer on road. For example, E car catch less fire in real world crash event as compare to ICE car. One e car catches fire in every 120 million miles driven and one ICE car catches fire to every 20 million miles driven. E car is less likely to roll due to its heavy battery which makes center of mass lower also it does not explode on impact. E car exceeds all the safety measures because their manufacturers of electric vehicles don't spare any expense on safety measure. EVs score is higher in crash test then the regular score for example Tesla Model has a perfect score.

Electric cars are quiet:

70 dB is the average interior noise produced by an ICE car at the speed of 65 mph whereas e car does not make much noise and are almost quiet. As per the study by the National Institute of Environmental Health Sciences (NIEHS) due to noise exposure tens of millions of American suffer from adverse health outcome like hearing loss and heart diseases .The same study also states that the people of US nearly 100 million that is half of its total population had annual exposure to traffic noise that was high enough to be harmful for health.

Savings: The fuel for e cars are very cheap and various incentives schemes are also offered by government to purchaser to get money back from government for going green.

Easier to use:

EVs are very easily fit in the life of EVs user. It is very easy to charge the EVs at home as well as working place means you never need to go out of your way to refuel. After work you can simply plugin for the night and next morning you will get it full charged. Similarly, at work also you can plugin during office hour.

Faster than you think:

High speed record is made by E cars in spite very advance technology of ICE car. For example, the Tesla Model S P100D did 0 to 60 mph in 2.28 seconds, that's faster than a Bugatti Chiron. It is difficult to match the instantaneous and constant torque of an electric motor even by most powerful engine of ICE cars.

Source: https://www.fleetcarma.com/everything-need-know-electric-cars/#what

<u>Electric car Characteristics:</u>

Efficiency - Electric motors are capable of **converting 75% of** the chemical energy from the batteries to power the wheels while ICE cars are capable of converting only 20% of the energy stored in oil.
Electric motors **convert 75% of** the chemical energy from the batteries to power the wheels while ICEs only **convert 20%** of the energy stored in gasoline.

- **Eco-friendly** – EV can use non-polluting electricity from renewable sources, such as hydro-, solar-, or wind-power and EVs also do not emit any pollution.
- **Performance** – Electric cars need less maintenance as compare to ICE. It is also less noisy, provides better pick up and smooth operations However, EVs have serious battery-related issues

- **Driving range** - ICE vehicles can cover over 300 miles before needing to re-fuel while most current EVs can only travel 100–200 miles before recharging.

- **Recharge time** – Normal charging a battery can take from 4 to 8 hours to charge to 80% capacity however quick charge" can take 30 min.
- **Cost** - Large battery packs are expensive and may need replacing more than once.
- **Size & weight** - Battery packs are heavy and can take up considerable vehicle space.
- **Recharge Points:** Unlike the petrol/Diesel pump the charging station of e vehicles are still in the development stages. So, one cannot find the charging stations like ICE vehicles fuel station. So, in long trip one may face problem of refueling.
- **Battery Replacement:** The life of battery of depends upon type and usage and almost all the e cars' batteries are required to be changed between 3-10 years.

Source:https://www.conserve-energy-future.com/advantages-and-disadvantages-of-electric-cars.php

ICE Car vs E car:

An electric car uses electrical energy stored in battery as a fuel to create force for the movement instead of petrol and diesel.

In Ice car the petrol or diesel are send through a pump into combustion chamber where fuel burns and produces heat and energy which moves the piston up and down and gear box passes the movement to wheels by which wheels rotates. In E cars all these powers are generated by battery pack. Battery pack is a group of many small pencil lithium ion cells. Battery pack is equipped by combining many battery racks.

DC power generated through this battery pack is converted into AC power through Inverter. This 3-phase induction power is used to run the electric motor. Induction motor is directly connected to wheel.

The power delivered by Ice engine is never equal and it is low initially and increases gradually while full power available by induction motor from start.

Ice engine can’t self-start it needs a motor starter and a battery for self-start similarly to increase or decrease the power it requires a transmission system (Gear box) while in E motor all these are not required. E motor speed increases if you give more power and decreases if you give less power.

E motor works on magnetic field that is one of the main reasons that it is very light almost 5-6 times as compare to ICE engine.

E motor always delivered almost double torque as compare to ICE engine from start to finish. Power to weight ratio is also around 100 times as compare to ICE engine.

One thing is common in both of them both become hot. For Ice engine to make them cool it require a full coolant system. While to cool induction motor coolant is used but in very less quantity.

There is also one more difference as petrol tank requires only 5 minutes to fill while battery requires at least 45 minutes to 1hour in case of fast charging. In case of Normal charging it requires 5-6 hours.

As discussed, to make a battery pack so many lithium ion packs are grouped. In order to fix them in a line chassis are designed accordingly because of that chassis become very strong. This is one of the reasons that center of gravity of e car is low and they provide better handling.

Because of strong chassis e car easily get five stars in almost every crash test. While it is very difficult to Ice car to get five-star rating.

Pickup of e car is almost 3-4 times as compare to Ice car because of constant power and almost double torque.

Petrol /diesel has reached almost top of the technology and there is very less prospect to improve it as it has almost reached at the saturation while there is huge opportunity for research and improvement in electric technology in future and it is going on.

E car also uses reverse charging technique which converts the energy generated during break in charging the battery.

E car also has very low maintenance as compare to Ice because it has very less component and equipment's as Ice car require so many components and equipment's like engine, coolant system motor starter, Gear box etc.

E car creates very less pollution almost zero so also called zero emission car.

Electric Car Running Costs

It has been seen that the petrol rates are terrible for the last many years as of now (2018), the petrol rates are around Rs 80 in some cities. The following calculations have made based on the 2018 rate

- After 4 years the cost of operating a small ICE car is around Rs 3,06,640 (Small ICE car for example, Maruti Celerio, Hyundai i10 or equivalent)
- After 4 years the operating cost of a small electric car hatchback is around Rs 39,000. (e2o Classic, e2o Plus))

Fuel cost and Maintenance cost has been considered for the analysis to obtain the operating cost after 4 years.

For an electric car, battery replacement costs only need to be considered after 8 or 9 years.

It is always suggested to look at the total cost of ownership over many years for comparison for both ICEs and EVs. EV's will be a winner as it has very low operating cost.

Petrol Car	Electric Car - Mahindra e2o
4 years	4 years
40000 km	40000 km
3333 litres of Petrol @ 12 kmpl	100 km per charge consuming 10 units
Rs 80 Per litre	So 40000 km consuming 4000 units
Rs 2,66,640 just on Fuel	Rs 24,000 on 'electricity' (@ Rs 6 per unit)
4 Year Maintenance & Servicing Cost = Rs 40,000	Battery Replacement Cost = Rs 0 (Change battery after 8 years)
Total Ownership Cost after 4 years = Rs 3,06,640	Misc Maintenance = Rs 20000
	Total Ownership Cost after 4 years = Rs 44000

Table 2.1: Comparison of total ownership cost of petrol car vs e car

Source: http://www.pluginindia.com/electricvehiclecosts.html

History of E car

The first prototype of electric vehicle was invented in 1832-1839 by Robert Anderson who was a Scottish inventor. The first Electric Car was practically developed in the year 1835 by an American Inventor Thomas Davenport.

During 1859 rechargeable lead-acid storage battery was invented by a French physicist Gaston Plate. Camille Faure during 1881 invented the basic lead-acid battery used in automobiles he also improved the ability of storage battery to supply current.

In 1891 William Morrison, a chemist from Des Moines, Iowa, built the first successful electric automobile in the United States.

During the starting months of the year 1897 Electric Taxis were started in the city of New York. The first large scale American electric automobile manufacturer was the Pope manufacturing company of Connecticut during the year 1900.

In the cities of Boston, Chicago and New York about one third of the cars found were electric. 28 % of cars were electric in every 4192 cars produced in the US. Thus, electric automobile was in its peak.

In1886 the first ICE car was developed in Germany by Benz and Daimler. There was huge competition between the two types but due to the advantage of low initial cost and flexibility Henry Ford, decided to select the ICE Vehicle for the first mass production of a car in history in 1908.

The first electric automobile starter was invented by Charles Kettering's in 1912 for ICE vehicles due to this invention the unwieldy used crank shaft was abolished and made ICE autos more attractive to customers which in turn cause dying of electric car.

There were many reasons for the downfall and dying of electric car during the 1920s. The electric car was not appropriate due to lack of power, lack of range and the easy availability fuel for ICE vehicles. Thus, BEV is replacing by ICEV but this was one of the major mistakes in the history of technology. ICEs vehicle became one of the major causes of urban air pollution due to fast growth and limited implementation of emission control; technique.

1966: To reduce air pollution the use of E-vehicles was recommended and a bill was introduced by the Congress 33 million (18%) Americans are interested in electric vehicles out of 179 million that was total population America in 1960 census as per Gallup poll.

1970s: An act was established in which the states were required to meet certain deadlines and take control of their air quality. A spark to alternatives of fueled vehicles was generated by The OPEC oil restriction, in which the prices of oil went high.

The entering of the Vanguard-Sebring's Citi Car in the Electric vehicle symposium at Washington D.C. was during the year 1974. The top speed of this car was around 30mph and range of this car in a reliable warm weather is 40 miles. The company became the sixth largest automaker in the US during the year 1975 after a few years the company was closed down.

To be used in a test program the Postal Service of US purchased 350 electric delivery jeeps from a division of AMC i.e. AM General during 1975.In 1975 The US Postal Service purchases 350 electric delivery jeeps from AM General, a division of AMC, to be used in a test program.

An act known as the Electric and Hybrid Vehicle Research, Development, and Demonstration was passed by the Congress during 1976. The motive to pass this act was to encourage the development of new technologies motors, improved batteries and other hybrid-electric components

For building a practical consumer electric car EV1 the CEO of GM i.e. Roger Smith agreed to fund it in the year 1988.

During the 1990 Zero Emission Vehicle order was passed by California’s government which required the vehicles in the states of California to comprise 2 % of no emissions vehicles till 1998 and 10 % till 2003

During the year 1997 Prius was unveiled by Toyota in japan where nearly 18,000 units were sold in the first production. Thus, it became the world’s first hybrid vehicle produced in a large quantity. 1997:

The first hybrid sold in US since the very starting was the Insight released by Honda during the 1999.

During the 2000 Prius was released worldwide which gained fast success with celebrities.

During the year 1997-2000 some big car manufacturers produced a few thousands of AEVs like, GM's EV1, Honda's EV Plus, Chevy's S-10 EV, Nissan's Altra EV, Toyota's RAV4 EV and Ford's Ranger but most of them are available for lease only.

During the November 2006 at the International Auto Show, San Francisco Tesla Roadster was revealed publicly it will be first sold in 2008 at a base price of $98,950.

To promote the use of electric cars in Israel the government of Israel announces its support for a sweeping project during the January 2008

In the decade the sales of car reach to their lowest due to the severe price increase of oil during the 2008, July. Automobile makers in America shifted their lines of production to smaller and more fuel-efficient vehicles from large vehicles and SUVs.

American presidential candidate Barak Obama said in 2008 that on the roads of America there will be more than one million PHEVs and EVs by the year 2015.

In the year December 2008 battery maker of china i.e. BYD became an automobile manufacturer and also released the world's first plug-in hybrid compact sedan known as F3DM.2008, December:

A subsidy of £ 2000 is being offered by the British government to the purchasers of electric car to promote electric vehicle use by British prime minister Gordon Brown during April 2009. A high ranked British government officer estimated that the percent of electric or hybrid cars in Britain should be 40% of all the total number of cars in Britain so that the country can reach its goal i.e. by 2050 80% of the country's CO2 discharge should be cut.

2009: Nissan launched new electric car LEAF in August 2009. The LEAF travel 100 miles on a full charge and has a battery that can be recharged to 80% of its capacity in 30 minutes.

Late 2009 Mitsubishi i MiEV, Chevrolet Volt are scheduled to hit the streets in the near future.

2010: To establish a manufacturing facility in California $465 million loan was given by Department of Energy's Loan Programs Office to Tesla. Tesla repaid the loan nine years early. In late 2010, the Chevy Volt and the Nissan LEAF were released in the US market.

2012: To make plug-in electric vehicles more as affordable as today's gasoline-powered vehicles by 2022 president Obama launched the EV Everywhere Grand Challenge.

As the model 3 was first revealed in March 2016, Tesla has secured an estimated 500,000 pre-orders for the Model 3. Starting at $35,000, the Model 3 is Tesla's first car geared at a consumer audience. Tesla will offer six color options for the Model 3. Affordability, with a starting price of $35,000 was the Tesla's big selling point for the Model 3. The base Model 3 can reach a top speed of 130 mph, can drive 220 miles on a single charge and accelerate to 60 mph in 5.6 seconds. With a range of 310 miles, Tesla will also sell a premium version of the Model 3 which is priced at $44,000, the car can reach a top speed of 140 mph and accelerate to 60 mph in 5.1 seconds.

Today: There are 23 plug-in electric and 36 hybrid models available in a variety.

*Source: (*The Andhra Journal of Industrial News)

E- Car Market in the world

Due to potential benefits of E car in terms of oil scarcity and zero emission as compare to ICE Car many countries want to adopt the electric car as a preferred mode of transportation as compare to ICE car. India, Norway, Britain and many other countries all wholly want to transformed from ICE car to Green car. The official target set by various countries for the adoption of Electric car is discussed below.

India: India is home to one of the highly polluted cities of the world. In India few cities are extremely affected by air quality problem. It also imports more than 80 % of crude oil. As per the government every vehicle sold in India by 2030 should be an electric vehicle

China – It is the biggest E Car market which buys more cars than any other country. According to IEA China records more than 40% of the electric cars sold in the world and more than double the number sold in the U.S.

Norway: Norway is leading e car market in the world. Last year around 40% electric or hybrid cars were sold in the country. Norway government is quiet ahead for the adoption of E Car they have a clear target for the adoption of E car. By 2025 all new passenger cars and vans needs to have zero-emission.

Britain: In 2040 Britain will stop the sales of any ICE car to clean up the country air. All new passenger cars sold in 2050 should be zero emissions vehicle.

France: France government also decided to end selling ICE cars by 2040 to support global warming. After that they will only allow environment friendly car which uses electricity as a fuel or some other cleaner fuel.

According to IEA the following countries have set official target to sell electric cars: Germany, Japan, Austria, Netherlands, Portugal, Denmark, Ireland, Spain and Korea In the United States at least eight states have set out goals however it doesn't have a central policy.

Source: CNNMoney (London)First published July 26, 2017

Source: http://money.cnn.com/2017/07/26/autos/countries-that-are-banning-gas-cars-forelectric/index.html

Global Electric car status in 2012:

Globally, in developed economies like Europe, the US and Japan over the past five years a significant growth record has been set by electric cars.

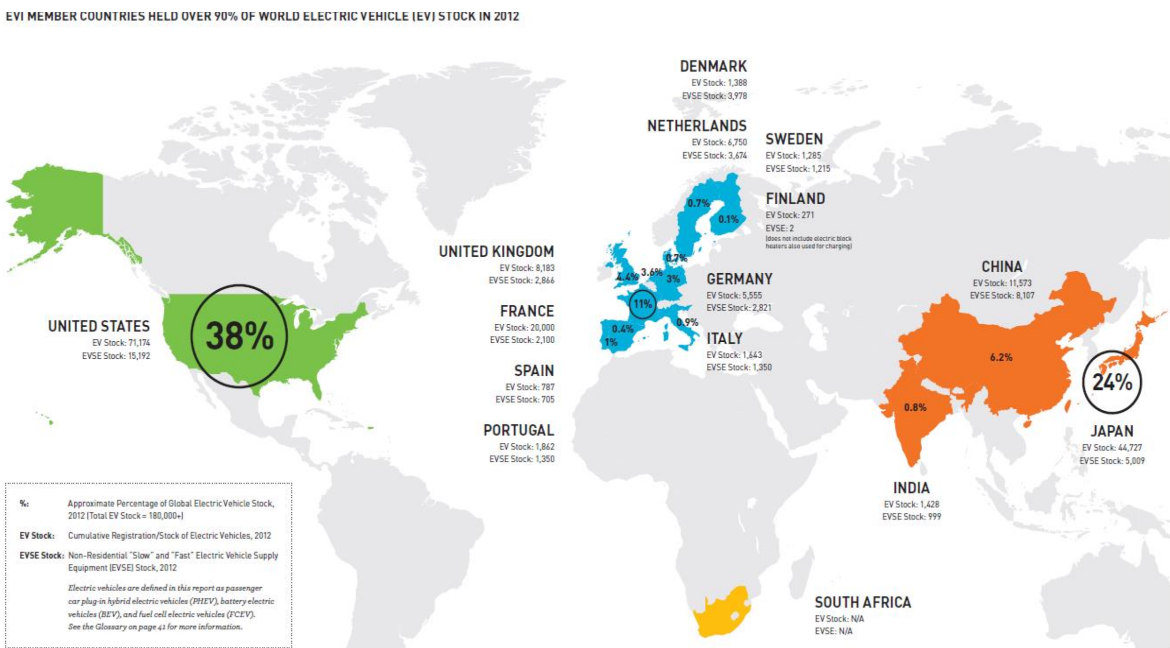


Figure 2.2: EVI member countries held over 90% of world's electric vehicle (EV) stock in 2012

Source: Global EV Outlook 2013

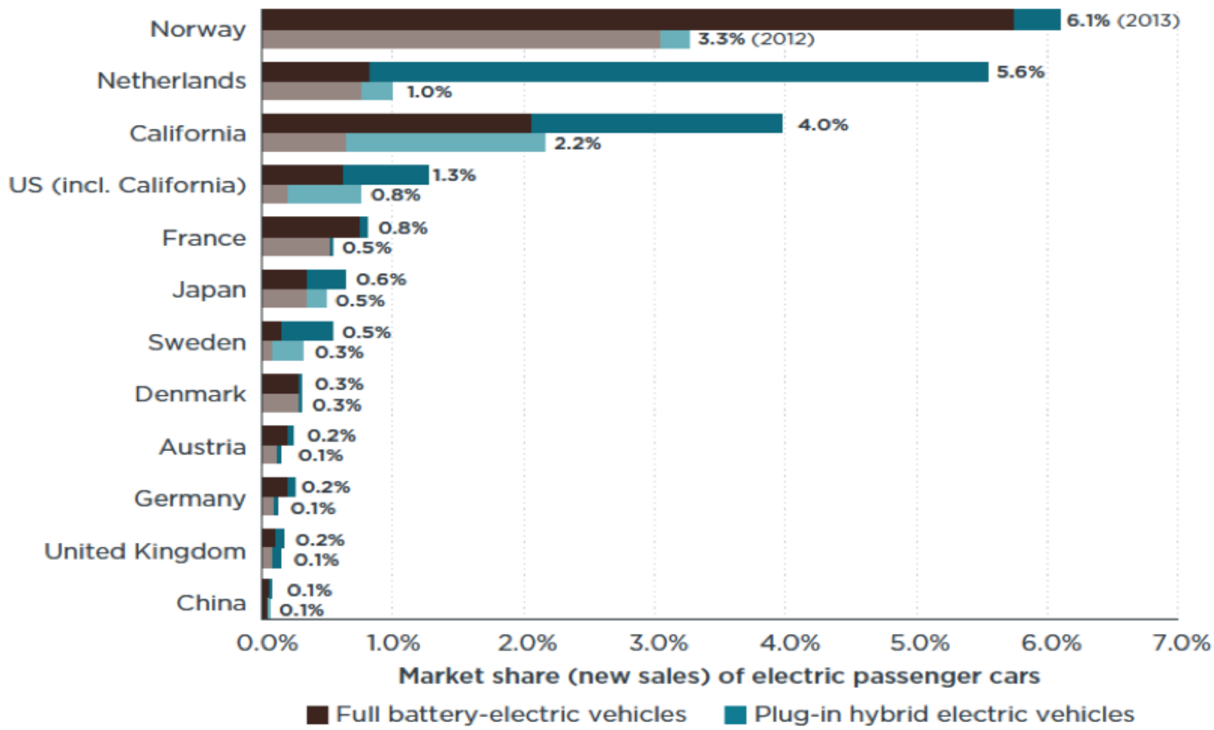


Figure 2.3: Market share (new sales) of electric passenger cars

Source: Global EV Outlook 2013

New registrations of passenger cars worldwide by region
(Units in 1,000s)

Region	2013	2014	Change in %
Europe	**15,992**	**16,181**	**1.2**
Western Europe	11,555	12,113	4.8
New EU countries	782	894	14.3
Eastern Europe	3,656	3,175	-13.2
America	**22,838**	**23,338**	**2.2**
NAFTA	18,334	19,415	5.9
thereof USA	15,532	16,435	5.8
Mercosur	4,504	3,922	-12.9
thereof Brazil	3,580	3,333	-6.9
Asia	**27,121**	**29,285**	**8.0**
Japan	4,562	4,700	3.0
China	16,303	18,369	12.7
India	2,554	2,571	0.7
South Korea	1,292	1,410	9.1
ASEAN	2,077	1,872	-9.9
other	333	363	9.1
Other countries	**7,126**	**7,262**	**1.9**
Total	73,076	76,066	4.1

New registrations of commercial vehicles worldwide by region
(Units in 1,000s)

Region	2013	2014	Change in %
Europe	**2,300**	**2,349**	**2.1**
Western Europe	1,638	1,758	7.3
New EU countries	155	166	7.4
Eastern Europe	507	425	-16.2
America[1]	**657**	**672**	**2.4**
NAFTA	430	483	12.4
thereof USA	352	407	15.6
Mercosur	227	189	-16.6
thereof Brazil	187	165	-12.2
Asia	**8,942**	**8,202**	**-8.3**
Japan	813	863	6.2
China	5,682	5,123	-9.8
India	687	606	-11.8
South Korea	246	250	1.5
ASEAN	1,446	1,290	-10.8
other	68	70	3.0
Other countries	**632**	**634**	**0.3**
Total	12,530	11,858	-5.4

[1] In America medium/heavy trucks and busses.
Source: VDA

Table 2.2: New registrations of passenger cars and commercial vehicles worldwide by region (Units in 1000's) Source: VDA

Country	Market Share 2013 (in %)	Market Share 2014 (in %)
Canada	0.1	0.3
United States	1.3	1.5
Netherlands	5.3	3.9
United Kingdom	0.2	0.6
Spain	0.1	0.2
Portugal	0.2	0.2
France	0.5	0.7
Norway	7.3	12.5
Sweden	0.6	1.4
Denmark	0.3	0.9
Italy	0.2	0.1
Germany	0.2	0.4
Japan	0.7	0.7
China	0.1	0.3

Country	EV stock	EVSE stock
Canada	10778	3117
United States	275104	21814
Netherlands	43762	12114
United Kingdom	21425	2866
Spain	3536	775
Portugal	743	1330
France	30912	8600
South Africa	48	0
Norway	40887	6208
Sweden	6990	3100
Denmark	2799	1721
Italy	7584	2520
Germany	24419	2821
India	2689	328
Japan	108248	11511
China	89198	30000

- Norway is the country with the highest market penetration per capita in the world, with four plug-in electric vehicles per 1000 inhabitants in 2013.
- In March 2014, Norway became the first country where over 1 in every 100 passenger cars on the roads is a plug-in electric.
- Norway also has the world's largest plug-in electric segment market share of total new car sales.

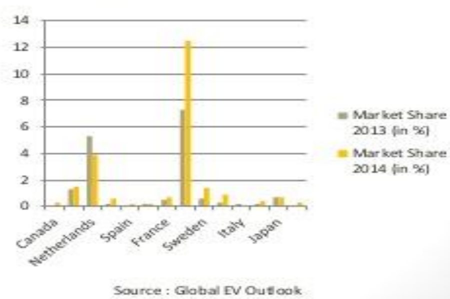


Figure 2.4: Market share of EV country wise

Source: Global EV Outlook

EVs see record sales again in 2017

A -new record -with more than half of global sales over 1 million electric cars were sold in China in 2017. More than 3 million electrics have been sold in worldwide, an expansion of over 50% from 2016.

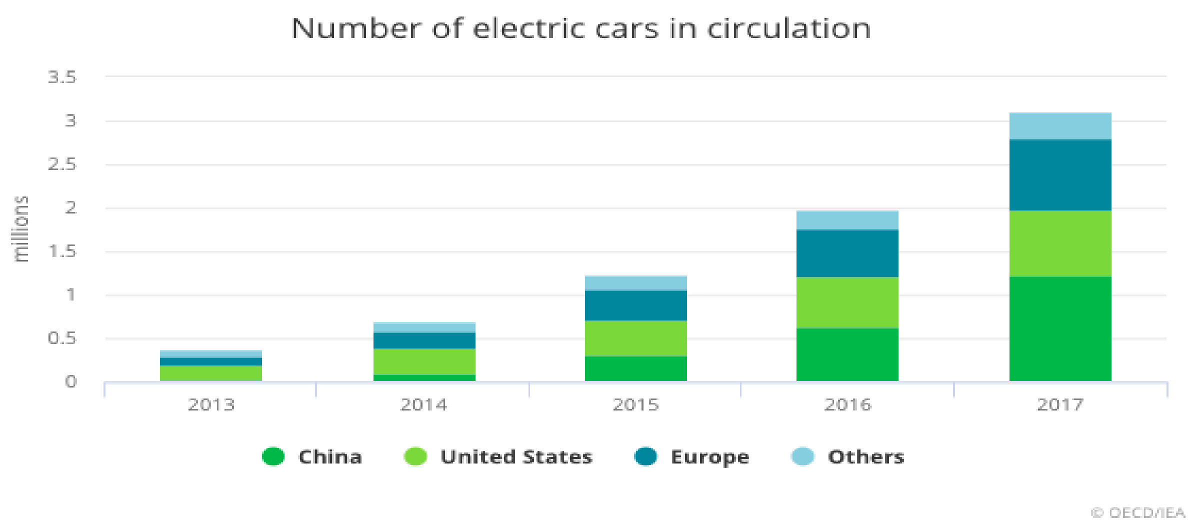


Figure 2.5: Key Findings from Global EV Outlook 2018

Source: EV outlook 2018

E car market share by country 2017:

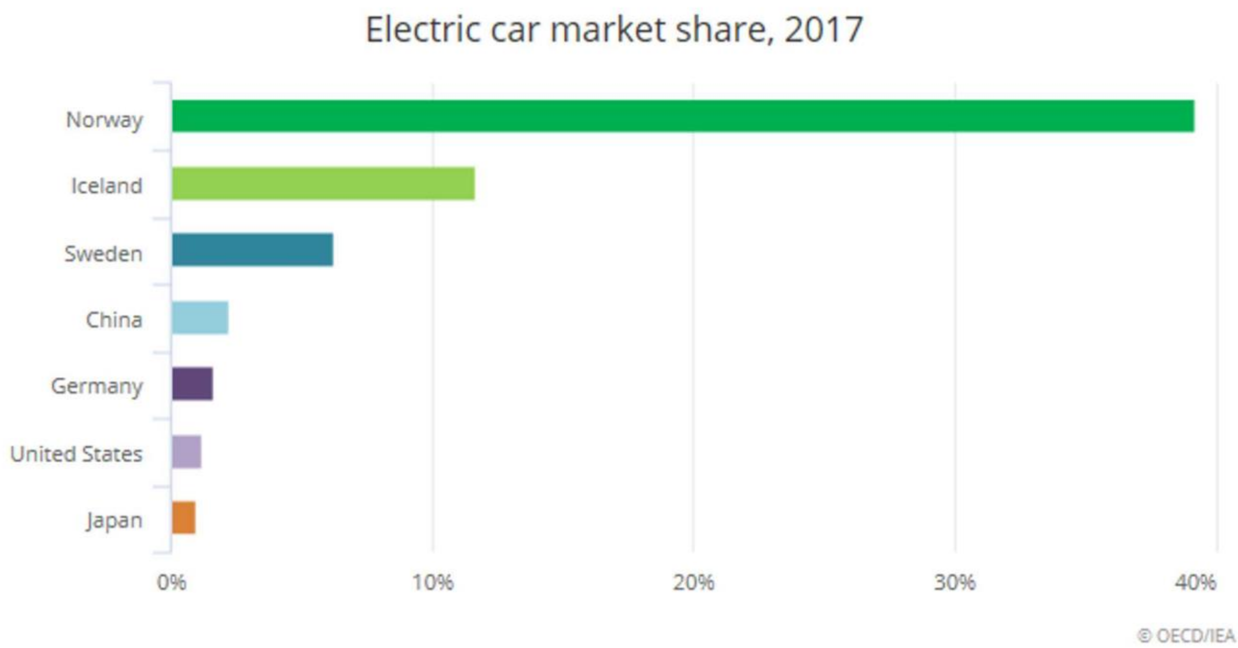


Figure 2.6: Electric Car market share by country in 2017

Only a handful of countries have significant market share

In 2017, with over 39% of new sales Norway remains the world's most advanced market for electric car sales. Iceland follows at 11.7%, then Sweden at 6.3%.

Source: EV outlook 2018

Electric Car Market share by Country 2005-16

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Canada								0.15%	0.20%	0.29%	0.39%	0.59%
China						0.01%	0.04%	0.06%	0.09%	0.38%	0.99%	1.37%
France						0.01%	0.13%	0.34%	0.55%	0.72%	1.22%	1.46%
Germany						0.00%	0.05%	0.11%	0.23%	0.42%	0.72%	0.73%
India				0.02%	0.01%	0.01%	0.02%	0.05%	0.01%	0.02%	0.04%	0.02%
Japan					0.03%	0.06%	0.35%	0.53%	0.63%	0.68%	0.58%	0.59%
Korea							0.02%	0.04%	0.05%	0.09%	0.21%	0.34%
Netherlands					0.01%	0.02%	0.16%	1.02%	5.38%	3.89%	9.74%	6.39%
Norway			0.01%	0.22%	0.15%	0.31%	1.33%	3.27%	6.00%	13.71%	23.63%	28.76%
Sweden						0.00%	0.05%	0.31%	0.53%	1.44%	2.37%	3.41%
United Kingdom	0.01%	0.01%	0.02%	0.01%	0.01%	0.01%	0.06%	0.13%	0.17%	0.60%	1.11%	1.41%
United States	0.01%			0.01%		0.01%	0.17%	0.44%	0.75%	0.74%	0.67%	0.91%
Others	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.06%	0.10%	0.21%	0.38%	0.52%
Total	0.00%	0.00%	0.00%	0.01%	0.01%	0.01%	0.10%	0.23%	0.38%	0.54%	0.85%	1.10%

Table 2.3: Electric cars market share

Source: Global EV outlook 2017

Electric Cars New Registrations by Country

Electric cars: New registrations

Table 9 • Battery electric cars, new registrations by country, 2005-15 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Canada							0.22	0.62	1.64	2.83	4.38
China						1.09	4.75	9.64	14.61	48.91	146.72
France	0.01				0.10	0.18	2.63	5.66	8.76	10.56	17.27
Germany	0.02			0.07	0.02	0.14	1.83	2.56	5.46	8.38	12.08
India				0.37	0.16	0.35	0.45	1.43	0.19	0.41	1.00
Italy	0.53			0.08		0.04	0.12	0.51	0.84	1.08	1.40
Japan					1.08	2.44	12.61	13.47	14.76	16.11	10.47
Korea						0.06	0.28	0.64	0.67	1.26	2.54
Netherlands				0.01	0.03	0.12	0.86	0.79	2.25	2.66	2.54
Norway				0.24	0.15	0.39	2.01	4.07	7.88	18.11	27.79
Portugal						0.02	0.20	0.06	0.17	0.20	0.64
South Africa									0.03	0.01	0.12
Spain						0.07	0.57	0.44	0.92	1.04	1.42
Sweden							0.18	0.27	0.43	1.24	2.96
United Kingdom					0.19	0.10	1.07	1.42	2.55	6.68	9.42
United States	1.12			1.47		1.19	9.75	14.65	47.69	63.42	71.04
Others*							1.68	1.85	3.50	7.97	16.99
Total	1.67			2.24	1.72	6.21	39.19	58.06	112.36	190.84	328.77

Table 2.4: Electric cars: New registrations

Electric Cars, Stock by Country

Battery electric cars, stock by country, 2005-16 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Canada							0.22	0.84	2.48	5.31	9.69	14.91
China					0.48	1.57	6.32	15.96	30.57	79.48	226.19	483.19
France	0.01	0.01	0.01	0.01	0.12	0.30	2.93	8.60	17.38	27.94	45.21	66.97
Germany	0.02	0.02	0.02	0.09	0.10	0.25	1.65	3.86	9.18	17.52	29.60	40.92
India				0.37	0.53	0.88	1.33	2.76	2.95	3.35	4.35	4.80
Japan					1.08	3.52	16.13	29.60	44.35	60.46	70.93	86.39
Korea						0.06	0.34	0.85	1.45	2.76	5.67	10.77
Netherlands				0.01	0.15	0.27	1.12	1.91	4.16	6.83	9.37	13.11
Norway			0.01	0.26	0.40	3.35	5.38	9.55	19.68	41.80	72.04	98.88
Sweden							0.18	0.45	0.88	2.12	5.08	8.03
United Kingdom	0.22	0.55	1.00	1.22	1.40	1.65	2.87	4.57	7.25	14.06	20.95	31.46
United States	1.12	1.12	1.12	2.58	2.58	3.77	13.52	28.17	75.86	139.28	210.33	297.06
Others					0.64	0.80	3.17	5.83	10.60	19.43	36.20	52.41
Total	1.37	1.69	2.15	4.54	7.47	16.42	55.16	112.94	226.78	420.33	745.61	1 208.90

Table 2.5: Electric Cars, Stock by Country

Evolution of global electric car stock 2010-2016

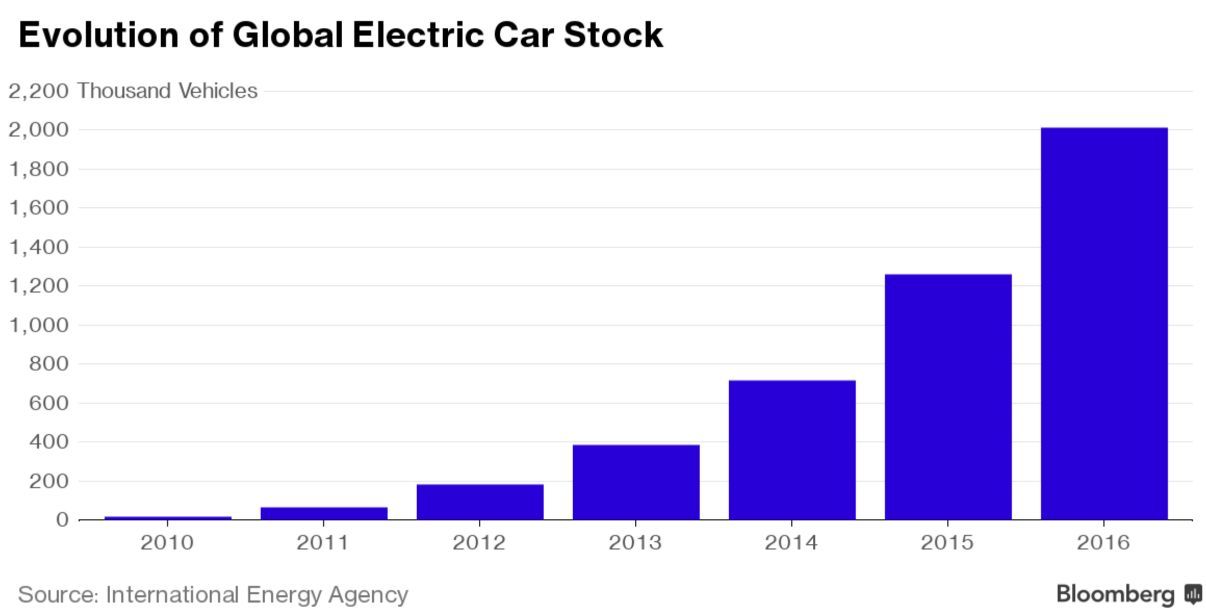


Figure 2.7: Evolution of global electric car stock

Evolution of global electric car stock 2013-2017

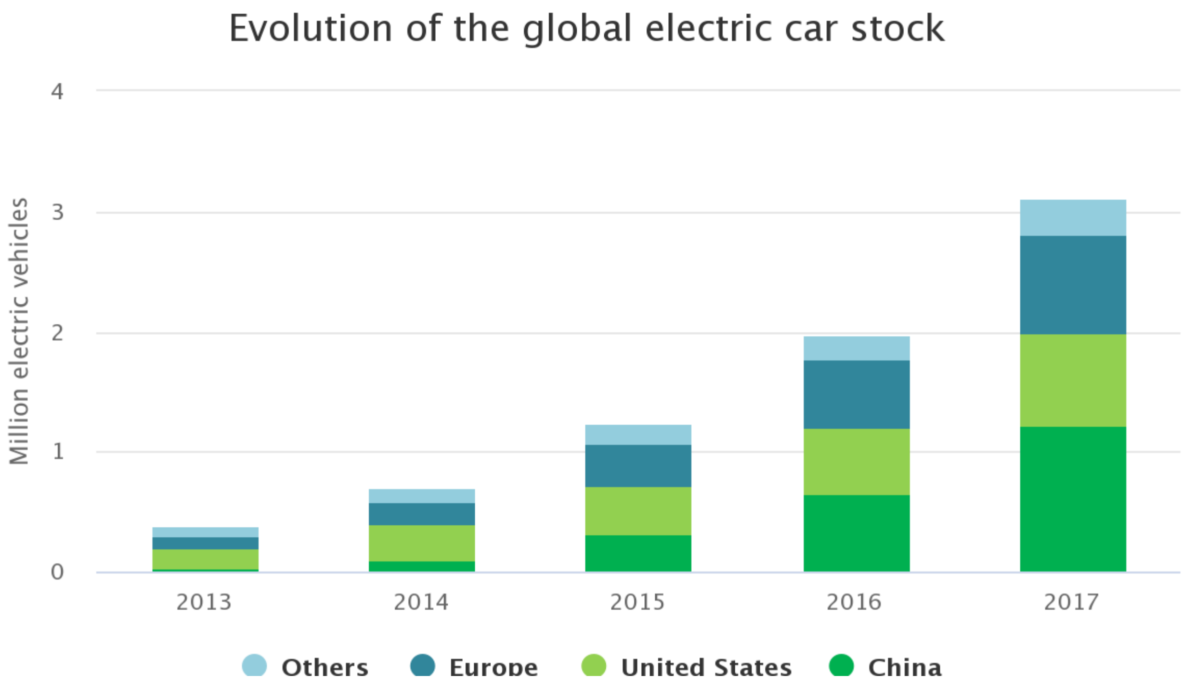


Figure 2.8: Evolution of the global electric car stock

The global stock of electric cars passed 3 million in 2017.

Source:IEA

Evolution of global electric car stock 2010-2016

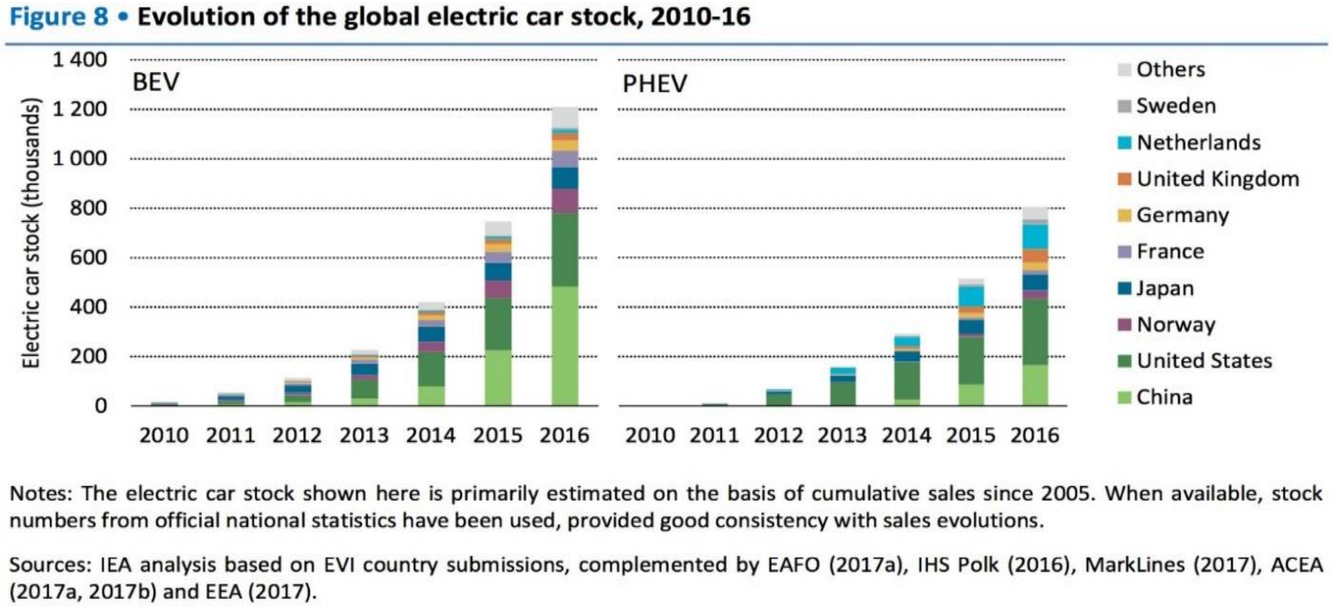


Figure 2.9: Evolution of the global electric car stock, 2010-2016

Source: Global EV outlook 2017

Electric car sales, market share, and BEV and PHEV sales in selected countries 2010-16

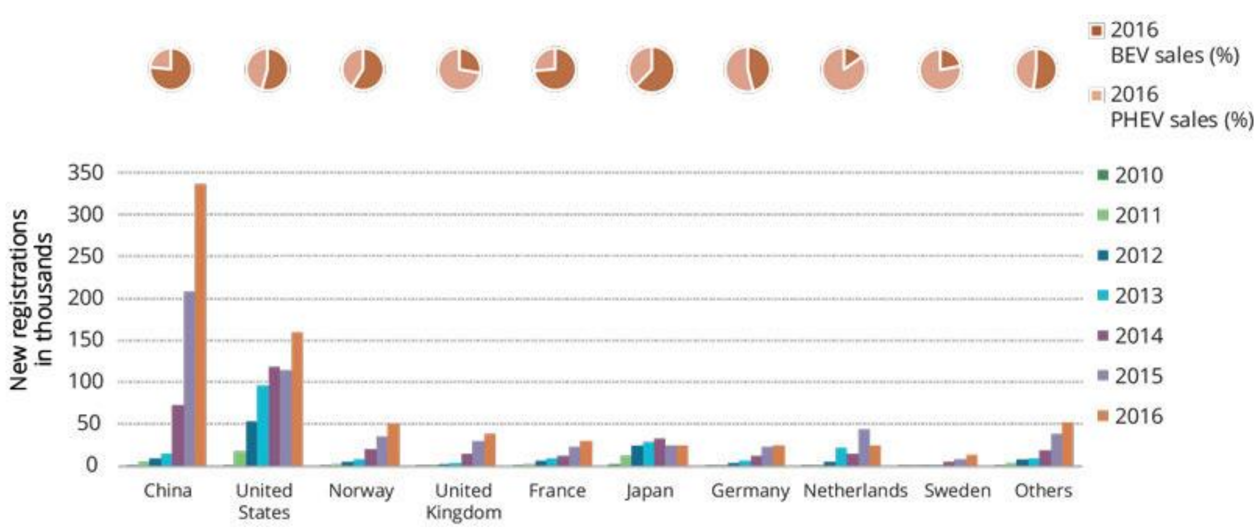


Fig. 2.10: Electric car sales, market share, and BEV and PHEV sales in selected countries,2010-16

Source: Global EV outlook 2017

Passenger electric car stock in major region and top ten EVI country:

Stock:

in 2017 an increase of 57% from the 2016 has been recorded and the global stock of electric passenger cars have reached to 3.1 million. Similar growth rate of 60 % was observed in 2015 and 2016. Among these two-thirds of the world’s electric car fleet are BEVs.

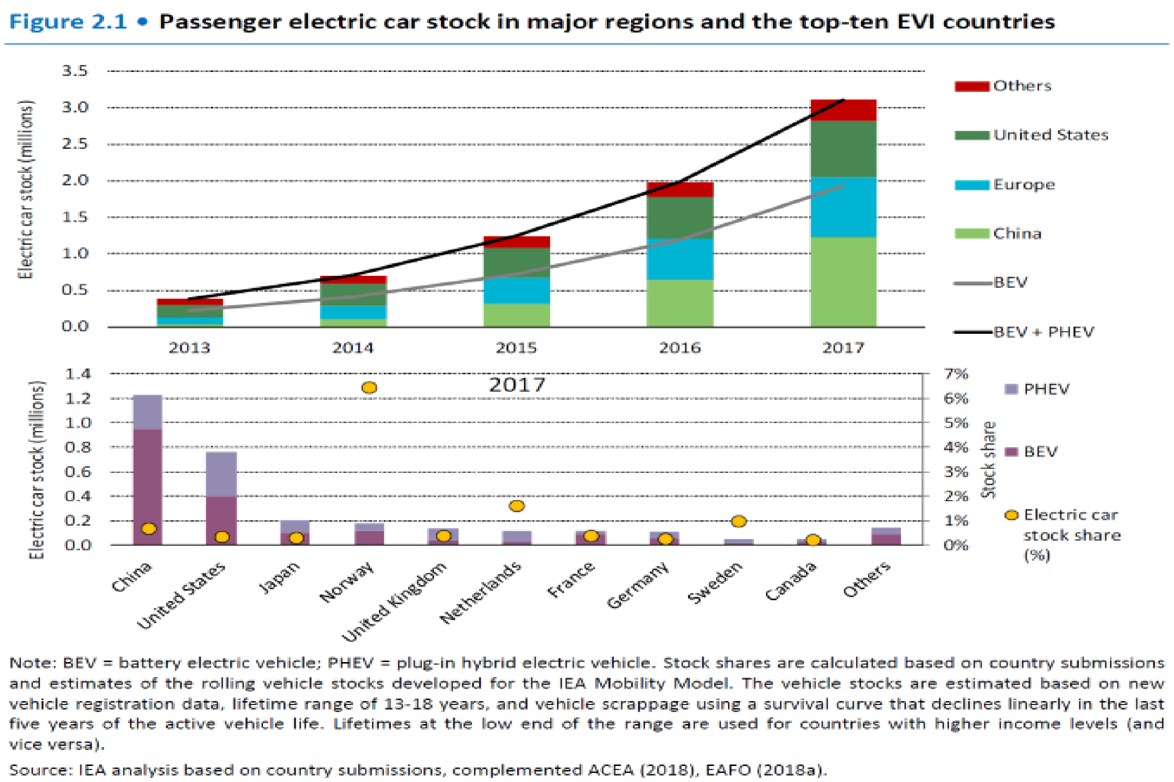


Figure 2.11: Passenger electric car stock in major region and top ten EVI country

Source: Global EV Outlook 2018

<u>Growth is Accelerating</u>

The sales of Plug in Volume have increased by almost more than thrice since 2013. 8 out of 10 cars sold in 2030 would be plugins if the same growth rate of 42 % continue. Seems very difficult today but it can be achieved in future. The data of world revels that the 1% market share have been captured by e cars globally in this year, but it is already crossed more than 1 % in some other markets like: Norway had 29 % plug-in share, Netherland 6.5% share and Sweden around 4. 0 %.

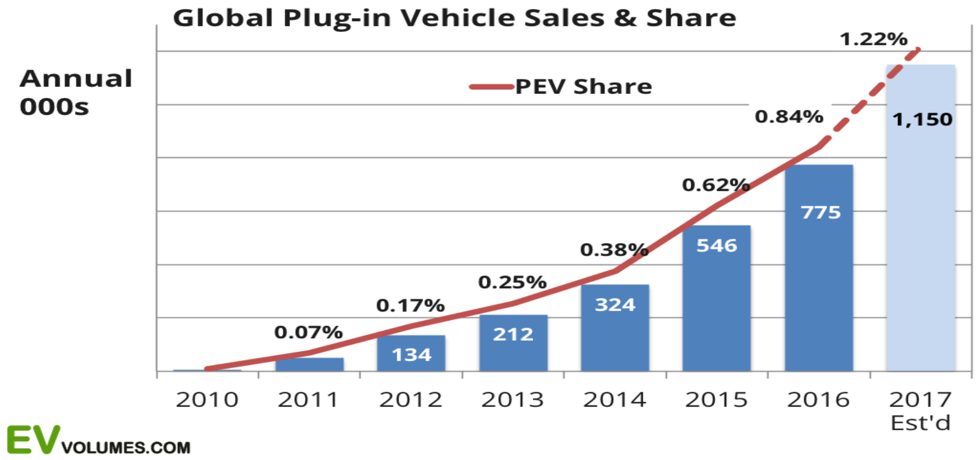


Figure 2.12: Global plug-in vehicle sales and share

Source: EV Volume.com

<u>Evident Trend Towards More BEV Sales</u>

In China, BEVs typically stand for over 80 % of "NEV" (New Energy Vehicle) sales.

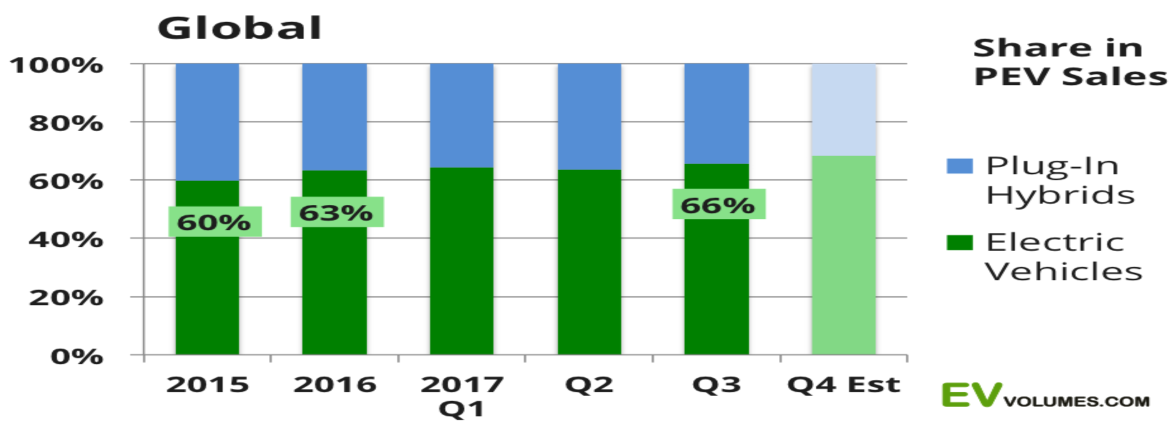


Figure 2.13: Global shares in PEV sales

Source: EV Volume.com

The Rise of China

To control smog, pollution and traffic congestion Chinese government designed some programmed in the past .One can see from the graph that China accounts for almost half of sales in 2017 thus the major volume driver for PEV expansion has been China. The sales of the Plug-in vehicle are pushed due to the sales of the Plug-in vehicle.

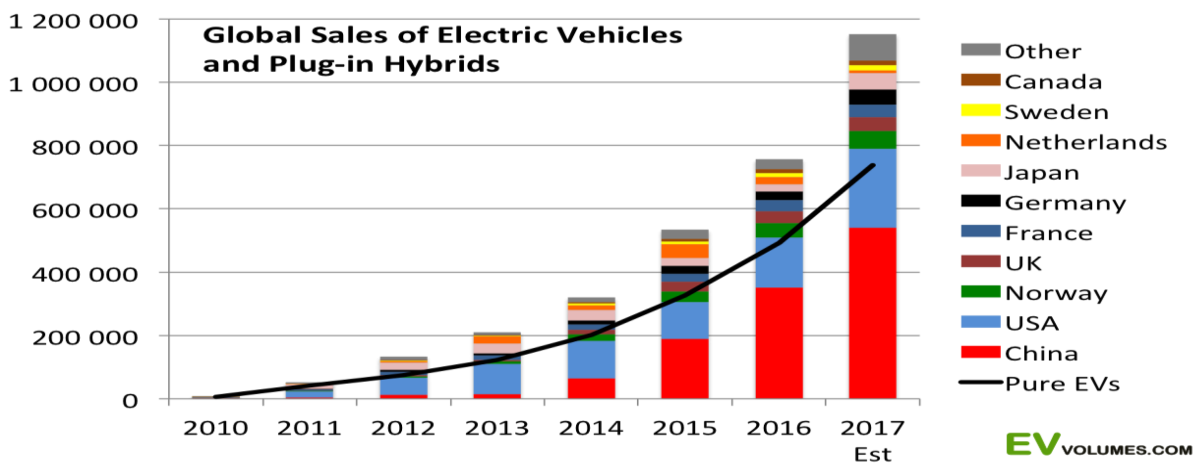


Figure 2.14: Global sales of electric vehicles and plug-in hybrids

Source: EV Volume.com

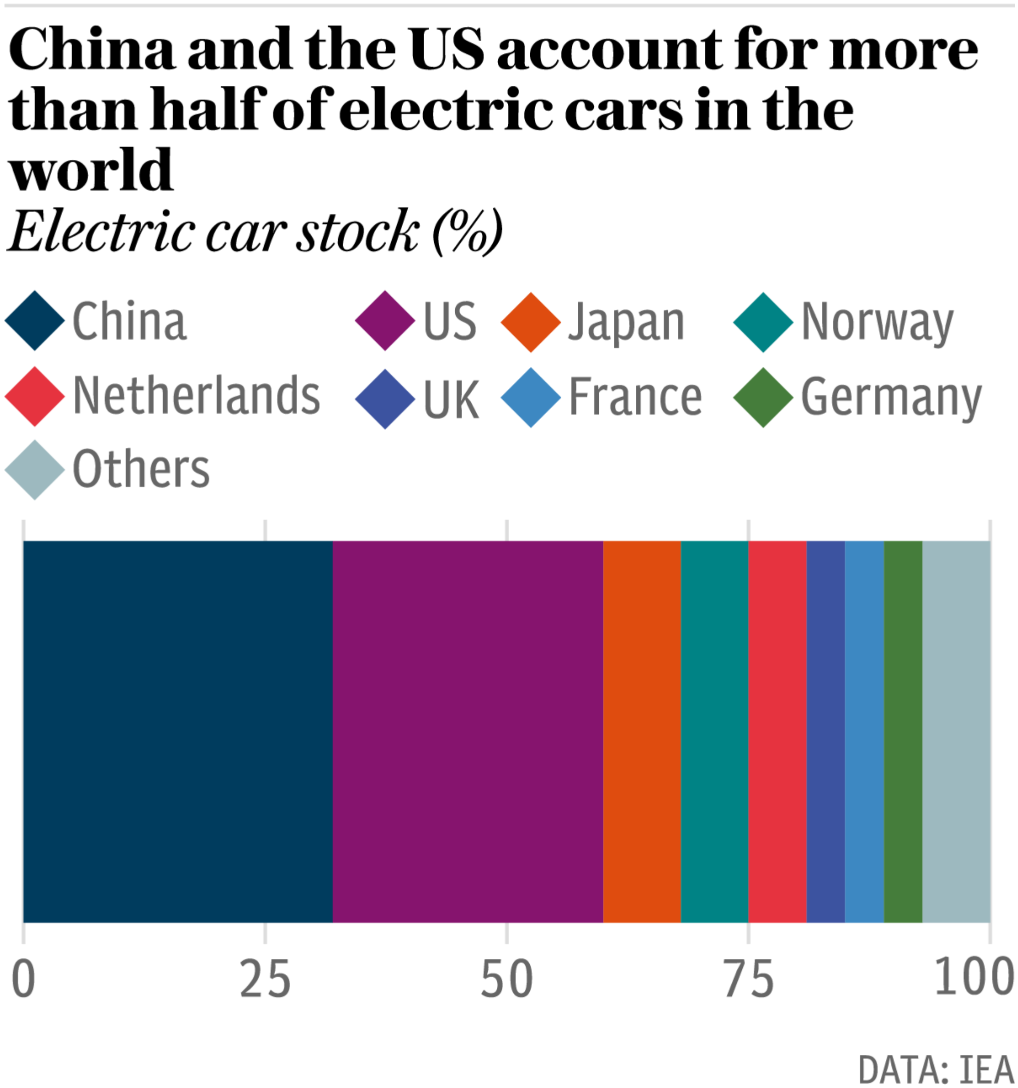


Figure 2.15: China and the US account for more than half of electric cars in the world

Source:IEA

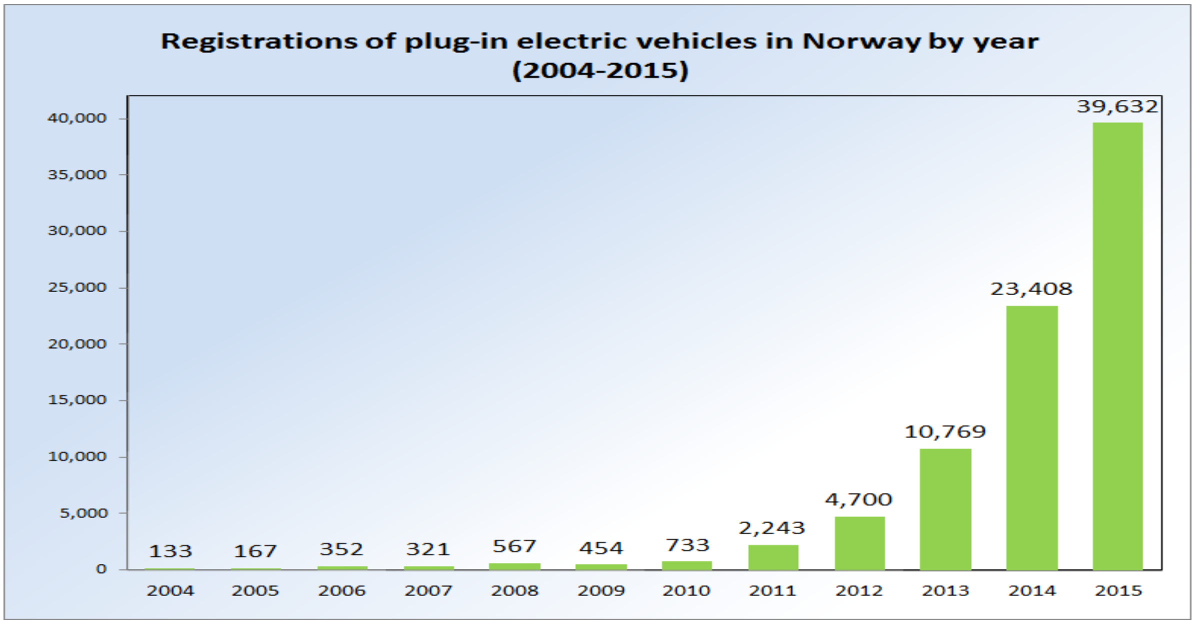


Figure 2.16: Registrations of plug-in electric vehicles in Norway by year (2004-2015)

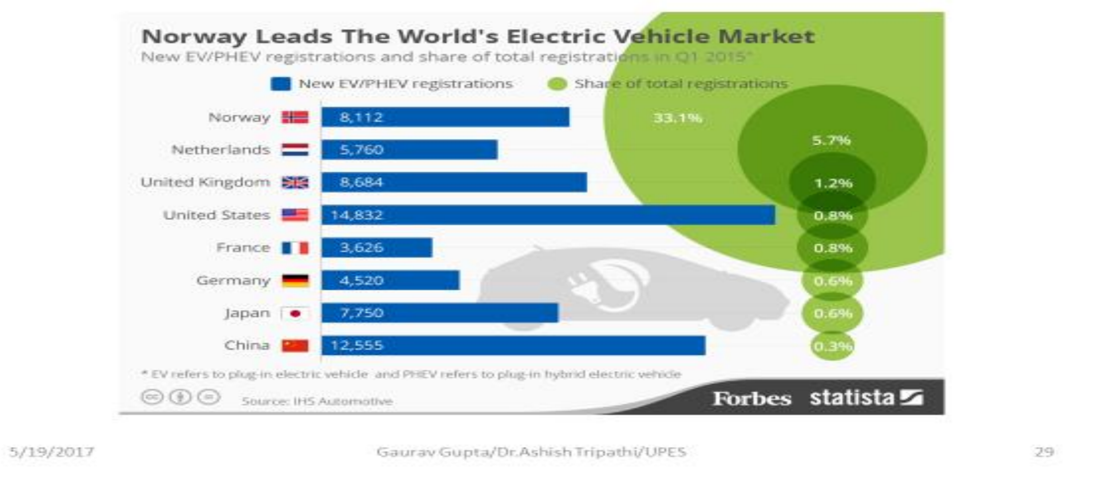


Figure 2.17: Norway leads the world's electric vehicle market

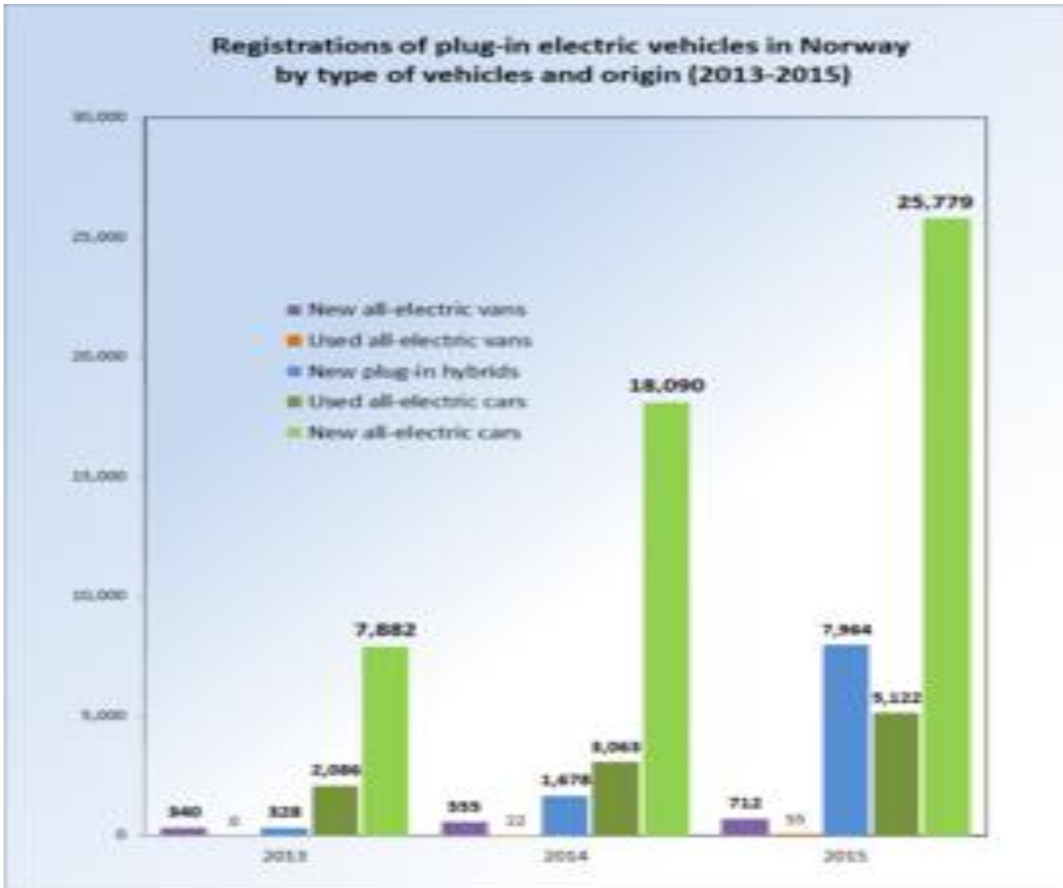


Figure 2.18: Registrations of plug-in electric vehicles in Norway by type of vehicles and origin (2013-2015)

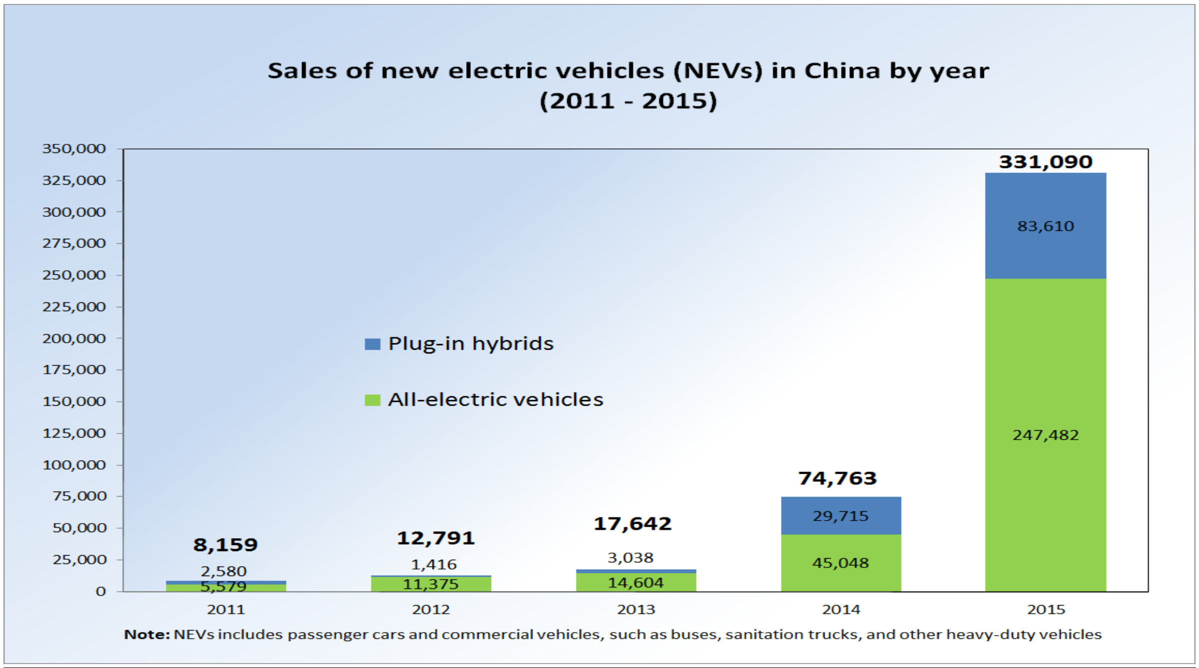


Figure 2.19: Sales of new electric vehicles (NEVs) in China by year (2011-2015)

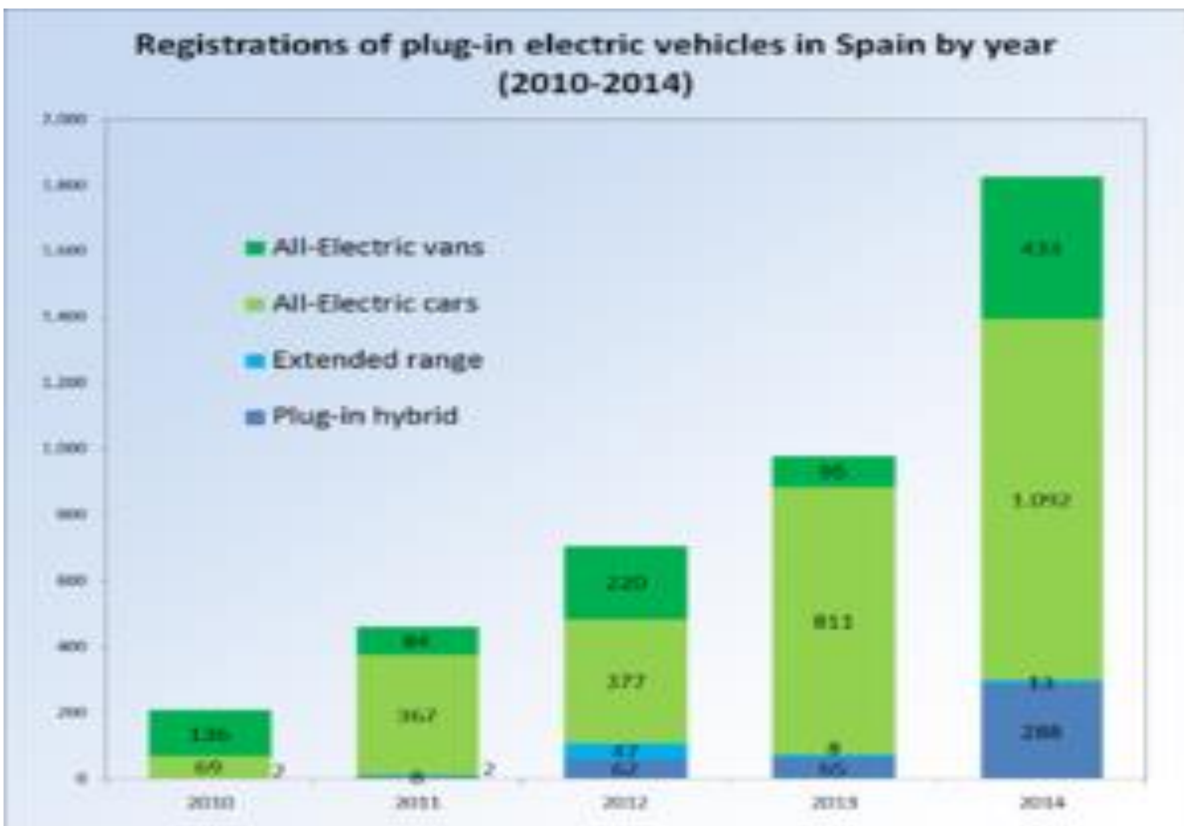


Figure 2.20: Registrations of plug-in electric vehicles in Spain in the year (2010-2014)

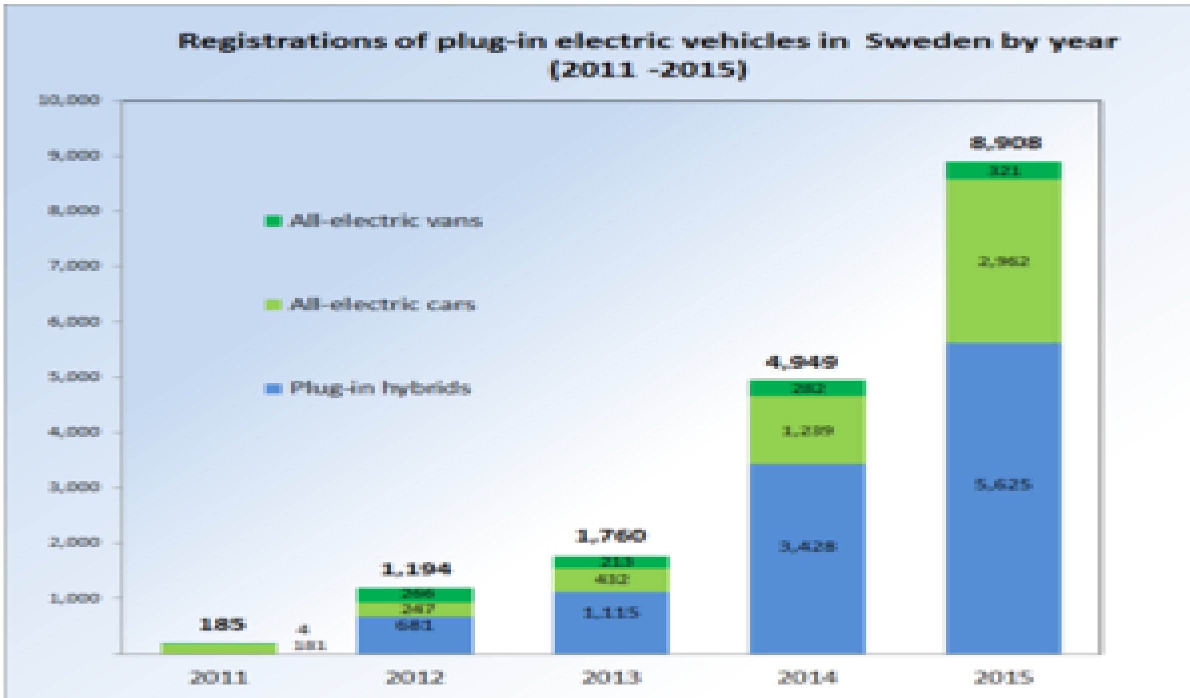


Figure 2.21: Registrations of plug-in electric vehicles in Sweden by year (2011-2015)

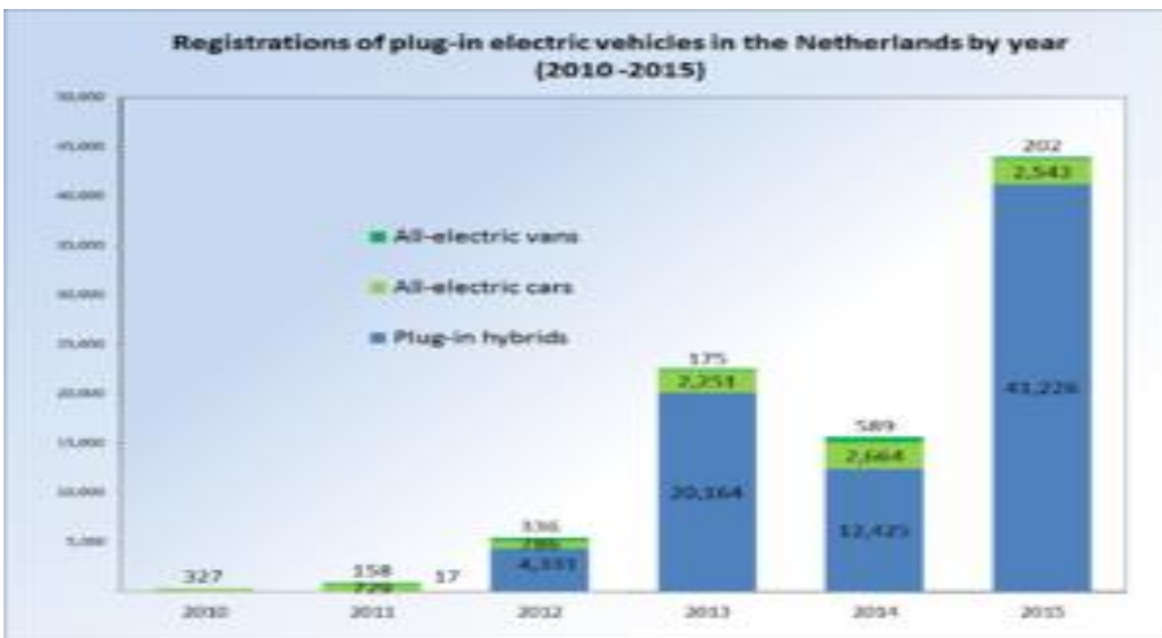


Figure 2.22: Registrations of plug-in electric vehicles in the Netherlands by year (2010-2015)

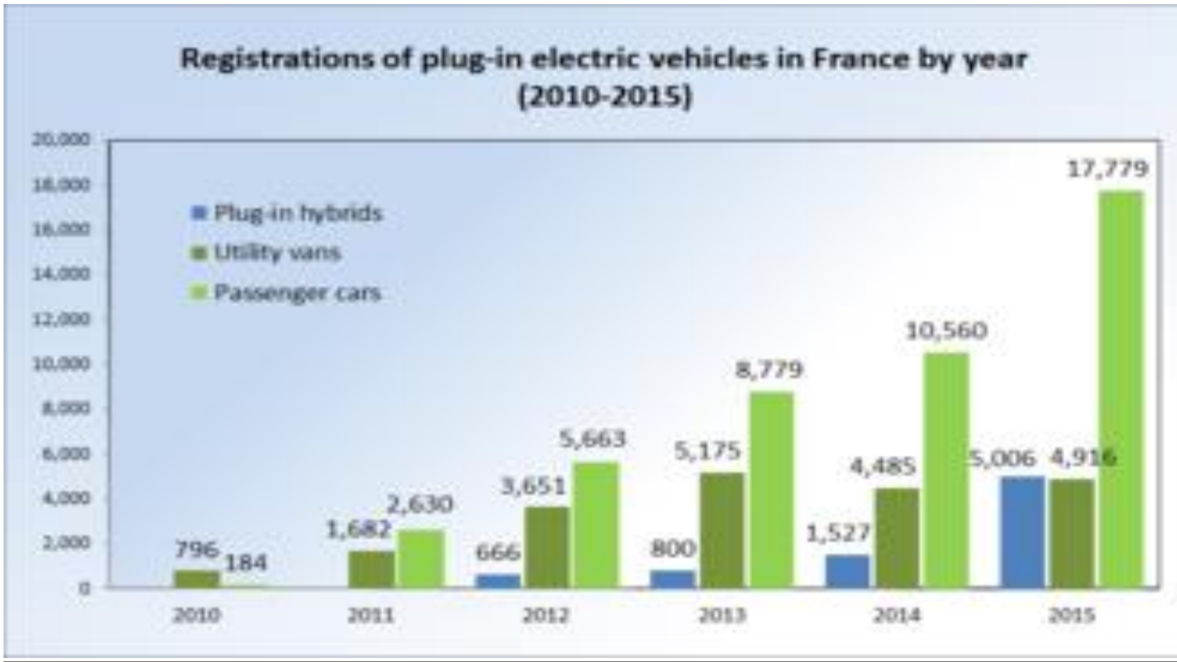


Figure 2.23: Registrations of plug-in electric vehicles in France by year (2010-2015)

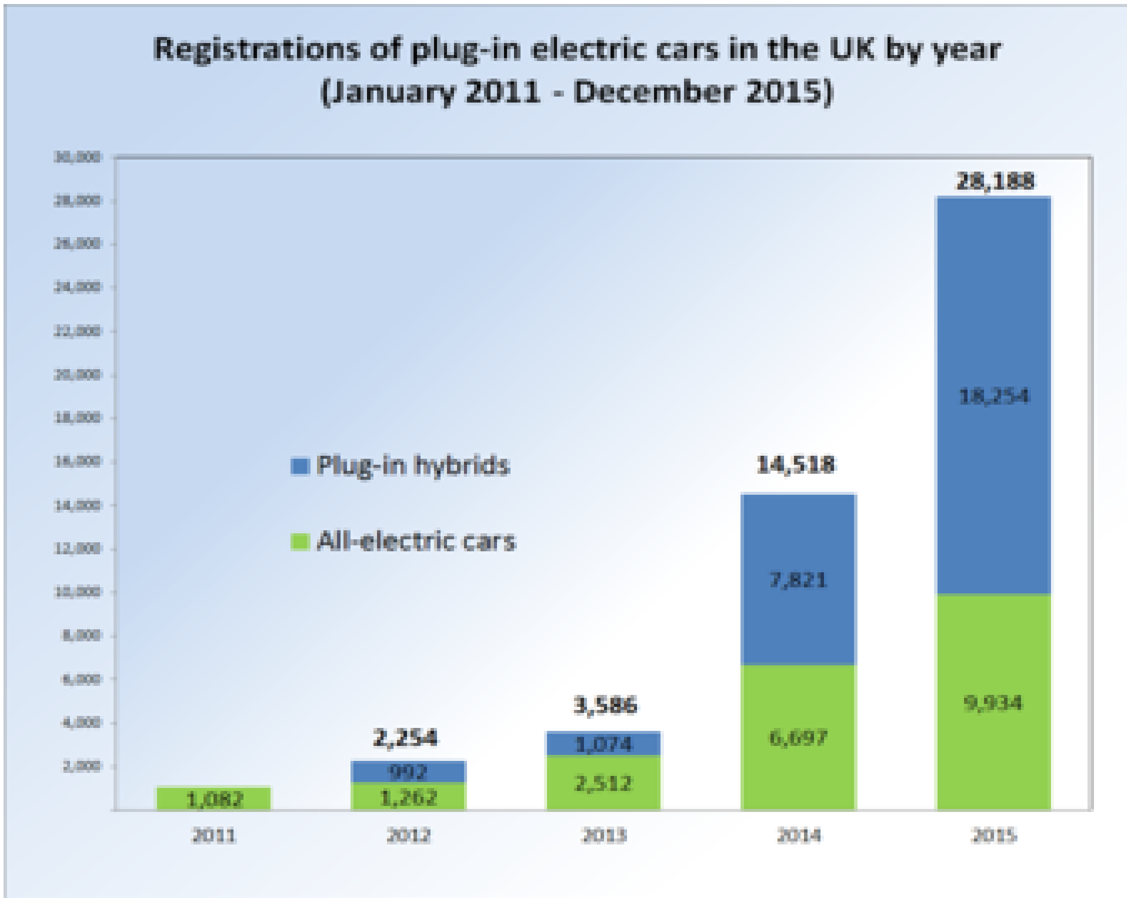


Figure 2.24: Registrations of plug in electric cars in the UK by year (January 2011- December 2015)

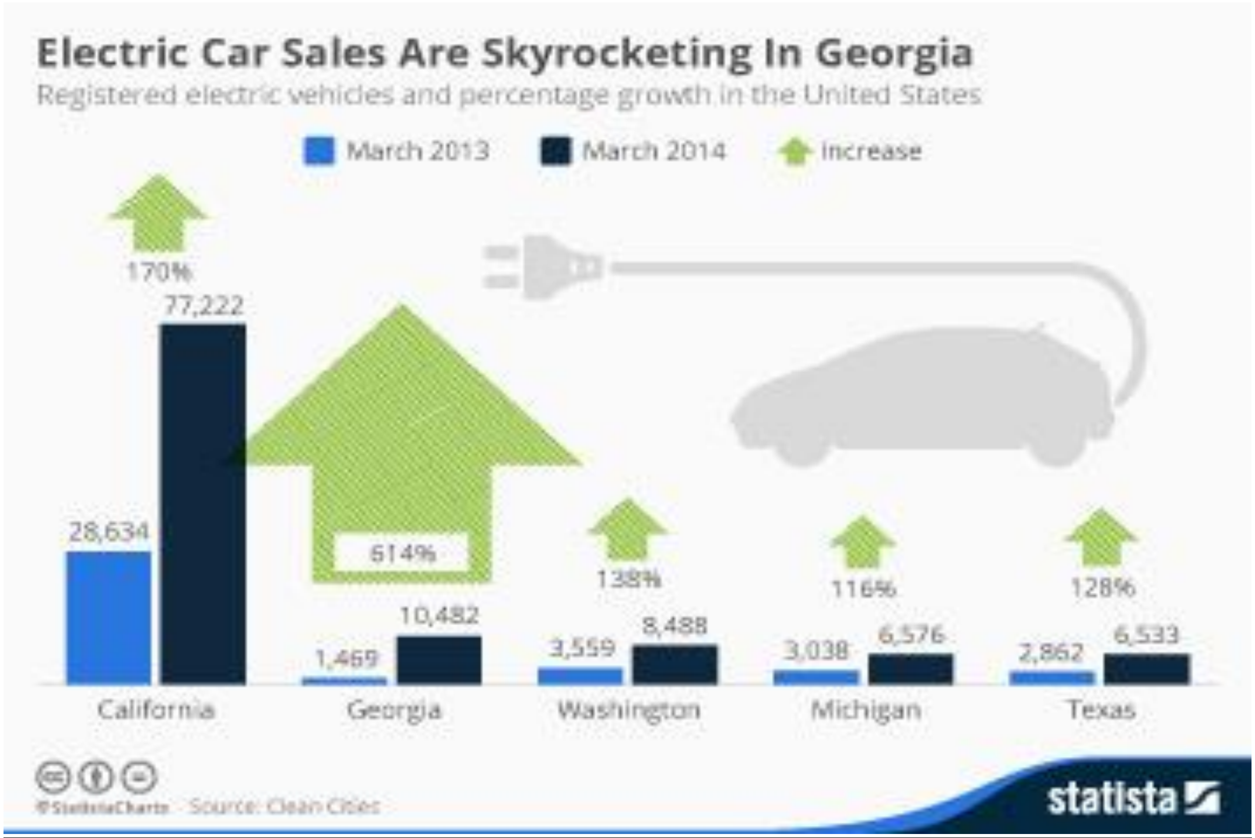


Figure 2.25: Electric car sales marketing are skyrocketing in Georgia

Source: Statista

E Car Market in India

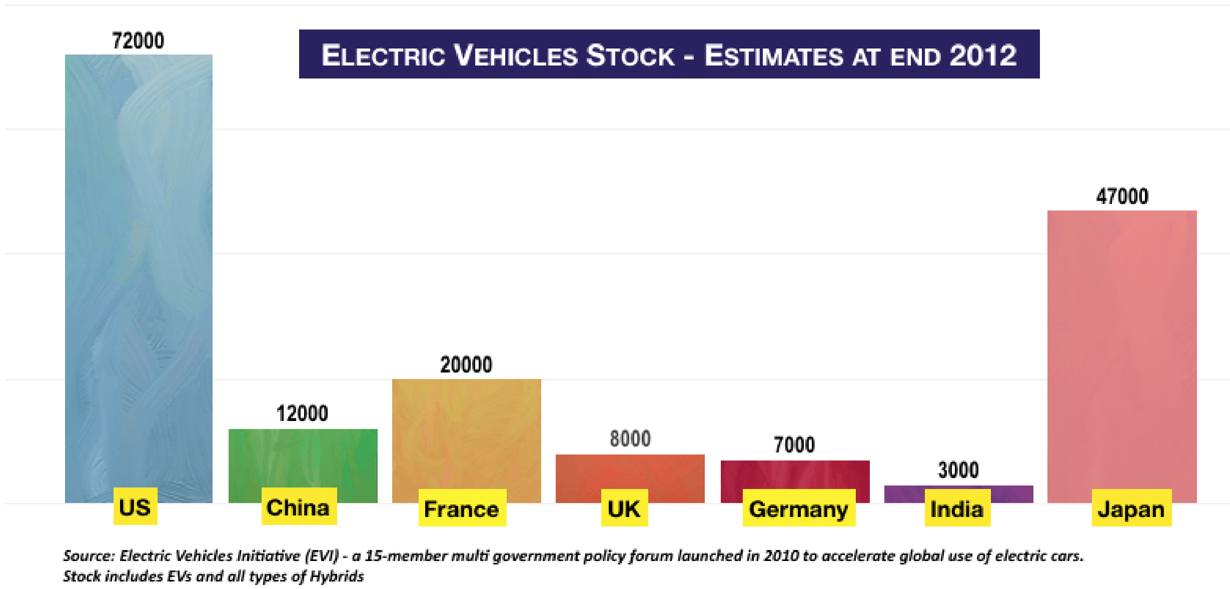


Figure 2.26: Electric vehicles stock-Estimates at end 2012

Source: EVI

Prior to the NEMMP's release, Ministry of New and Renewable Energy (MNRE) offered an incentive scheme to push sales of EVs in India. The scheme was effective from November 11, 2010 to March 31, 2012 and had a budget outlay of INR 95 crore (USD 14.6 million[7]). Although the incentives were low, the EV market especially in the two-wheeler segment witnessed a significant uptake. But termination of the scheme resulted in steep downfall of the EV market. After two months of its termination, close to 33% of dealers reverted to their earlier business and more than 20% closed their shutters[8]. A similar trend was observed in the sales of India's only EV car manufacturer – *Mahindra Reva*; number of manufactured units fell by 40% after the termination of subsidy (see figure 1). This underlines **the need for stability in policy and fiscal incentives** if the government wants to establish a vibrant EV market in India.

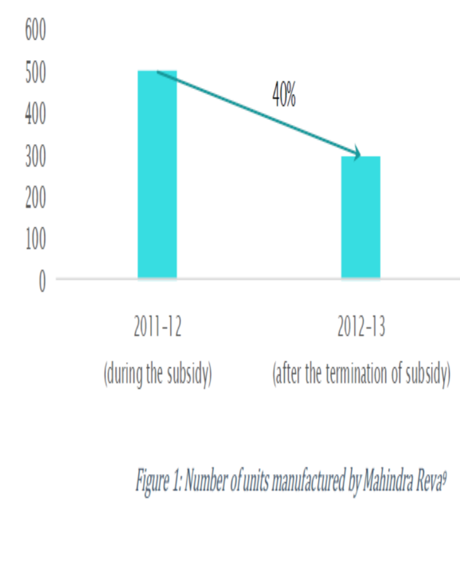


Figure 2.27: Number of units manufactured by Mahindra Reva

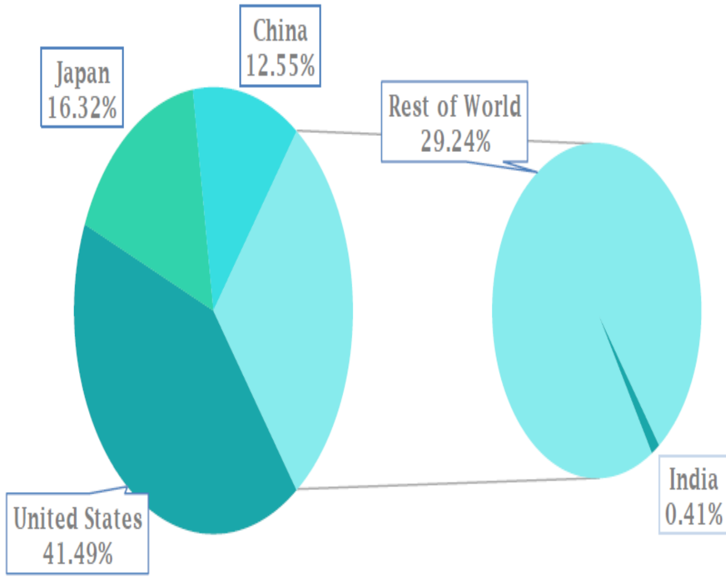


Figure 2.28: For the EVI member countries, their contribution in EV markets share or stock is shown.

Source: Global EV Outlook 2013

In 2001, REVA Electric Car Company (RECC) launched first commercial electric car but the just only 4000 cars were sold that is very low. In 2004 the RECC started exporting REVAi to Europe and has reportedly sold over 4,600 units across the world.

As of now India had only one electric car e20 + by Mahindra. Recently Mahindra has also launched second e car named e vertigo. Tata has also started focusing on E Car.

Source: http://indiaautoreport.com/part-evs-india-massive-potential-enough-charge/?print=pdf

Table A.2: Battery electric car (BEV) stock by country, 2005-17 (thousands)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Australia							0.05	0.22	0.41	0.78	1.54	2.21	3.42
Brazil										0.06	0.12	0.25	0.32
Canada							0.22	0.84	2.48	5.31	9.69	14.91	23.62
Chile							0.01	0.01	0.02	0.02	0.03	0.05	0.16
China					0.48	1.57	6.32	15.96	30.57	79.48	226.19	483.19	951.19
Finland							0.06	0.11	0.17	0.36	0.61	0.84	1.35
France	0.01	0.01	0.01	0.01	0.12	0.30	2.93	8.60	17.38	27.94	45.21	66.97	92.95
Germany	0.02	0.02	0.02	0.09	0.10	0.25	1.65	3.86	9.18	17.52	29.60	40.92	59.09
India				0.37	0.53	0.88	1.33	2.76	2.95	3.35	4.35	4.80	6.80
Japan					1.08	3.52	16.13	29.60	44.35	60.46	70.93	86.39	104.49
Korea						0.06	0.34	0.85	1.45	2.76	5.67	10.77	24.07
Mexico								0.09	0.10	0.15	0.24	0.57	0.78
Netherlands				0.01	0.15	0.27	1.12	1.91	4.16	6.83	9.37	13.11	21.12
New Zealand				0.00	0.00	0.01	0.03	0.05	0.08	0.19	0.49	1.65	4.58
Norway			0.01	0.26	0.40	0.79	2.63	6.81	15.01	33.10	58.88	83.10	116.13
Portugal													1.78
South Africa									0.03	0.05	0.17	0.27	0.33
Sweden							0.18	0.45	0.88	2.12	5.08	8.03	12.39
Thailand		0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.08
United Kingdom	0.22	0.55	1.00	1.22	1.40	1.65	2.87	4.57	7.25	14.06	20.95	31.46	45.01
United States	1.12	1.12	1.12	2.58	2.58	3.77	13.52	28.17	75.86	139.28	210.33	297.06	401.55
Others	0.53	0.53	0.53	0.61	0.64	0.79	2.56	4.85	8.23	15.23	27.40	38.98	57.14
Total	1.89	2.23	2.69	5.16	7.48	13.87	51.95	109.72	220.58	409.09	726.91	1 185.60	1 928.36

Table 2.6: Battery electric car (BEV) stock by country 2005-2017 (thousands)

Table A.5: New battery electric car (BEV) sales by country, 2005-17

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Australia							0.05	0.17	0.19	0.37	0.76	0.67	1.21
Brazil								0.07	0.13	0.06	0.06	0.13	0.07
Canada							0.22	0.62	1.64	2.83	4.38	5.22	8.71
Chile							0.01	0.01	0.01		0.01	0.02	0.10
China					0.48	1.09	4.75	9.64	14.61	48.91	146.72	257.00	468.00
Finland							0.03	0.05	0.05	0.18	0.24	0.22	0.50
France	0.01	0.01	0.01		0.01	0.19	2.63	5.66	8.78	10.57	17.27	21.76	25.98
Germany	0.02			0.07	0.02	0.14	1.40	2.21	5.31	8.35	12.08	11.32	25.07
India				0.37	0.16	0.35	0.45	1.43	0.19	0.41	1.00	0.45	2.00
Japan					1.08	2.44	12.61	13.47	14.76	16.11	10.47	15.46	18.10
Korea						0.06	0.27	0.51	0.60	1.31	2.92	5.10	13.30
Mexico								0.09	0.01	0.05	0.09	0.21	0.21
Netherlands				0.01	0.03	0.12	0.86	0.79	2.25	2.66	2.54	3.74	8.63
New Zealand						0.01	0.01	0.02	0.03	0.11	0.30	1.16	2.94
Norway			0.01	0.24	0.15	0.39	1.84	4.18	8.20	18.09	25.78	24.22	33.03
Portugal						0.72	0.19	0.05	0.14	0.19	0.64	0.79	1.78
South Africa									0.03	0.01	0.12	0.10	0.07
Sweden							0.18	0.27	0.43	1.24	2.96	2.95	4.36
Thailand							0.01	0.01	0.01	0.01	0.01		0.03
United Kingdom	0.22	0.32	0.45	0.22	0.18	0.26	1.21	1.71	2.68	6.81	10.10	10.51	13.55
United States	1.12			1.47		1.19	9.75	14.65	47.69	63.42	71.04	86.73	104.49
Others	0.53			0.09	0.03	0.15	1.78	2.28	3.57	7.18	11.51	12.15	18.37
Total	1.89	0.34	0.47	2.46	2.13	7.11	38.25	57.89	111.32	188.86	321.00	459.91	750.49

Table 2.7: New battery electric car (BEV) sales by country 2005-2017

Table A.8: Market share of battery electric (BEV) cars by country, 2005-17 (%)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Australia							0.01%	0.02%	0.02%	0.04%	0.1%	0.1%	0.1%
Brazil												0.01%	
Canada							0.02%	0.05%	0.1%	0.2%	0.3%	0.4%	0.6%
Chile											0.01%	0.01%	0.05%
China					0.01%	0.01%	0.04%	0.1%	0.1%	0.2%	0.7%	1.0%	1.8%
Finland							0.02%	0.05%	0.05%	0.2%	0.2%	0.2%	0.4%
France						0.01%	0.1%	0.3%	0.5%	0.6%	0.9%	1.1%	1.3%
Germany							0.04%	0.1%	0.2%	0.3%	0.4%	0.3%	0.7%
India				0.02%	0.01%	0.02%	0.02%	0.05%	0.01%	0.02%	0.04%	0.02%	0.06%
Japan					0.03%	0.1%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
Korea						0.0%	0.02%	0.04%	0.1%	0.1%	0.3%	0.4%	1.1%
Mexico								0.01%			0.01%	0.02%	0.02%
Netherlands					0.01%	0.02%	0.2%	0.2%	0.5%	0.7%	0.6%	1.0%	2.1%
New Zealand						0.01%	0.01%	0.01%	0.02%	0.05%	0.1%	0.5%	1.1%
Norway			0.01%	0.2%	0.1%	0.3%	1.3%	3.0%	5.8%	12.5%	17.1%	15.7%	20.8%
Portugal						0.3%	0.1%	0.1%	0.1%	0.1%	0.4%	0.4%	0.8%
South Africa									0.01%		0.03%	0.03%	0.02%
Sweden							0.05%	0.09%	0.15%	0.38%	0.82%	0.75%	1.34%
Thailand													
United Kingdom	0.01%	0.01%	0.02%	0.01%	0.01%	0.01%	0.1%	0.1%	0.1%	0.3%	0.4%	0.4%	0.5%
United States	0.01%			0.01%		0.01%	0.1%	0.1%	0.3%	0.4%	0.4%	0.5%	0.6%
Others							0.03%	0.05%	0.1%	0.2%	0.2%	0.2%	0.3%

Table 2.8: Market share of Battery electric (BEV) cars by country 2005-2017 (%)

Table A.10: Publicly accessible chargers (slow and fast) by country, 2005-17

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Australia													476
Brazil													
Canada								724	1179	2321	3508	4215	5841
Chile							3	15	17	26	30	32	51
China										30000	58758	141254	213903
Finland									267	383	848	858	885
France								809	1802	1827	10568	15567	15978
Germany								1518	2447	2846	5328	17509	24289
India											25	25	222
Japan						312	801	1381	1794	11517	22110	24372	28834
Korea							62	177	292	388	790	1566	5612
Mexico													1528
Netherlands						400	400	2803	5791	11981	18044	26448	33431
New Zealand													104
Norway						2800	3123	3746	4651	5385	5703	7758	9530
Portugal							1086	1135	1171	1189	1214	1233	1476
South Africa													124
Sweden								505	1020	1165	1520	2162	4071
Thailand													96
United Kingdom							1503	2840	5691	7742	9377	11208	13534
United States			374	381	419	542	4392	13160	16867	22633	31674	40473	45868
Others							1306	4145	5980	8237	14301	18887	24298
Total			374	381	419	4 054	12 676	32 958	48 969	107 640	183 798	313 567	430 151

Table 2.9: Publicly accessible chargers (slow and fast) by country, 2005-2017

Source: Global EV outlook 2018

From the above data it is clear that many countries are doing well as far as E car success is concerned as compare to India. India's condition is not really appreciating as depicts by sales figure and stock. India electric car market share is only .02 % for 2015-16. The new E Car registration in India in 2016 is only .45 thousand i.e. 450 only while in China it is 257 thousand. As far as E car stock is concerned, India has only 4.80 thousand stocks for 2016 while china has 483 thousand stocks for 2016. Being the most polluted city of the world - Delhi is really struggling for the successful adoption of zero emission car. So, it is matter of concern to understand why consumer is not ready to adopt the E car is in Delhi -India even after almost 15-16 years of its launch.

E- Car Market in Delhi

Pilot study for Proposed vs Actual sales in Delhi

Sample	Proposed Sales	Actual Sales	Gap	Gap (%)
Dealer 1	50*12=600	2*12=24 (4%)	576	96%
Dealer 2	50*12=600	1*12=12(2%)	588	98%
Dealer 3	No response	No response	No response	No response
M Reva NCR sales Head	100*12= 1200	20*12=240(20%)	960	80 %

Table 2.10: Pilot study for Proposed vs Actual sales in Delhi

Govt. initiatives for E- car

1-NEMMP: In the year 2011, to encourage electric mobility in the nation National Mission on Electric Mobility (NMEM) was approved by the govt. of India. Later, in Jan 2013, NEMMP 2020 (National Electric Mobility Mission Plan 2020) was discovered. Thinking about the fuel security and environmental pollution in the country NEMMP 2020 was designed. NEMMP objective is the diffusion of 6-7 million e-vehicles by 2020 so that a collective saving of about 2.2-2.5 million tons of fuel may result which in turn help in decreasing the pollution and greenhouse gas emission of 1.3%-1.5%.

A scheme named FAME -India [Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles in India] was framed by the Department of Heavy Industry. The scheme is intended to support the e vehicle market manufacturing and development during the tenure of 6 years, till 2020 so that it can achieve the self-sustain. To reduce the pollution from road transport sector this scheme is will be one of the major contributors. One of the green initiatives of the Government of India this scheme has 4 focus areas i.e., Demand Creation, Charging Infrastructure Technology Development and Pilot Projects.

Objectives: 1- To increase the number of EVS to 6-7 million on road by 2020, out of them 4-5 million should be two-wheeler.

2-To decrease fossil fuel dependency as it leads to massive foreign exchange deficit because more than 80 % of fossil fuel is imported.

3-To promote cleaner technologies

The economic growth dependency on fossil fuel import may increase to 92 % by 2020 as of now only 87 % of country's fossil fuel is imported.

According to the IEA, 3/4th of the increase oil demand in future will be from transportation as there will be a sharp rise in vehicle population.

Source: SMEV http://www.smev.in/industry-info/nemmp-2020/

By 2020, there may be a monitory saving of Rs. 30,000 crores if NEMMP implemented successfully as it will result in 2.2 – 2.5 million tons of fossil fuel savings. Carbon di-oxide emissions and vehicular emission will also be decrease by 1.3% to 1.5% by 2020. To achieve cleaner future, quality jobs and economic growth it is must to invest in the manufacturing and development of hybrid and electric vehicles in India.

Source: http://www.simplydecoded.com/2013/04/29/national-electric-mobility-mission-plan-2020

FAME: Faster Adoption and Manufacturing of Electric Vehicle: To incentivize the manufacturing and enhancing of green vehicles including electric vehicles and hybrid vehicles Ministry of Heavy Industry and public enterprises launched the scheme in 2015 as part of NEMMP. Initially the scheme was launched for two years with an outlay of Rs 795 crore i.e. Phase I (2015-17). Later on, the scheme has been extended four times by six months till 31st 2019. Phase II is also expected to be launched by government in near future and is expected to invest 14000 cr to develop the infrastructure and endorsing e vehicle.

Component of the Scheme	2015-16 (in Rs. Crore)	2016-17 (in Rs. Crore)
Technology Platform (incl. testing)	70	120
Demand Incentives	155	340
Charging Infrastructure	10	20
Pilot Projects	20	50
IEC/Operations	5	5
Total	260	535
Grand Total	795	

Table 2.11: Component of the FAME scheme

Source : DHI India

Pilot projects under FAME

At Taj Mahal (Agra) running pure electric vehicles (7-seater) in the radius of 2 Kms.

Home delivery (Dominos, KFCs etc) using Pure Electric 2-wheeler vehicles

By means of clean electric 3 wheelers/small 4 wheelers the distribution of fruit, vegetable and garbage disposal.

For taxi fleets, rental scheme and corporate hire electric cars should be used.

E vehicle connectivity from metro stations

Public transport using Hybrid and electric buses

Vehicle Segment	Minimun Incentive (INR)	Maximum Incentive (INR)
Scooter	1800	22,000
Motor Cycle	3500	29,000
3-wheeler (CNG/Diesel)	3300	54,000
3-wheeler (Petrol)	3300	61,000
4-wheeler (length not more than 4 meters)	13,000	124000
4-wheeler (length more than 4 meters)	11,000	1,38,000
LCV (CNG/Diesel)	17,000	1,87,000
Bus (CNG)	34,00,000	66,00,000
Bus (Diesel)	30,00,000	61,00,000
Retrofit Category	15% or 30,000 if reduction in fuel consumption is 10-30%	30% or 90,000 if reduction in fuel consumption more than 30%

Table 2.12: Vehicle wise incentives

- As per the estimation of ministry, Rs 14,000 crore will be needed for the successful implementation of scheme. Till now, Rs 795 crore has been assigned.

Source: http://trak.in/tags/business/2015/04/09/7m-electric-vehicles-2020-incentives-offered/

After the launch of FAME and to match the national EV policy many other states have also came up with their EV policy to address state specific requirements. Few of the states are Karnataka, Kerala, Telangana, Maharashtra and Andhra Pradesh, Uttar Pradesh & Delhi. But in spite of Central and State government incentives, the pure EV diffusion remains quite low in India as in 2017 about 0.1% for cars, ~0.2% for 2 wheelers and almost zero for commercial vehicles.

Delhi EV Policy 2018. (Law) The Government of Delhi has formulated the Delhi EV Policy 2018 for five years from the date of announcement. The policy aims to adoption of EV in Delhi and to identifies the new approach needed for its adoption. Thus, the focus will be on to identify the various hurdles of EV adoption and measures to control it.

Objectives:

To reduce the emission from the transport sector thus improving the air quality of Delhi. To accomplish this there is a need of fast adoption of BEVs such a way that out of all new vehicle's registration by 2023, 25 % should be BEVs.

To find the measures to support the charging of EVs, creation of jobs, financing, servicing and selling.

To increase adoption of EVs and capitalize on decreasing of vehicular emissions, the focus of policy will be on:

1. Incentivizing the purchase and use of electric two wheelers, and
2. Supporting the electrification of public/shared transport.

Some of the main features of policy are as follows.

1-The electric vehicles which are eligible for FAME India demand incentive should be exempted from registration fees, road tax and MCD one-time parking fee. The applicability of this exemption will be valid for the period of the policy i.e. 2018-2023.

2-Charging infrastructure: It has been found that in various cities of the world that one of the key drivers of EV adoption is the availability of charging infrastructure. So, one of the focus of the policy will be to create an enabling environment for the establishment of public as well as private charging infrastructure.

3-One of key objective of the policy is to provide public charging facilities from anywhere in Delhi within 3 km travel.

4-Public Battery Swapping Infrastructure in Delhi is also one of the objectives of this policy.

5-Favorable electricity tariff for Energy Operators and Battery Swapping Operators

6**-** Payment infrastructure and information sharing

7- Recycling Ecosystem – Battery and EVs

8- Reuse of EV batteries

9-Funding -Feebate concept

10-Pollution Cess

11- Parking Surcharge

12-Road Tax

13-Congestion fee

14- Creating Jobs – Vocational Training and R&D

Charing Station Guidelines by Indian Government (Law):

To enable faster adoption electric vehicles in India by ensuring safe, reliable, accessible and affordable charging infrastructure and eco system some of the necessary action are mention below.

1-Private charging residence and offices will be permitted.

2-Any individual entity should be free to set up public charging station and setting up of public charging station will be a delicensed activity.

Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

YEAR	Loss in million
2003	-107.806607
2004	-93.114359
2005	-9.610902
2006	-80.417123
2007	-55.164671
2008	-115.735317
2009	-209.922708
2010	-171.293987

Table 2.13: Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

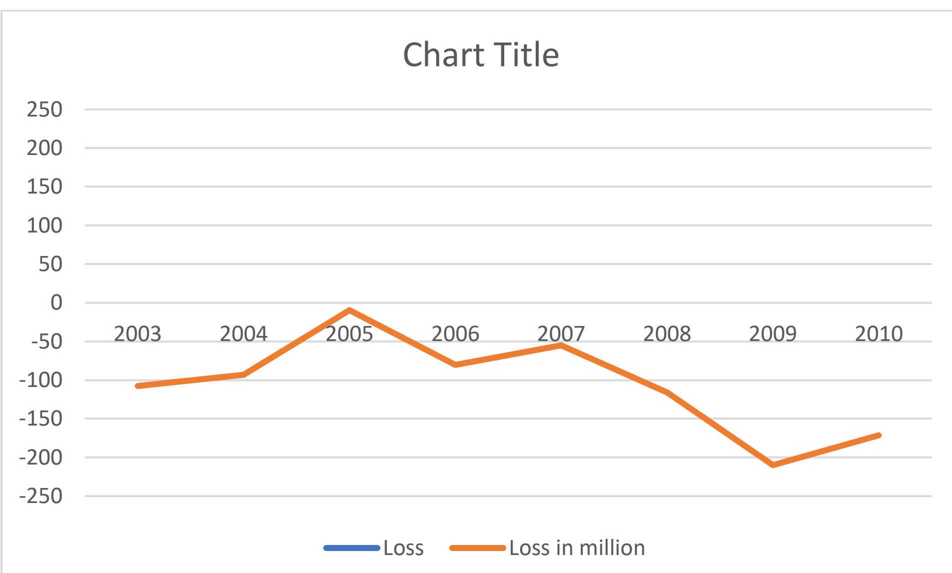


Figure 2.29: Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

<u>Cumulative Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)</u>

Year	Cumulative loss in million
2003	-107.806607
2004	-200.920966
2005	-297.029986
2006	-377.447109
2007	-432.611779
2008	-548.347096
2009	-758.269804
2010	-929.563791

Table 2.14: Cumulative Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

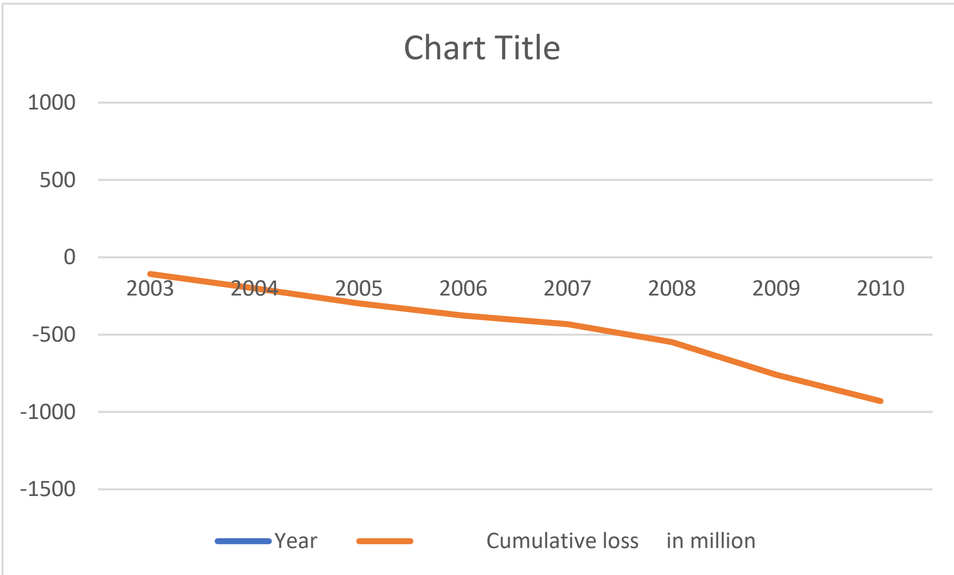


Figure 2.30: Cumulative Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

<u>Financials losses of Mahindra Reva Electric Vehicle limited (2011-2015)</u>

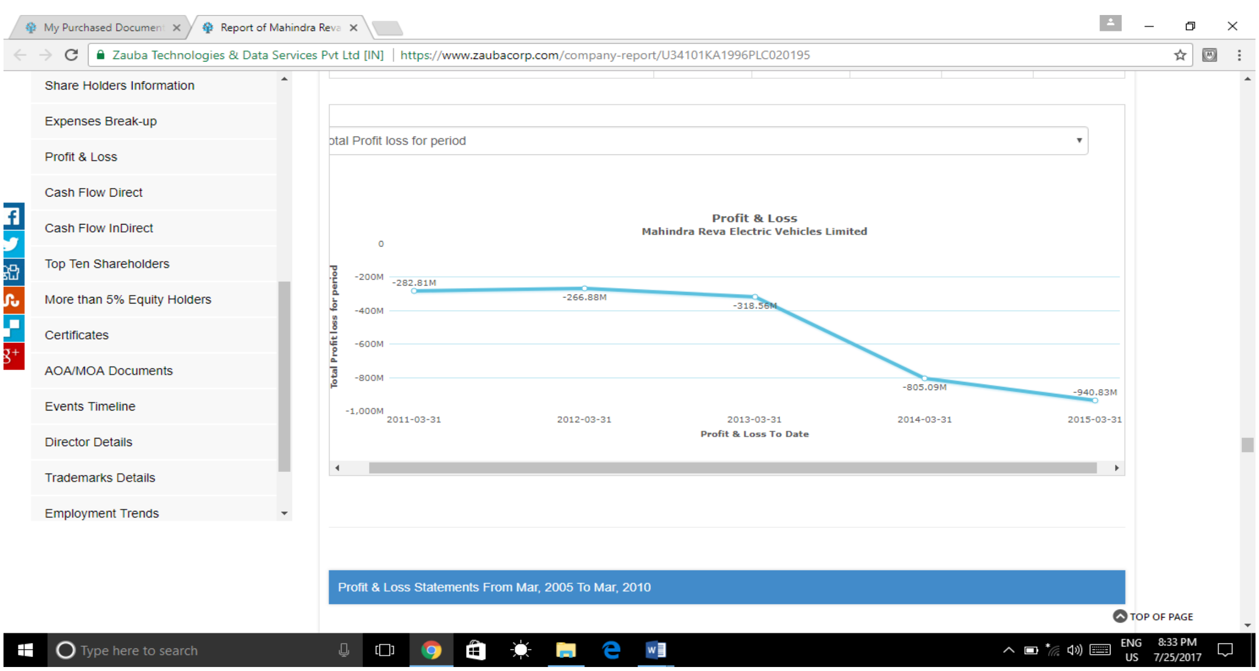


Figure 2.31: Financials losses of Mahindra Reva Electric Vehicle limited (2011-2015)

Source: https://www.zaubacorp.com/company-report/U34101KA1996PLC020195

Chapter 3

Business Problem

E-Cars introduced in India in 2001 have many potential benefits to society like less pollution thus improved health, reduce dependency on oil & energy efficient .(Driving cleaner More E vehicle means less Pollution, Environment America Research and policy Centre Elizabeth Ridlington, Frontier Group) In spite of benefits of E-Cars and efforts by the manufacturer for its acceptance the adoption of the car is not picking up. Total cumulative loss of the company is Rs. 929.56 million since its inception to 2010 and thereafter the cumulative loss is Rs.2614.17 since 2011 to 2015.

Low adoption will also lead to lack of success of NEMMP launched by Government of India for adoption of electric vehicles.

To achieve national fuel security by promoting hybrid and electric vehicles in the country National Electric Mobility Mission Plan (NEMMP) 2020 was launched in 2013 by government of India. NEMMP objective is to achieve diffusion of 6-7 million e-vehicles by 2020 which helps in collective saving of about 2.2-2.5 million tons of fuel equivalent to a monetary saving of Rs 30,000 crore and that may result in decreasing the pollution and greenhouse gas emission by 1.3%-1.5%.

source: http://www.simplydecoded.com/2013/04/29/national-electric-mobility-mission-plan-2020

This scheme of government will not only reduce the GHG emission in country but also reduce the country’s fuel dependency on imports.

In November 2010, Rs 95 crore subsidy scheme was introduced by the Ministry of New and Renewable Energy (MNRE) to provide incentives to electric vehicle buyers. After the launch of the scheme the sales increased by close to 70 per cent in 2011 touching 100,000 units thus the scheme appeared to work.

- But sales dropped soon after the program expired in March 2012.

Source: Society of Manufacturers of Electric Vehicles India (2015)

Statement of the problem

Low adoption of E- Car by consumers has led to financial losses to the company/Industry in Delhi.

Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

YEAR	Loss in million
2003	-107.806607
2004	-93.114359
2005	-9.610902
2006	-80.417123
2007	-55.164671
2008	-115.735317
2009	-209.922708
2010	-171.293987

Table 3.1: Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

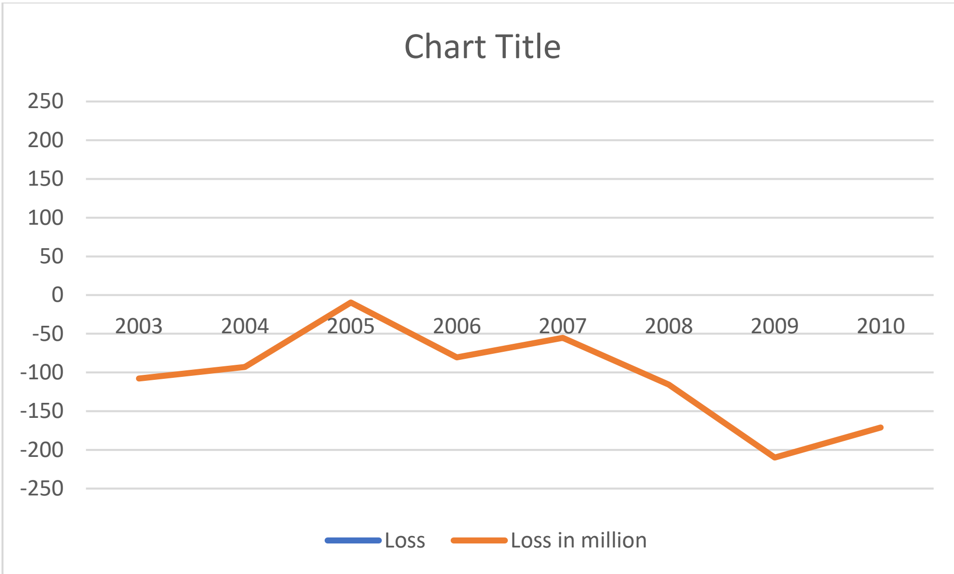


Figure 3.1: Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010**)**

Cumulative Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

Year	Cumulative loss in million
2003	-107.806607
2004	-200.920966
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2006	-377.447109
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2010	-929.563791

Table 3.2: Cumulative Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

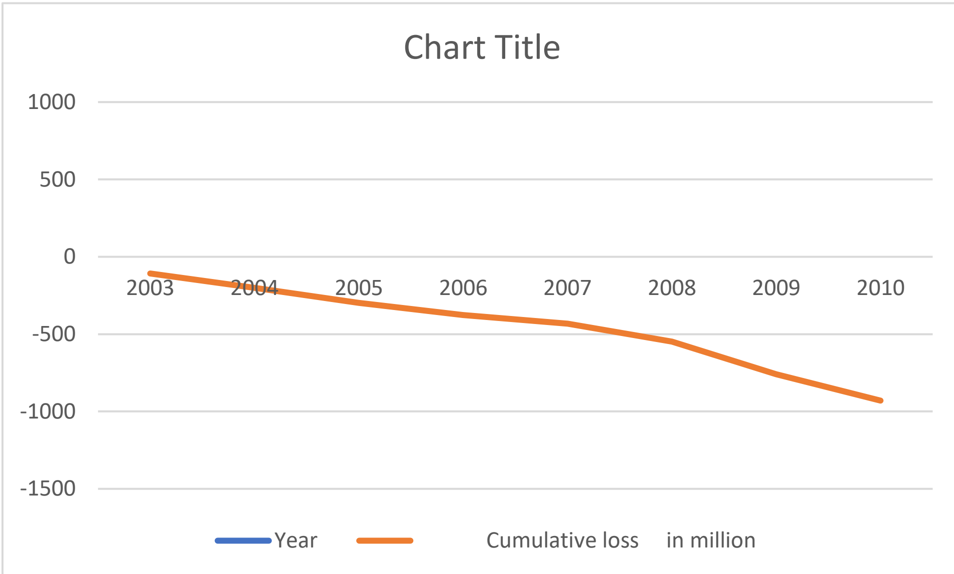

Figure 3.2: Cumulative Financials losses of Mahindra Reva Electric Vehicle limited (2003-2010)

Financials losses of Mahindra Reva Electric Vehicle limited (2011-2015)

Figure 3.3: Financials losses of Mahindra Reva Electric Vehicle limited (2011-2015)

Source: https://www.zaubacorp.com/company-report/U34101KA1996PLC020195

<u>India's e-vehicle dream crashes</u>

- **21,000**: Total number of electric two-wheelers sold in India in 2013-14 (79% drop from 100,000 units sold two years earlier)
- **960**: Number of e-bike dealers that have shut shop in the past 18-24 months (50% of total number of dealers in the country are out of business)
- **26:** Number of major electric two-wheelers manufacturers (of the 35 at the peak sales period) that have wound down businesses
- **10,000**: Number of jobs lost directly or indirectly with key firms exiting business
- **1,000:** Total number of e20 electric cars that Mahindra Reva has managed to sell in the past 15 months (against a target of 500 units a month)
- Source: Business Standard http://www.rediff.com/business/kk6oYhS4/auto-indias-e-vehicle-dream-crashes/20140826.htm August **26, 2014 21:44 IST**
- **Proposed vs Actual Sales in India**

Proposed Sales	Actual Sales	Gap	Gap (%)
500 * 15 = 7500	1000 (14%)	6500	86%

- Table 3.3: Proposed vs Actual Sales in India

Prior to the NEMMP's release, Ministry of New and Renewable Energy (MNRE) offered an incentive scheme to push sales of EVs in India. The scheme was effective from November 11, 2010 to March 31, 2012 and had a budget outlay of INR 95 crore (USD 14.6 million[7]). Although the incentives were low, the EV market especially in the two-wheeler segment witnessed a significant uptake. But termination of the scheme resulted in steep downfall of the EV market. After two months of its termination, close to 33% of dealers reverted to their earlier business and more than 20% closed their shutters[8]. A similar trend was observed in the sales of India's only EV car manufacturer – *Mahindra Reva*; number of manufactured units fell by 40% after the termination of subsidy (see figure 1). This underlines **the need for stability in policy and fiscal incentives** if the government wants to establish a vibrant EV market in India.

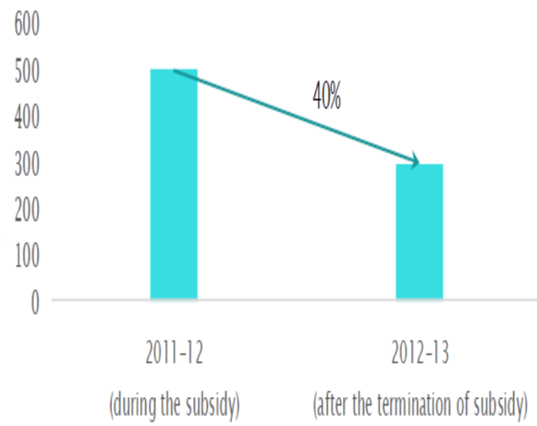

Figure 1: Number of units manufactured by Mahindra Reva[9]

Figure 3.4: Number of units manufactured by Mahindra Reva

Source: Electrical Vehicles in India a Comprenhsi.pdf

- Through National Electric Mobility Mission Plan 2020 , Rs14,000 crore ($2.25 billion) of incentives for the electric vehicle industry was declared by government in Jan 2013. But progress has been very slow so far—and carmakers are still hurting.

  Source: http://qz.com/319822/heres-another-reason-why-electric-cars-may-never-take-off-in-india/

- There is a 37.5% per cent jump over the last fiscal year (2014-2015). Encouraging growth for EVs have been seen for the fiscal year 2015-16. 22,000 units (20,000 two wheelers & 2000 four-wheelers) have been sold for the fiscal 2015-16 as compared to 16,000 EVs during FY 2014-15.

  Source: http://auto.ndtv.com/news/electric-vehicles-sales-grow-by-37-5-per-cent-in-fy-2015-16-1339465

India's electric vehicle sales grow 37.5% to 22,000 units**, only 2,000 were four-wheelers units.**

At these stages, it is very difficult for the country to meet the objective of selling 6 million electric vehicles by 2020 as mention in National Electric Mobility Mission Plan 2020 and FAME by the government.

Source: http://www.livemint.com/Industry/lBkrw7B4nyVbSYAlrak9CK/Indias-electric-vehicle-sales-grow-375-to-22000-units.html

Pilot study for Proposed vs Actual sales in Delhi

Sample	Proposed Sales	Actual Sales	Gap	Gap (%)
Dealer 1	50*12=600	2*12=24 (4%)	576	96%
Dealer 2	50*12=600	1*12=12(2%)	588	98%
Dealer 3	No response	No response	No response	No response
M Reva NCR sales Head	100*12= 1200	20*12=240(20%)	960	80 %

Table 3.4: Pilot study for Proposed vs Actual sales in Delhi

Chapter 4

Literature review

For Literature review the title has divided down into themes and sub themes. Following three themes have been identified.

- 1-Vehicular Growth in India – Delhi
- 2- Energy Security & Pollution- Health

  Sub Themes:
  a-Energy Security
  b-Pollution & It's Health Impact
  c-Socio economic point of view
- 3-Adoption of EV
  Sub Themes:
  a-Adoption in India:
  b-Adoption in other countries

Business Problem	Themes	Justification
Low adoption of E-Car by consumers has led to financial losses to the company/Industry in Delhi.	1-Vehicular Growth in India -Delhi	To understand the non-adoption of new technology i.e. E car business. It is important to recognize the demand & growth pattern of vehicles in Indian context.
	2-Energy Security Pollution & health	Although it is not directly related to losses of the company, but low adoption of E vehicle is directly related to oil security, pollution and thus low success of NEMMP launched by Government of India for adoption of electric vehicles. These are two additional but important aspect of vehicular growth.
	3-Adoption of EV	To explore the status, policy makers role, Industry role and consumer role of adoption of Electric vehicles in India and other countries.

Table 4.1: Justification for themes

1-Vehicular Growth in India – Delhi

Most of the Indian metropolitan cities like Delhi, Chennai, Bengaluru and Hyderabad have experienced an outstanding rise in transport demand .This rise in demand is because of increase in household income, availability of motorized transport and growth in population as a result of both migration from rural areas and natural growth . A massive shift to personalize transport like cars and two-wheeler has been caused due to failure of public transport. There will be increase in domestic demand for vehicles among Indian population due to increased affordability and rising income. **(Singh, 2012**)

According to a study about Delhi in 2009 it has been found that 7% of the total motor vehicles in India are in Delhi -the Indian Capital which also accounts for 1.4 % of total Indian population. A similar study ***by (Urban Transport in India Challenges and Recommendations IIHS RF Paper on Urban Transport***) There have been a significant growth in the total number of vehicles per thousands of people in Indian metropolitan cities since 2001. Between the year 1991 and 2009 the number of total registered vehicles grew at a CAGR (Compounded Annual Growth Rate) of 9.8 per cent in the country. 9.6 % was the CAGR of personalized private vehicles like cars while two-wheeler grew at CAGR of 10.3 per cent. 54 per cent of the total vehicles in the metropolitan cities comes from five metro cities which have vehicle registration rates in excess of 500 per 1,000 people as of 2011 (Sarma et al., 2011). In 2011, 6.3 million vehicles were the highest vehicle population in Delhi. 12.3 per cent of the total number of vehicles i.e. around 17 million vehicles is constituted by four cities in India i.e. Bengaluru, Delhi, Hyderabad and Chennai in 2011. 5 % of the total motor vehicles in India comes from Delhi which has population of 1.4 % of the total Indian population..

As per the study (**CREATING THE CLEAN ENERGY ECONOMY, Analysis of the Electric Vehicle, Paul Krutko, FM**, International Economic development council Industry, globally, the demand for passengers' cars is increasing in China and India due to their rising middle class. 750 million cars were there in 2010 by 2050 this number of units will reach to 1.5 billion

As per the report by ***(INDIAN AUTOMOBILE INDUSTRY VISION "2020)*** *A*utomobile market of India is among the world's fastest developing automobile markets. Seven large automobile manufacturing countries dominates the global automotive Industry. 12.7 million vehicles are produced by India each year and thus is counted among the world's top seven automobile producing country. In this leaderboard countries ahead India are Japan, China, USA, Germany, Brazil and South Korea. According to ***Society of Indian Automobile Manufacturers (*****Siam)** for the first time during the year 2016 the sales of passenger vehicles in India crossed three million, rising at the fastest rate in six years majorly due to demand for (SUVs) sports utility vehicles.

As per the study by (**Dr. C. Gopalakrishnan, Recent Trends in Indian Automobile** Sector) There will be an increase in domestic demand for vehicles among Indian population due to increased affordability and rising incomes.

According to a study since the year 1990 the output of automobile industry increases at an unmatched speed (**Singh, 2014**).

Four-wheeler segment in automobile has lot of scope in future. Automobile industry as a whole too will have good growth in future. Various moves are applied by the major auto companies to increase their sales as four-wheeler is not owned by majority of people in India thus the Indian market is still untapped. Since 20006 due to strong economic growth and government incentives car sales in India have risen at a fast pace**. (Sarwade, 2015)**

Indian vehicles are experiencing an exponential growth. Personalized mode recorded highest growth accompanied by falling number of more sustainable modes. Currently private mode of transportation dominates other transportation ways in India **(Singh ,2015)**

As per the **(www.makeinindia.com/sector/automobiles,Make in India**) 45% of the country’s manufacturing gross domestic product (GDP) is dominated by the automotive industry and 7.1 % of the country’s GDP comes from the automotive industry. The automotive Industry also employs about 19 million people.

With an average annual production of 24 million vehicles India is world’s top sixth producer. By 2026 annual passenger vehicle production may grow to 9.4 million units.

As per the news by live mint (**Passenger vehicle sales crossed the three million mark for the first time in India in 2016**) For the first time the sales of passenger vehicles crossed three million mark during the fiscal year which ended on 31 March in India. It was the fastest growth rate in six years as the demand of SUVs increased. Society of Indian Automobile Manufacturers (Siam) released the data for this information.

As per the article **(India's passenger vehicle density to nearly double by 2020, -Live mint Feb 2015)** The number of passenger vehicles will cross 48 million by 2020 as comparison to 29 million in 2015. India is one of the world's most attractive vehicle markets due to its low vehicle penetration i.e.1000 people owns 32 vehicles in 2015.

According to a recent study by the **International Energy Agency (IEA**)-(**India's Passenger Car Ownership to Grow 775 per Cent by 2040)** Over next 24 years there will be a growth of 775 % of passenger car ownership in India .The number of passenger vehicle ownership has around tripled in just the last decade. Also, the number of vehicles per 1000 people will be 175 as compare to 20 vehicles per 1000.

As per the **(WHITE PAPER ON POLLUTION IN DELHI,1997**) There is an expected vehicular population of 60 lakh in 2011 which has increased phenomenally to 26.29 lakhs in 1996 from 2.35 lakhs in 1975. Today the number of vehicles in Delhi is three times than Mumbai whereas these figures was about the same in 1975. In Delhi 67 % of the total pollution is contributed by vehicles.

As per the forecast by **(DIFFUSION OF MOTOR VEHICLE SALES IN DELHI,2011)** total number of vehicles will be 11.71 million in 2020-21 which will be nearly fifty per cent of the projected population of Delhi and out of these, 96 per cent will be private vehicles. Now, motor vehicles being the worst air polluters apart from most energy intensive mode of transport, this growth of motor vehicles will pose a challenge to the policy makers, at the front of environment, energy consumption and parking.

As per the forecast by in a study in 2010 the level of car ownership in Delhi the capital city of India in the year 2020-21will be 34.83 lakhs. And this figure is almost close the actual figure in 2018. (**Das,2010**)

As per the study by **(Proliferation of Cars in Indian Cities: Let Us Not Ape the West 2014, POLICY BRIEF June 2014 The Energy and Resources Institute TERI**). Many estimations have projected that by 2025 the increase in the number of cars will be around 35 cars per 1,000 population in India. This may lead to around 45–60 million cars in Indian roads while in some cities the count may be around 300 cars per 1,000 population. This may have a considerable increase in the total number of cars in Delhi from 2 million in 2011 to about 10 million by 2025 i.e. about 380 cars per 1,000 population in Delhi. The exponential expansion in the number of cars will have solemn consequences for energy security.

As per the study by CSE (**Centre for Science and Environment)** it has been found that in the current scenario the total number of cars entering daily in Delhi are more than that got registered in the city in one year - 2014-15. Break-up confirms that 55% were cars out of all the vehicles entering the city. As per the data the total number of cars enter the city from various entrance were around 4 lacs i.e. almost double to the total number of 1.65 lakh cars registered in Delhi in the year 14-15

As per the article in **(Hindustan times, www.hindustantimes.com/ Delhi- news/)** The Delhi-city has almost population of 20 million and it has almost 10 million vehicles. Delhi ranks as one of the most polluted cities of the world as per the WHO. Delhi also has the highest density of vehicles in India.

As per the (**ISGF white paper 2015/00012 Version 1.0 Dated 22 December 2015 ELECTRIC** VEHICLES: A SUSTAINABLE SOLUTION TO AIR POLLUTION IN DELHI) There were 88 million vehicles in Delhi as in 2015 which increased from 3 million in 2007 thus Delhi is one of most speedily rising automobile market.

As per the article in Times of India **(Times of India,4 June 2017, Vehicle numbers cross one crore mark in Delhi)** More than one crore i.e. 1,05,67,7129 vehicles have been registered in Delhi till May 2017. Out of them 31,72,842 are the registered cars till May 2017.

Thus, it is clear that in Delhi and other metro cities there is a fabulous vehicular growth.

2- Energy Security & Pollution- Health

a-Energy Security:

As per the report by MoPNG**,** In India there is a big gap in the production and consumption of crude oil. The consumption of oil has increased at a rate of more than 4 percent annually while the production has increased at an usual rate of 1.6 percent from 2001- 2010. The reserves to production (R/P) ratio of crude oil for India shows adequate reserves for 30 years while (R/P) ratio of crude oil for world shows adequate crude oil for 46 years. ***(TERI, 2011)***. India dependency on crude oil will continue to rise. India imports almost 80 per cent of crude oil to fulfill the demand with this consumption rate by 2032 the crude oil import will increase to 90 per cent. (***TERI, 2011a).*** India is forced to spend billions of rupees to import the crude oil which can be used for the development of the country thus India's energy security and of course domestic economy growth is at risk. (Electric vehicles in India challenges and opportunity, TERI)

As per the study by **(Proliferation of Cars in Indian Cities: Let Us Not Ape the West,2014, TERI)** The largest user of petroleum product at 55% is the transport division. The electricity share in transport fuel is only 2% the remaining 98% of transport fuel is petroleum products (TERI 2012). Within transport sector, more than 90 % of the fuel is consumed by the road sector with road freight transport consuming around 35% and road passenger transport around 65%. If we focus on the fuel consumption by cars, then it currently consumes approximately 20% of fuel and by 2030 the consumption of fuel by cars may increase to about 30%. As the demand for crude oil will increase in the future and thus dependency on the import of crude oil too so taking this into consideration the consumption of fossil fuel should be reduced to the extent possible.

As per the study (**CREATING THE CLEAN ENERGY ECONOMY, Analysis of the Electric Vehicle, Paul Krutko, FM)** 70 percent of all the oil consumed in the U.S. is used for transportation. Out of this 70 percent of transportation oil is used by the passenger vehicle. Globally, the demand for passengers' cars and thus demand for oil is increasing in China and India due to their rising middle class. 750 million cars were there in 2010 by 2050 this number of units will reach to 1.5 billion. The idea of alternative fuel for transportation i.e. Electricity is smart investment due to limited and inevitable oil supplies in the world.

As per the report by (**Electric Vehicles in India A GERMI White paper**) In India, transport sector alone consumes about one third of the total crude oil. If we focus only on the consumption by the road transport then one third of total crude oil i.e. 80 % consumed by road transport. It has been assessed that transportation will be responsible for the three quarters of the projected increase in oil demand from 2006 to 2030. In addition, **the World Energy Outlook,** 2015 states that second largest source of CO2 emissions globally is the fossil fuel-based transportation after power generation. This emphasizes the need for alternative cleaner fuels including electric mobility, especially in India which is one of the largest automotive markets in the world with a total of more than 141 million user vehicles registered (till 2011).

Indian Vehicles are experiencing an exponential growth. Personalized mode recorded highest growth accompanied by falling number of more sustainable modes Currently private mode of transportation dominates other transportation ways in India due to which dependency on petroleum products has increased and national energy security has decreased. The emissions of greenhouse gas (GHG) and of pollutants have also increased due to the increased oil consumption. Railway is not highly energy intensive as compare to the road sector. Road sector consumes most of the energy from petroleum products in transport sector**(Singh,2015)**

As per the study by **(Proliferation of Cars in Indian Cities: Let Us Not Ape the West 2014, POLICY BRIEF June 2014 The Energy and Resources Institute TERI**) Different estimates show that currently the number of cars is about 15 million in India which is equivalent to 13 cars per 1,000 population. As far as Delhi is concerned the ownership level of Delhi is about 157 cars per 1,000 people. Many estimations have projected that by 2025 the increase in the number of cars will be around 35 cars per 1,000 population in India. This may lead to around 45–60 million cars in Indian roads while in some cities the count may be around 300 cars per 1,000 population. This may have a considerable increase in the total number of cars in Delhi from 2 million in 2011 to about 10 million by 2025 i.e. about 380 cars per 1,000 population in Delhi. The exponential expansion in the number of cars will have solemn consequences for energy security.

As per the study (**Growth of personal vehicle with petrol consumption and carbon monoxide emission in Delhi,2009**) Based on the data of four-wheelers from and two-wheelers 1965–1966 to 2005–2006, a long-term trend in the growth of personal vehicles is projected up to the year 2020. In 2020 the projected growth of personal vehicles will demand nearly double the quantity of petrol in comparison with the level of 2005–2006 in Delhi. Similarly, carbon monoxide emission will increase to 2.5 times more than the 2005 level Delhi.

According to the analysis **(Assessing and accelerating vehicle deployment in India)** which focus on electric passenger cars says that it is possible to save 270 million tons of CO2 emission and 4.8 billion barrels of oil by 2030 if government target of EV car adoption continue in to the decade beyond 2020.

According to the Planning Commission's 2006 Integrated Energy Policy the main hurdle in maintain a GDP growth rate of 8 % is the cost of energy **(Chowudhury,2015).**

According to data of the Union ministry of petroleum and natural gas the biggest user of oil and oil products is India's transport sector which uses roughly about 30 per cent of the total consumption. 6.52 % is the average monthly transportation expenditure of all Indian citizen whereas Delhi's citizens average monthly expenditure is 8.9 per cent which is much higher than the all-India average of 6.52 per cent. In India, 4-8 per cent of non-food expenditure spent by lower income groups on commuting. However, 12-13 per cent spent by the urban poor in Delhi. 15-16 per cent of non-food expenditure on conveyance spend by more wealthy urban class of Delhi which 2-4 per cent greater than the all-India average.

A per the study by (**Vehicles powered with renewables can save Rs 40,000 annually, Jan 24,2018, IANS**) Bengaluru-based finance research firm Equitorials specifies that the complete adoption of electrical vehicles and substitution of ICE (Internal Combustion Engine) vehicle as well as the probable decrease in the cost of solar and wind power by 2030 could help India to save $28 billion by reduction in importing oil.

As per the (**ISGF white paper 2015/00012** Version 1.0 Dated 22 December 2015 **ELECTRIC VEHICLES: A SUSTAINABLE SOLUTION TO AIR POLLUTION IN DELHI)** To reduce carbon emissions, increase energy security and improve air quality it has been found that electric vehicles (EVs) is one of the most considerable solution.

b-Pollution & It's Health Impact:

As per the study by **(Naveen Kishore and Surinder Deswal-Analysis of Air Pollution In Indian Cities - A Literature Review)** In urban areas of developing countries air Pollution has its name in the major problems of the world caused due to a fast pace growth of people , industrialization and growth in the total number of vehicles. 60 to 70 % of pollution found in urban areas is due to motor vehicle and thus the major source of pollution in the urban areas. The condition of air pollution in Indian cities may get worse in future due to continuous rise in population and lack of measure of air pollution control. Due to this human health could be harmed by various diseases such as respiratory disease and cardiovascular, increased risk of preterm birth , Neurological impairments and even death. Some pollutant which are contributing towards environmental pollution are Particulate Matter, Sulphur Dioxide and Nitrogen Dioxide.

As per the study by **(World Energy Outlook Special Report, IEA, Energy and Climate Change,2015)** It states that fossil fuel-based transportation is the second largest source of CO2 emissions globally after power generation. This highlights the need for alternative cleaner fuels including electric mobility especially in India which is one of the largest automotive markets in the world with a total of more than 141 million user vehicles registered. (till 2011).

As study by **(WHO- Ambient air pollution and a global assessment of exposure and burden of disease)** Almost all the regions of the world are affected by the ambient air pollution and it kills around 3 million people annually. Only about 10 % of people of the world breath air that comply with WHO air quality guidelines while the rest 90% does not.

One more study **(Sunil Gulia 1, S.M. Shiva Nagendra Journal of Atmospheric Pollution Research Volume6/issue2/APR-15-033**) In most of the countries of the world the major urban air pollution source is motorized road transport. According to the WHO, UAP has been increased in developing countries causing almost 2 million deaths per year with problem of respiratory tract. (WHO, 2005; Cities Alliance, 2007; WHO, 2014).

As per the study by **(Dr. Vinish Kathuria, Vehicular Pollution Control – Concept note Madras School of Economics)** A huge growth of vehicular pollution is being experienced by developing countries. In India 60 % of total vehicular emission is released by 20% bad in-service vehicles.

As far as pollution in Delhi is concerned a study says that 67 % of the total pollutant emitted daily in Delhi comes from vehicular emission and 12 % by coal-based power plant. These both together are the major contributor of the 3000 metric tons of pollutants emitted daily in Delhi. According to CPCB (Central Pollution Control Board) there was a rising movement from 1989 to 1997**. (Gupta,2013)**

As per the study says that In the age of motorization the greatest evil for the health of humans, plants and animal is vehicular pollution. One of the major air pollutants produced by automobile is Nitrogen dioxide. Increased airway resistance in asthmatics, increased susceptibility to respiratory infection and decreased pulmonary function can be caused by direct exposure to nitrogen dioxide**. (Das,2013)**

As per the article by (**14 most polluted cities in world are all in India, Times news network)** The city's annual average of PM 10 and PM 2.5 was 292 microgram per cubic meter and 143 micrograms per cubic meter respectively which was 4.5 times for PM 10 and 3 times for PM 2.5 more than the national safe standard respectively.

As per the article by (**Delhi-NCR ranks worst in vehicular pollution, Hindustan times, Aug 18)** Centre for Science and Environment (CSE) — a Delhi-based research organization conducted a study to assess transport-related emissions from urban commuting. In energy consumption, Delhi came on the top in overall toxic emissions and heat-trapping emission. High volume of vehicles and higher population than other cities were found to be the major factors for this ranking.

As per the article **(Delhi-pollution-vehicles-not-stubble-burning-main-cause-India Today)** Teri's study shows that 28 per cent of PM2.5 emissions is caused by vehicular pollution and 18 per cent of PM2.5 levels is caused by the dust pollution however Industries are responsible for 30 per cent to PM2.5 levels. The residential area of Delhi responsible only for 10 per cent to the pollution**.** As far as **s**tubble burning by farmers is concerned It only takes place for 15-20 days and contributes only 4 per cent top pollution levels during the winter season. But when it is burnt in winter at that time it is the cause of 30 per cent of Delhi's pollution. thus, pollution levels spike during stubble burning. The main cause of PM 10 are industries. Industries are responsible for 27 per cent of the pollution, Dust for 25 per cent, vehicular pollution for 24 per cent, households for 9 per cent and stubble burning for 4 per cent.

As per the study by **(Urvashi Narain and Alan Krupnick, The Impact of Delhi's CNG Program on Air Quality)** Sulphur dioxide, Particulate Matter 10 and Carbon Monoxide concentration in the air has been reduced by the conversion of buses from diesel to CNG whereas in the case of three wheelers from petrol to CNG the result is not same due to poor technology**.**

Study by **(Maureen L. Cropper; Nathalie B. Simon; Anna Alberini; Seema Arora; P. K. Sharma American Journal of Agricultural Economics**) The deaths as per the age group due to air pollution is very different for developing country then USA. In USA the most effected age group is 65 and above while in developing countries it is 15 -44 thus indicating more life-years to be lost in developing countries.

As per the article in **(Hindustan times, www.hindustantimes.com/ Delhi- news/)** The Delhi-city has almost population of 20 million and it has almost 10 million vehicles. Delhi ranks as one of the most polluted cities of the world as per the WHO. Delhi also has the highest density of vehicles a principal source of air pollution in city. Vehicles establish 25% of the city's air pollution According to IIT-Kanpur report. 6,502 people died of respiratory diseases as per the latest government data making it one of the leading causes of death in 2015.

As per the article **(Delhi pollution: Survey says 35 per cent residents want to leave NCR, - India today,2018)** An online survey has found that Delhi's pollution may be pushing people to move from the national capital to environmentally safer places. As many as 35 per cent of those participating in the survey said they want to shift from Delhi to other cities, which have cleaner air. The survey was conducted by social engagement platform Local Circles. The survey found that the residents of Delhi are not happy with the efforts taken by the Centre and NCT government to combat pollution in the city. The survey results are verified by a study conducted by the ASAR. The ASAR report titled "Perception Study on Air Quality" said about 89 per cent people in Delhi feel sickness or discomfort due to the bad air quality.

As per the (ISGF white paper 2015/00012 Version 1.0 Dated 22 December 2015 ELECTRIC VEHICLES: A SUSTAINABLE SOLUTION TO AIR POLLUTION IN DELHI) BEVs are one of the most probable solution by which carbon emissions can be reduced, energy security can be increased and air quality can be improved.

CARBON EMISSION COMPARISON

Fuel Type	Carbon Emission
Petrol	.2325
Diesel	.273
EV	.103

Table 4.2: CARBON EMISSION COMPARISON

1 kg of CO2 is emitted when 1 kWh of energy is generated in coal power plant. In the table above, approximately the mileage of the petrol/diesel car in cities is taken as 10 km while an e car run 10 km with 1 kwh of electricity. The CO2 emission of petrol and diesel car is double as compare to that of e car even if electricity used for charging the EV is generated through fossil fuel. It should be notifying that electricity used for charging the EVs is generated in power plants located many hundred kilometers from cities which are facing issues of air pollution. Even more important point is that the emission from EVs can be made nil by charging them through renewable energy sources.

As per the analysis by (**Assessing and accelerating vehicle deployment in India)** As per the study by NEMMP emissions of 4 million tons of CO2 and importing of 120 million barrels of oil can be avoided if the target of India can be achieved i.e. deploying of 400,000 BEVs passenger cars by 2020. Also, emission of 270 million of CO2 and importing of 4.8 billion of oil barrels can be avoided by 2030 if the rate of adoption of BEVs remains the same.

Though BEV is more expensive as compare to ICE vehicles but still because of better fuel economy they are a highly cost-effective way to reduce oil consumption in India. Moreover, BEV range of 100 km is sufficient for more than 99% of trips.

To controlling the vehicular pollution in cities EVs will be one of the permanent and justifiable solution.

C-Socio economic point of view

As per the report by **(Elizabeth Ridlington Environment America Research and policy Centre, Frontier Group, June 2014)** As compare to ICE vehicles the electric vehicles with cleaner electricity grid, are capable of reducing the pollution by 18.2 million metric tons caused by global warming by 2025.

As per another report (**OTHER ALTERNATIVE FUELS AND TECHNOLOGIES, Auto fuel policy report)** E -Car reduces pollution and total cost per km is less as compared to other fuel.

A study by **(Anders Schriever, Christensen A Social Cost-Benefit Analysis of an Electric Vehicle)** a Social Cost-Benefit Analysis is conducted in order to find whether e vehicle is suitable for the society. The overall recommendation is that the EV as compared to a diesel vehicle is worth purchasing from a societal point of view.

Another study **by Israr Ahmad* and Kum Kum Dewan World Review of Intermodal Transportation Research, Vol. 1, No. 3, 2007)** the pollution level caused by all the cars and jeeps can be reduced from 1,01,051 tons to 75,991 tons per year if the people choose for the Electric Vehicle (EV). A saving of Rs. 1225.25 crores which is spent annually on petrol can be observed on the adoption of EV cars in Delhi.

As per the study by (**CREATING THE CLEAN ENERGY ECONOMY, Analysis of the Electric Vehicle,2013, Paul Krutko**,) Globally, the demand for passengers' cars and thus for oil is increasing in China and India due to their rising middle class. 750 million cars were there in 2010 by 2050 this number of units will reach to 1.5 billion. This huge growth in demand of cars provide an opportunity to new vehicle technology. The idea of alternative fuel for transportation such as electricity is a smart investment due to limited oil supplies also it is inevitable one. New jobs can be generated and demand for existing jobs can also be generated by switching to electric vehicles. By reducing the energy spending, improving quality of life and decreasing dependency on imported crude oil the electric vehicles will create additional economic development opportunities.

As per the study by (**Socio-Economic Aspects of Electric Vehicles, Christian Hanke, Michael Hülsmann**) – The user who drove the electric vehicles are very excited about the electric technology as the electric vehicles have great potential from a user viewpoint. There is some weakness of the electric vehicle as compare to ICE vehicles like range. Keeping this in knowledge an analysis is needed that how customer will accept new mobility concept. Furthermore, psychological barriers must break up, so that people reconsider their mobility behavior.

As per the study by **(Anders Schriver Christensen,2011A Social Cost-Benefit Analysis of an Electric Vehicle)** Ev has less operating, maintenance, environment and noise cost however magnitude of cost depends on number of km driven. The electric vehicle becomes relatively less costly as distance travelled will increase. The overall recommendation is that the E car is worth purchasing from a societal point of view.

3-Adoption of EV

a-Adoption in India:

As per the report by **net scribes Automotive and Logistics Industry Series- Electric vehicle markets for India** (Global market intelligence and content management firm,2014) the main drivers for e vehicles adoption are Low Maintenance Cost , Low Operating cost ,Government Initiatives , Zero emission , Dependence on imported crude oil and high fuel costs of ICE vehicles. While major barriers for the same are high capital cost, Inefficient Battery, Low Vehicle Performance, Lack of Infrastructure, Power Shortage. Indian market for electric vehicle is at a developing stage there is huge opportunities for the players. As the adoption of electric vehicle will increase its impact will be seen in the form of reduced pollution and significant fuel saving in the country.

A study conducted by **(Ishrar Ahmad and KK Dewan Electric vehicle: a futuristic approach to reduce pollution -A case study of Delhi) in** 2006 on a sample of 500 respondents unveils that 95.6% people wants that the pollution level should be reduce in Delhi and 93 % agree that EV may reduce the pollution. Availability of Charging facility and reduce charging time of batteries will make 85.8 % of respondents to shift to EVs. As per the data currently, 1.8% diesel and 24.8% petrol car owner are interested in changing their vehicle to Electric. But due to high initial cost, limited range on a single charge, electric problem, seating capacity and easy availability of petrol 73.4% people are not interested in shifting to EVs.

A **report by Yes Bank** In spite of having a growth rate of 5% per annum of 4W ICE vehicle the growth rate of EV 4W is not the same due to the various challenges of market. Even after the various supporting and sales promoting parameters like government support in form of subsidy, good advertising on environmental and economic issues, high price of petrol and diesel the sales of 4W EV has not increased as desired. The sales are also impacted by few other parameters while making a decision to purchase the vehicles and these parameters are battery longevity, range anxiety, high purchase costs and cabin capacity.

As per the report by **(Electric Vehicles in India A GERMI White paper)** Availability of only one manufacturer creates lack of competition in the market and one of the major problem in the country .The ICE vehicle market is highly cost competitive as there are many players to manufacture the ICE cars as compare to E cars ,the only manufacturer is Mahindra Reva for e car. Thus, the competition with many ICE cars is also one of the reasons of failure of low range and high capital cost car e car.

A study for e bike in India by **(Ramachandran alamelu1, Chandrasekaran- preference of e-bike by Women in India–a niche market for auto manufacturers)** suggest that charging stations ,variety of models with carrying capacity and subsidy from government are the key measures to purchase e- bikes in future. So, it is suggested that variety of models should be design by the manufacturer specially in case of women. Most importantly, the customer preference is established by way of guarantee and warranty for the spare parts of two-wheelers which are sustainable for a longer duration.

As per the study (Potential Need for Electric Vehicles, Charging Station Infrastructure and its Challenges for the Indian Market) by **Praveen Kumar and Kalyan Dash November 2013** the petrol/Diesel as a fuel for ICE vehicle approximate 50%-60% costlier as compare to the electricity i.e. fuel of EV. In spite of this difference in the fuel cost there is a need of charging infrastructure to be installed throughout the country before inspiring the people for adoption of EVs. Indian customer can be attracted by focusing on government subsidy, public awareness, instant technical support and extended manufacturer warranty. Country should inspire more and more foreign direct investment to serve a faster, better and greener charging infrastructure instead of solely depending on local OEM.

As per the report **Assessing and Accelerating Electric Vehicle Deployment in India**, Clean Energy ministerial, EVI,2014 India has the potential to realize all the benefits if it meets the targets set by NEMMP.

as per the study by (Electric Vehicles in India: Market Analysis with Consumer Perspective, Policies and Issues **by Pritam K. Guajarati, Varsha A. Shah, June 2018**) EV and PHEV will have promising future in India, however, the sales are very poor and it is definitely limited by poor policies and awareness creation.

As per the report **(Study on Electric Mobility in India by Amit Garg Indian Institute of Management**, **Ahmedabad, Srinivas Cherla**) The Indian EV sales are a mere of .02% of total auto sales in 2016 due to lack of clear government policies, lack of vehicle standards and wait and watch attitude of large auto makers.

The government consistency for the announced policies are desired by the Industry as huge investment has made in the technology development and to recover the investment industry require long term stability. Industry also wants active participation of Govt. in building charging stations and other infrastructure to make the country for EV movement.

It has been found that the awareness of consumer about EVs and government schemes/policies related to EVs is very poor. This is because of the ineffective promotion and marketing industry and lack of awareness activity program me by government. If consumer is educated properly for the EVS the consumer may show the preference towards EV

As per the study, **Study on Electric Vehicles in India Opportunities and Challenges, by Mohamed M, G Tamil Arasan 2018** To cut oil expenses and to reduce greenhouse gases emission the implementation of EVs are necessary. The Indian govt. focus to meet vision 2030 is a difficult and ambitious task. The challenges should be handled by suitable ways and also take the advantage of available opportunities to implement the Eves.

b-Adoption in other countries

As per the report by (**Electric Vehicles in India A GERMI White paper)** In this study a comparison between India's Mahindra Reva strategy and rest of the world is discussed. It has been found that Mahindra Reva positioned the car as affordable car and the entire efforts was on being economical (even though it fails to do so) but the customer felt very awkward to drive such a car. The world has focused on both economic viability (e.g. Nissan's Leaf) and expensive but performance-driven vehicles (e.g. Tesla motors) while India's EV sector has complete focus on being economical.

India is lacking behind to other countries in terms of allocation of funds in terms of Infrastructure, R &D and incentives. The capital cost, Lack of awareness, negligible charging infrastructure, lack of manufacturer, long term policy clarity, subsidy, battery swapping is found to be major barriers in the report.

As per the study by **(Ole Henrik, Håvard Malvik, The future is electric! The EV revolution in Norway – explanations and lessons learned)**. The sales of EV in Norway is Noteworthy. A country with only population of 5 million has sold as many cars as big countries like, France Germany and the UK. This is because of the Incentive model adopted by the Norway. In comparison to other European countries the ICE cars are taxed heavily in Norway. Weight, CO2 emissions and NOx emissions are some parameters used to tax the cars on Import. Moreover, cars 25% VAT are applicable to cars.

NO import tax and VAT are applicable on BEVs. The operating costs of ICE vehicles are also significantly higher than for a similar EVs. Consequently, the Total Cost of Ownership (TCO) for BEVs compares favorably with ICE cars.

BEVs are also exempted for road toll on Norwegian roads and also allowed in bus lane. No fee for BEVs national road ferries (for the car – not the driver). If BEV is used as company car than it attracts 50% tax benefit. Free parking to BEVs in all publicly owned parking spaces. €6,5 million have been granted by govt. in 2009 to quicken the building of charging points. There are around 3.700 charging points in Norway as of January 2013.

Incentives	Norway	Sweden	Denmark	Germany	Portugal	Ireland
Financial Incentives	Yes	Yes	Yes	Yes		Yes
Access to Bus lane	Yes	Limited				
Free parking & no road toll	Yes	Limited	Some			
Charging Infrastructure	Yes	Some	Y		Yes	Yes

Table 4.3: Country wise incentives for EV's

The reason of success of electrical vehicles in Norway is as they applied both push and pull system in their incentive scheme. While the incentives in many other countries are generally limited to free parking and free charging on one side or financial incentives on the other.

As per the study- (**Incentives for promoting Battery Electric Vehicle (BEV) adoption in Norway by Ystmark Bjerkan, Tom E. Nørbech 2014)** The study identifies the major incentives for deciding to buy a BEV and as per the study the strongest incentive in promoting BEV adoption is purchase cost reduction.

As per the study (**Factors Influencing the Behavioral Intention towards Full Electric Vehicles: An Empirical Study in Macau by Ivan K. W. Lai 2015**). As per the study that major factor that motivates the customer's behavior intention towards purchase of a full electric vehicle is environmental concern.

As per the study **(Statistical Analysis of Electric Vehicle Adoption in Trinidad and Tobago by Anthony A. Manohar K and Ramnath**,oct 2018) As per the study the purchase decisions of an electric vehicle are not affected by human factors such as age and gender influences. The study applies the principal component analysis to determine the main factors of purchasing decision and theses are costs associated with the electric vehicle, Support Systems and Safety. Support systems includes the charging infrastructure of the EV, Government Incentives and the provision of proper maintenance and servicing systems.

As per the study **Factors affecting the intention to buy electric vehicles: Empirical evidence from Thailand by Prattana Punnakitikashem,Trin Thananusak -2017** As per the study the reasons which affects the decision to purchase EVs are mainly environmental concern and Thai customer also agree to purchase the car at higher price for envoi mental concern. But anyhow this high price factor may negatively affect the relationship between the environmental concern and intention to buy. Thai car buyers not concerned much with infrastructure and financial factors (purchase price, operation and maintenance costs, resale price) however other performance factors like (e.g., driving range, speed, safety) are critical to them.

As per the study **(Does Driving Range of Electric Vehicles Influence electric Vehicle Adoption) by Seiho Kim , Jaesik Lee and Chulung Lee, Oct 2017** As per the study various parameter of electric vehicles lik**e** driving range, number of models available in market and relative price of electric vehicle compared to internal combustion engine vehicle are corelated to the market share of electric vehicles. . On the other hand, an insignificant relationship was observed between the market share of electric vehicles and recharging infrastructure—an important factor for electric vehicle adoption in many studies.

<u>Gaps identified from all research papers have been funneled down to the final gaps</u>

S.No.	Theme	Number of studies	Identified Gaps	Final Gaps
1.	Vehicular Growth in India -Delhi	17	1-Scope for further research for the use of latest technology to get an edge over competitor. 2- Scope for further research to find enablers and barriers of technology innovations to compete in market. 3- Scope for further research for the reduction of vehicular emission & traffic Congestion. 4- Scope for further research at the front of environment, energy consumption and parking. 5- Scope for further research for the promotion of hybrid vehicles.	Although a number of studies have been found related to ICE vehicle growth in India and Delhi but researcher did not come across any study related to barriers to E car growth in Delhi Region.

			6-Scope for further research to formulate and enforce policy for reduction of various kind of emission to control negative health impact.	
2	Energy Security & Pollution & health	34	1- Scope for further research to use cleaner alternative fuel like CNG, E-battery for reduction of Petrol demand. 2-Scope for further research for the promotion of hybrid vehicles. 3-Scope for further research on positive impact of air quality regulation on health. 4- Scope for further research on how to	Although a number of studies have been found related to energy security, pollution & it's health impact but researcher did not come across any study encouraging adoption of E car as a mode of transportation in Delhi to mitigate these effects.

			encourage use of cleaner technology. 5-Scope for further research to increase the adoption of E Vehicle in Delhi. 7- Scope for research to mitigate the challenges and risk for the expansion of EV.	
3	Adoption of EV	33	1-Scope for further research to find the enablers for the adoption of E Car in Indian context. 2- Scope for research to find the barriers for the adoption of E Car in Indian context. 3-Scope for further research to increase the adoption of E Vehicle in Delhi. 4- Scope for further research for strategy formulation as per the	Although a number of studies have been found related to E vehicles in India but researcher did not come across any study related to barriers to adoption of E car in Indian context.

			different geographic locations. 5- Scope for further research to understand the consumer preference dynamics for novel technologies.	

Table 4.4: Gaps identified from all research papers have been funneled down to the final gaps

Theme wise Literature review:

S.No.	Theme	Number of studies	Major Findings/Summary/Inferences	Gaps
1	Vehicular Growth in India-Delhi	17	Most of the Indian metropolitan cities like Delhi, Chennai, Bengaluru and Hyderabad have experienced an outstanding rise in transport demand. This rise in demand is because of increase in household income, availability of motorized transport and growth in population as a result of both migration from rural areas and natural growth. A massive shift to personalize transport like cars and two-wheeler has been caused due to failure of public transport. Automobile market of India is among the world's fastest developing automobile	Although a number of studies have been found related to ICE vehicle growth in India and Delhi but researcher did not come across any study related to barriers to E car

			markets. It is counted among the world's top seven automobile producing country. Four-wheeler segment in automobile has lot of scope in future. There were 8.8 million vehicles in Delhi as in 2015 which increased from 3 million in 2007 thus Delhi is one of most speedily rising automobile market. Delhi ranks as one of the most polluted cities of the world as per the WHO. Delhi also has the highest density of vehicles in India. More than one crore i.e. 1,05,67,7129 vehicles have been registered in Delhi till May 2017. Out of them 31,72,842 are the registered cars till May 2017. Different estimates show that currently the number of cars is about 15 million in India which is equivalent to 13 cars per 1,000 population. As far as Delhi is concerned the ownership level of Delhi is about 157 cars per 1,000 people. Many estimations have projected that by 2025 the increase in the number of cars will be around 35 cars per 1,000 population in India. This may lead to around 45–60 million cars in Indian roads while in some	growth in Delhi Region.

			cities the count may be around 300 cars per 1,000 population. This may have a considerable increase in the total number of cars in Delhi from 2 million in 2011 to about 10 million by 2025 i.e. about 380 cars per 1,000 population in Delhi	
2	Pollution- Health & Energy Security	34	In India there is a big gap in the production and consumption of crude oil. The consumption of oil has increased at a rate of more than 4 percent annually while the production has increased at an usual rate of 1.6 percent from 2001- 2010. The reserves to production (R/P) ratio of crude oil for India shows adequate reserves for 30 years while (R/P) ratio of crude oil for world shows adequate crude oil for 46 years India dependency on crude oil will continue to rise. India imports almost 80 per cent of crude oil to fulfill the demand with this consumption rate by 2032 the crude oil import will increase to 90 per cent. India is forced to spend billions of rupees to import the crude oil which can be used for the development of the country In India, transport sector alone consumes about one third of the total crude oil. If we focus only on the consumption by the road transport then one third of total crude oil	Although a number of studies have been found related to energy security, pollution & it's health impact but researcher did not come across any study encouraging adoption of E car as a mode of transportation in Delhi to mitigate these effects.

			i.e. 80 % consumed by road transport. It has been assessed that transportation will be responsible for the three quarters of the projected increase in oil demand from 2006 to 2030 The electricity share in transport fuel is only 2% the remaining 98% of transport fuel is petroleum products The idea of alternative fuel for transportation i.e. Electricity is smart investment due to limited and inevitable oil supplies in the world. 60 to 70 % of pollution found in urban areas is due to motor vehicle and thus the major source of pollution in the urban areas. It states that fossil fuel-based transportation is the second largest source of CO_2 emissions globally after power generation. This highlights the need for alternative cleaner fuels including electric mobility especially in India Almost all the regions of the world are affected by the ambient air pollution and it kills around 3 million people annually.	

			In most of the countries of the world the major urban air pollution source is motorized road transport UAP has been increased in developing countries causing almost 2 million deaths per year with problem of respiratory tract. 67 % of the total pollutant emitted daily in Delhi comes from vehicular emission and 12 % by coal-based power plant. In USA the most effected age group is 65 and above while in developing countries it is 15 -44 thus indicating more life-years to be lost in developing countries. Delhi ranks as one of the most polluted cities of the world as per the WHO. Delhi also has the highest density of vehicles a principal source of air pollution in city. Due to this human health could be harmed by various diseases such as respiratory disease and cardiovascular, increased risk of preterm birth, Neurological impairments and even death. To controlling the vehicular pollution in cities EVs will be one of the permanent and justifiable solution.	

			It is possible to save 270 million tons of CO2 emission and 4.8 billion barrels of oil by 2030 if government target of EV car adoption continue in to the decade beyond 2020. Adoption of electrical vehicles and substitution of ICE (Internal Combustion Engine) vehicle as well as the probable decrease in the cost of solar and wind power by 2030 could help India to save $28 billion by reduction in importing oil.	
3-	Adoption of EV	33	In November 2010, Rs 95 crore subsidy scheme was introduced by the Ministry of New and Renewable Energy (MNRE) to provide incentives to electric vehicle buyers. After the launch of the scheme the sales increased by close to 70 per cent in 2011 touching 100,000 units thus the scheme appeared to work. But sales dropped soon after the program expired in March 2012 and the discontinuation of the scheme witnessed a 65% decline in the sales of EVs. To achieve national fuel security by promoting hybrid and electric vehicles in the country National Electric Mobility Mission Plan (NEMMP) 2020 was launched in 2013 by government of India. NEMMP objective is to achieve diffusion	Although a number of studies have been found related to E vehicles in India but researcher did not come across any study related to barriers to adoption

			of 6-7 million e-vehicles among them 4-5 million are expected to be two-wheeler by 2020 which helps in collective saving of about 2.2-2.5 million tons of fuel equivalent to a monetary saving of Rs 30,000 crore and that may result in decreasing the pollution and greenhouse gas emission by 1.3%-1.5%. Faster Adoption and Manufacturing of Electric Vehicle, A subsidy scheme as part of NEMMP. FAME India scheme with an outlay of Rs. 795 crores have been launched for the initial two years – Phase I (2015-17) Through National Electric Mobility Mission Plan 2020 , Rs14,000 crore ($2.25 billion) of incentives for the electric vehicle industry was declared by government in Jan 2013. But progress has been very slow so far—and carmakers are still hurting There is a 37.5% per cent jump over the last fiscal year (2014-2015). Encouraging growth for EVs have been seen for the fiscal year 2015-16. 22,000 units (20,000 two wheelers & 2000 four-wheelers) have been sold for the fiscal 2015-16 as compared to 16,000 EVs during FY 2014-15.	of E car in Indian context.

			In spite of having a growth rate of 5% per annum of 4W ICE vehicle the growth rate of EV 4W is not the same due to the various challenges of market. Even after the various supporting and sales promoting parameters like government support in form of subsidy, good advertising on environmental and economic issues, high price of petrol and diesel the sales of 4W EV has not increased as desired. The Indian EV sales are a mere of .02% of total auto sales in 2016 due to lack of clear government policies, lack of vehicle standards and wait and watch attitude of large auto makers. It has been found that Mahindra Reva positioned the car as affordable car and the entire efforts was on being economical (even though it fails to do so) but the customer felt very awkward to drive such a car. The world has focused on both economic viability (e.g. Nissan's Leaf) and expensive but performance-driven vehicles (e.g. Tesla motors)	

			One of the main problems in the Indian EV car market is the presence of only one manufacturer. The main drivers for e vehicles adoption are Low Maintenance Cost, Low Operating cost, Government Initiatives, zero emission, Dependence on imported crude oil and high fuel costs of ICE vehicles. While major barriers for the same are high capital cost, Inefficient Battery, Low Vehicle Performance, Lack of Infrastructure, Power Shortage. Indian market for electric vehicle is at a developing stage there is huge opportunities for the players. There are various types of promotions that has been adopted by various countries like Financial and Non-Financial Incentives. `Financial Incentives like subsidy, Tax free, Vat free, no toll road charge, Registration free, Driving privilege for license, Free parking. Non-financial incentives include Access to bus taxi lane, Premium for Vehicle emitting less pollution, Charging Infra, Free charging. India is lacking behind to other countries in terms of allocation of funds, Infrastructure,	

			R &D and incentives. The capital cost, Lack of awareness, negligible charging infrastructure, lack of manufacturer, long term policy clarity, subsidy, battery swapping is found to be another major factor.	

Table 4.5: Theme wise Literature review

The all the Final gaps obtained from literature review strongly indicating towards adoption of innovation. As far as adoption of innovation is concern a lot of theory is available in literature for adoption of innovation but Innovation diffusion theory is the basic theory and increasingly becoming a focus of academic research and found to be most appropriate for the study.

Theoretical premise -Adoption Theory

Rogers described one of the most popular models of adoption and the for the last more than 30 years study is going on for the process of adopting new innovations. In the area of technology diffusion and adoption, Rogers' theory has been defined as the extensively used theoretical framework. by Dooley (1999) and Stuart (2000). The model as framework has been used by many researches from a variety of discipline. Public health, communications, technology, history, political science, economics, and education, are several of these disciplines defined by Dooley (1999) and Stuart (2000). *(DETAILED REVIEW OF ROGERS' DIFFUSION OF INNOVATIONS THEORY AND EDUCATIONAL TECHNOLOGY-RELATED STUDIES BASED ON ROGERS' THEORY Ismail SAHIN <isahin@iastate.edu> Iowa State University)*

Academic research highly considers the Innovation of diffusion theory because it helps in predicting the future of new products for business. It has been used in IT services, consumer durables, pharmaceutical industry and other industry research. Thus, on the decision making and management it has great significance. A lot of theory used by researcher but the theory of diffusion of innovation by Rogers found to be most appropriate for the study as this is the basic theory. Some researcher has done modification in the theory according to the specific situations. In our case also we can make some changes if required.

Diffusion of innovation is one of the most sought research topics in the last 40-50 years. Everett Rogers one of the leading researchers in his field developed the DOI theory in 1962. It is considered as firstborn social science theories detailing how innovation and technologies spread through a culture. Rogers has published a lot of work on Diffusion of Innovation. It describes the way the innovation and technologies spread through a social system.

This theory is helpful to business to understand the process of adoption and engagement of a new product or technologies by buyers over time. The theory may be used by the companies during the introduction of an existing product in a new market or during the launch of a new product or service.

"Adoption" is the acceptance of a new idea and product by the consumer. Every new product is launched for being adopted. But all new products do not necessarily become huge successes. The product innovation needs to possess certain basic attributes for it to spread quickly to the target market.

The first edition of Diffusion of innovations was launched in 1962 and now is its fifth edition (2003). The definition proposed by Rogers

The definition proposed by Rogers (1983) is: “Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system.” (Rogers 1983). Over-all, the process through which the consumers accept the new product is defined as the diffusion of innovation. In our case the new product is the electric car. Adoption process takes place within a social system where people interact and is influenced by government and social pressure also known as institutional pressure (IP).

After reviewing the literature of diffusion of innovation of last twenty years it has been concluded that a significant progress can be observed in the research of innovation diffusion theory since it was proposed. And the theory is applied to new areas of research by constantly revised, providing theoretical guidance for the launch of new products**. (Ying li, Mengqing Sui,2011)**. As per the study by **(Jason MacVaugh, Francesco Schiavone 2009) v**ariety of variables should be consider by the firms launching new products to maximize their adoption in the market. Non-adoption of new technology is one of the minimum understood areas of innovation diffusion. As per the study by (**Rajesh Sharma and Rajhans Mishra**) existing models of technology adoption may found to be inadequate in numerous new areas of research. As per the study by **(Jennifer P. Wisdom Ka Ho Brian swqChor)** A lack of precise definitions and measurement of constructs suggests further work is needed to increase our understanding of adoption of innovations. As per the study **(Ismail SAHIN,2006)** emphasized that providing training is a main strategy to increase computer use.

As per the study by **Bansal and Roth (2000)**, Adoption behavior is influenced by institutional pressure. One more area of innovation to explore is maximizing consumers finally replace old technology by new technology **(Davis, 1989; Rogers, 1962, Venkatesh et al., 2003),** but market study shows it does not do that so easily. Many variables effect the individual decision to adopt or reject new technology thus firms should consider a variety of variables while launching new products **(Jason MacVaugh, Francesco Schiavone, 2009**). The focus of the majority of diffusion research is on the characteristics of the consumer of innovation and innovation product characteristics.

Chapter 5

Theoretical Premises -Adoption theory models

Adoption of technologies are described by two approaches. One approached relates to adoption at individual level and the other at organizational level. If the intention or usage by an individual is the focus of study, it is described as the adoption at individual level. If the intention or usages by the organization is the focus of study, it is called adoption at organization level. Adoption at individual and organizational levels leads to mass adoption which is termed as the diffusion of technology. Below are the theories and models that have grown for describing adoption of technology.

<u>Adoption Theory Models</u>

Some of the adoption theory -Model are given below

1-Diffusion of Innovation Theory Roger (Roger, 1960)

2-Theory of Reasoned action: (Fishbein and Ajzen, 1975)

3- Theory of Planned Behavior (Ajzen, 1991)

4- Technical Adoption Model (Fred D Davis, 1989):

5- Extended TAM2 model (Venkatesh and Davis, 2000)

6- The Model of PC Utilization (Thompson et. al. 1991)

Diffusion and Adoption of Innovation

1-Diffusion of Innovation Theory (Roger, 1960):

Everett Rogers in 1962 developed the DOI theory which is one of the oldest social science theories. It describes the way the innovation and technologies spread through a social system.

This theory is helpful to business to understand the process of adoption and engagement of a new product or technologies by buyers over time. The theory may be used by the companies during the introduction of an existing product in a new market or during the launch of a new product or service.

Diffusion: A macro process through which a new product is spread to the consuming public from its source is called Diffusion.

Adoption: A micro process that concern on the stages through which an individual consumer passes when deciding to accept or reject a new product.

Adoption play a major role in the diffusion of innovation as through it only consumer decides whether or not to try and adopt innovative product/services.

In simplest words, "Adoption" is the acceptance of a new idea and product by the consumer. Every new product is launched for being adopted. But all new products do not necessarily become huge successes. The product innovation needs to possess certain basic attributes for it to spread quickly to the target market.

Theory of Innovation: DOI is a **theory** that explain how, why, and at what rate new ideas and technology spread through cultures.
Four elements were proposed by Rogers which influenced the spread of new Idea. These are

- Innovation itself
- Communication channel
- Time
- Social system

STAGES OF ADOPTION PROCESS:

- **AWARENESS:** First exposure & lack info
- **INTEREST:** Show interest and searches for more information
- **EVALUATION:** Consider to judge the product
- **TRIAL:** Innovation is tested or experimented
- **ADOPTION/REJECTION:** Decides to reject or adopt

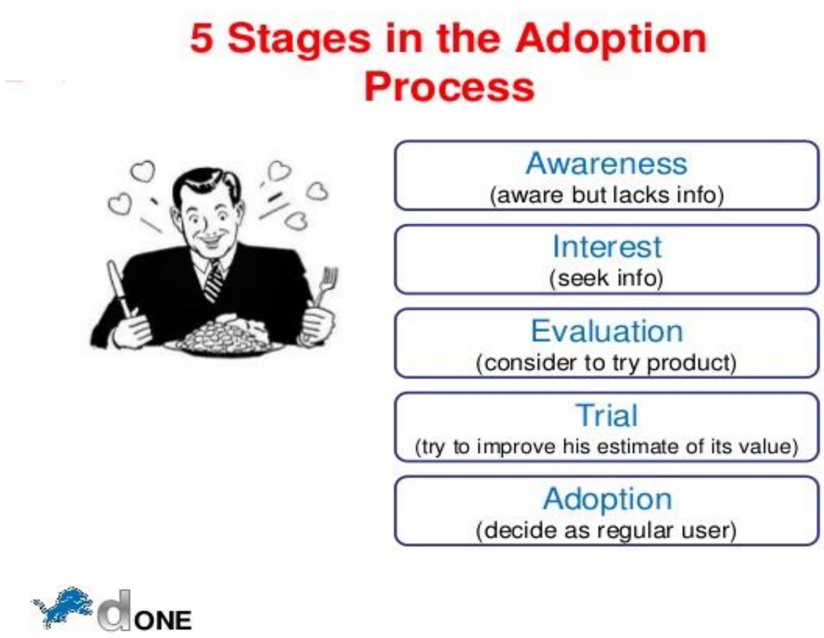

Figure 5.1: Five stages in the adoption process

Product characteristics that influence diffusion

1-Relative advantage: It defines the extent to which potential customer thinks about the superiority of a new product as compare to current product. E.g. HDTV over standard TV

2-**Compatibility:** The extent to which potential customer think that new product is reliable with their present wants and value.

E.g. Gillete Mach3 Turbo over disposable razor

3-**Complexity:** It defines the degree to which innovation is difficult to understand or use

E.g. Disposable razors

4-**Trialability:** It defines the degree to which an innovation is tested or experimented before a promise to accept is made.

E.g. Free trial software

5: **Observability:** It defines the extent to which a products characteristic can be observed, to possible customers. E.g. TV

Adopter categories:

- Innovators
- Early adopters
- Early majority
- Late majority
- Laggards

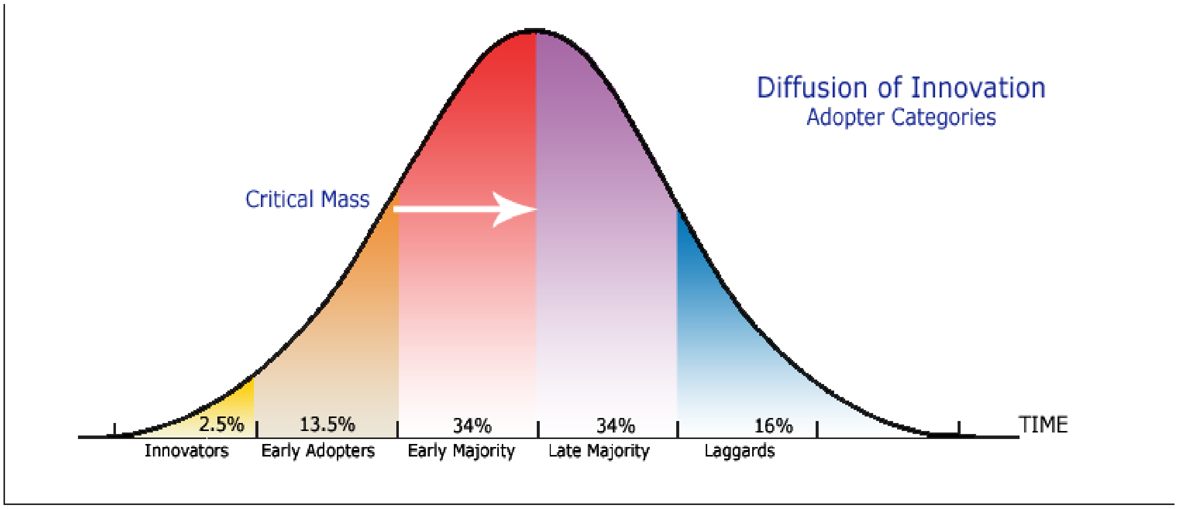

Figure 5.2: Diffusion of innovation adopter categories

Rate of Adoption

According to Rogers there are five categories of adopters for the diffusion process**.**

Basically, it represents the five types of customer type for the adoption of new product and also help a business to understand to engage with five types categories.

It describes how, an idea or new product make his place in the market over time and diffuses (or spreads) through a or social system or population. The outcome of this diffusion is that people adopt a new idea or product. Adoption means that a person does something differently than what they had previously (i.e., purchase or use a new product). The key to adoption is that the person must perceive the idea, behavior, or product as new or innovative. It is through this that diffusion is possible.

Adoption does not occur quickly, but adoption is a process in which some people are more suitable to adopt it as compare to others. It has been found that early adopter has different characteristics to late adopters. So, it is significant to recognize the characteristics of target population before promoting an innovation which in turn help in adoption.

As we know that there are five adopter categories and a major portion of the population fall in the middle categories in spite of that it is important to understand the characteristics of all the target population. Different strategies are used to appeal different categories when promoting an innovation.
Source: http://www.smartinsights.com/marketing-planning/marketing-models/diffusion-innovation-model/

- **Rate of adoption:** Time taken by a new product/services for the adoption by the population. Diffusion of new product/services has become faster and shorter.
- **Penetration policy**: To keep the introductory price low to penetrate the market so that market leadership can be established quickly.
- **Skimming policy**: Introductory price are kept high initially but to attract additional market segment gradually lowers the price.

- **Epidemic model of adoption**: The concept of S-shaped curve of adoption is called as the epidemic model of adoption.

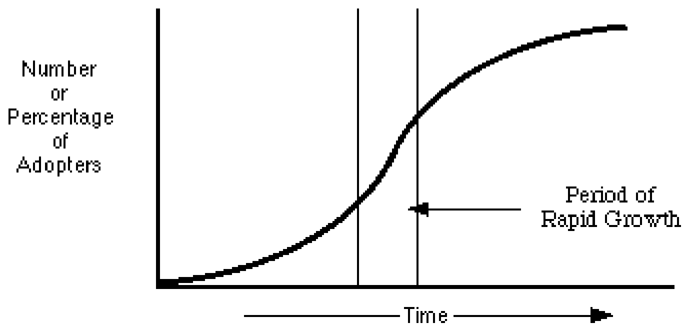

Figure 2. S-curve representing rate of adoption of an innovation over time

Figure 5.3: S-curve representing the rate of adoption of an innovation over time

1. Innovators - These people are very willing to take risks. They are financially stable and can afford to try new things. These are people who want to be the first to try the innovation. They are adventurous and interested in new ideas and are often the first to develop new ideas. Very little, if anything, needs to be done to appeal to this population.
2. Early Adopters – These are the people who holds high social position and capable of taking some risk. They are comfortable for adopting new products or ideas as they understand the necessity to change. They do not require any advice to influence them to change. These are opinion leaders. They enjoy leadership roles.
3. Early Majority – First major segment of population to adopt an innovation. These people adopt new ideas/products before the common person. They are hardly leaders and want evidence of innovation effectiveness.
4. Late Majority – When most of the population has adopted the innovation only after that they adopt it because they are doubtful of change. Strategy used to request this segment is providing information about the number of people who have already adopted the idea or new product.

5. Laggards – These people adopt the idea/new product in the last as these are very conservative and bound by custom. They do not want to change. It is very difficult to prepared them for adoption of innovation. Strategies used to request to this segment are pressure from people in the other adopter groups, fear appeals and statistics.

Diffusion of Innovations offers three valuable insights into the process of social change:

- What qualities make an innovation spread?
- The importance of peer-peer conversations and peer networks.
- Understanding the needs of different user segments.

New Product Adoption Theory

The consumer decision stages that lead to innovation acceptance/rejection

A micro process that focuses on internal forces of the consumer

* Intra Personal (Psych) Influences
* Inter Personal (Social) Influences
* Product Selection Criteria

<u>Theory of Reasoned action: (Fishbein and Ajzen, 1975):</u>

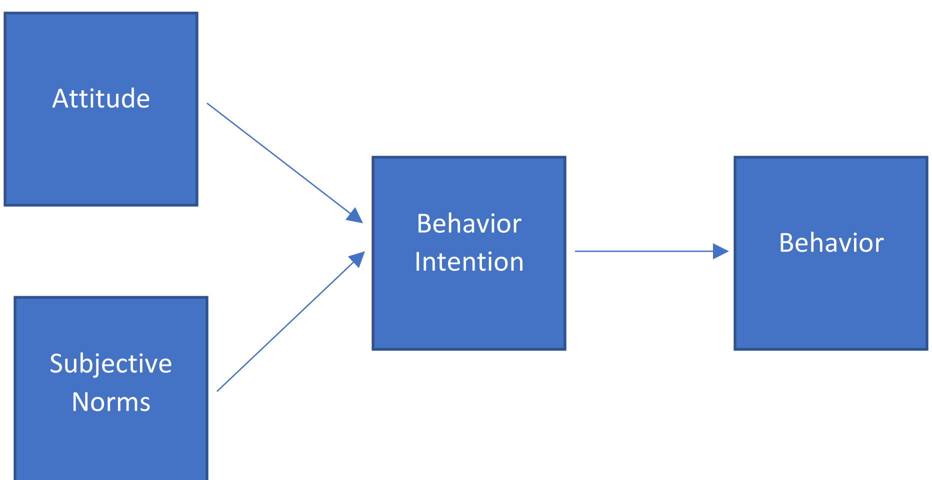

Figure 5.4: Theory of Reasoned action

(subjective norm is "the perceived social pressure to perform or not to perform the behavior)

(Attitude: A feeling or opinion about something or someone, or a way of behaving that is caused by this)

The theory can be described with the help of all the constructs of theory, namely " attitude (A), subjective norm (SN) and behavioral intention (BI)". According to TRA attitude and subjective norms influence and make the behavioral intention of a person. It can be understood mathematically that summation of the attitude and subjective norms will be equal to behavioral intention. Moreover, it explains that action of a person is the outcome of behavior intention of that person if behavior intention is strong enough to behave in a specific manner.

Theory of Planned Behavior (Ajzen, 1991)

Icek Ajzen in 1991 proposed the theory of Planned Behavior (TPB) and it was developed from the Theory of Reasoned Action (TRA). One more construct i.e. Perceived Behavioral Control (PBC) was added to the constructs attitudes and subjective norms which make the TRA. Perceived behavioral control refers to " ease or difficulty of performing the behavior of interest as per the people's perception. In this way, the criticism faced by TRA that it is based on relatively static construct of attitude and thus cannot be used for prediction of behavioral outcome has been addressed by TPB.

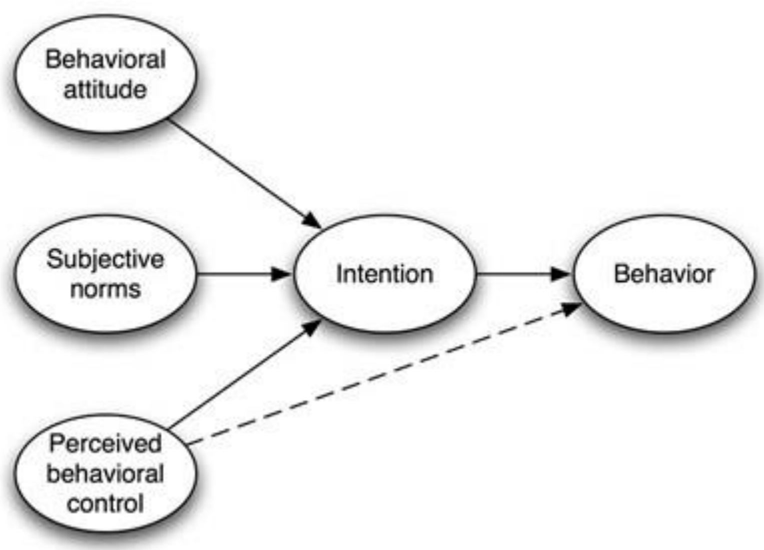

Figure 5.5: Theory of Planned Behavior

Technical Adoption Model (Fred D Davis, 1989):

It is one of the extensively used model in technology adoption studies. The model is very simple as it has only two constructs namely, "perceived usefulness" and "perceived ease of use" which is the strength of the TAM. These two constructs of TAM predict the degree of adoption of new technologies at individual level.

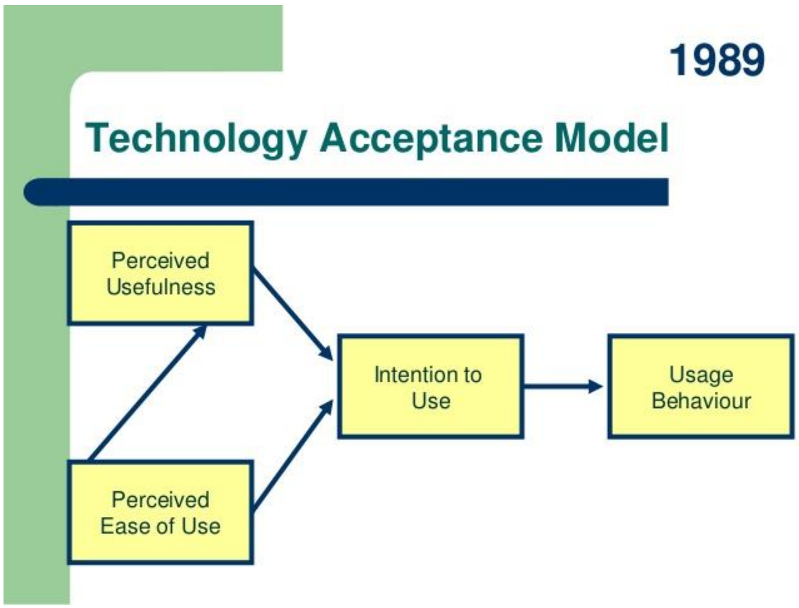

Figure 5.6: Technology Acceptance Model

Construct	**Definition**
Perceived usefulness	The degree to which a person believes that using a particular system would enhance his or her job performance
Perceived ease of use	The degree to which a person believes that using a particular system would be free of effort.

Table 5.1: Table for Technology Acceptance Model

Source: Davis 1989

In IBM Canada the TAM was initially tested for the adoption of email service It has been found that in the TAM the perceived usefulness is a stronger factor as compare to perceived ease of use that drives technology adoption.

Extended TAM2 model (Venkatesh and Davis, 2000)

TAM was modified as extended TAM model by Venkatesh & Davis by including additional constructs to perceived usefulness and intention to use constructs of TAM's model.

The additional constructs included social influence processes (subjective norm, voluntariness and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability and perceived ease of use

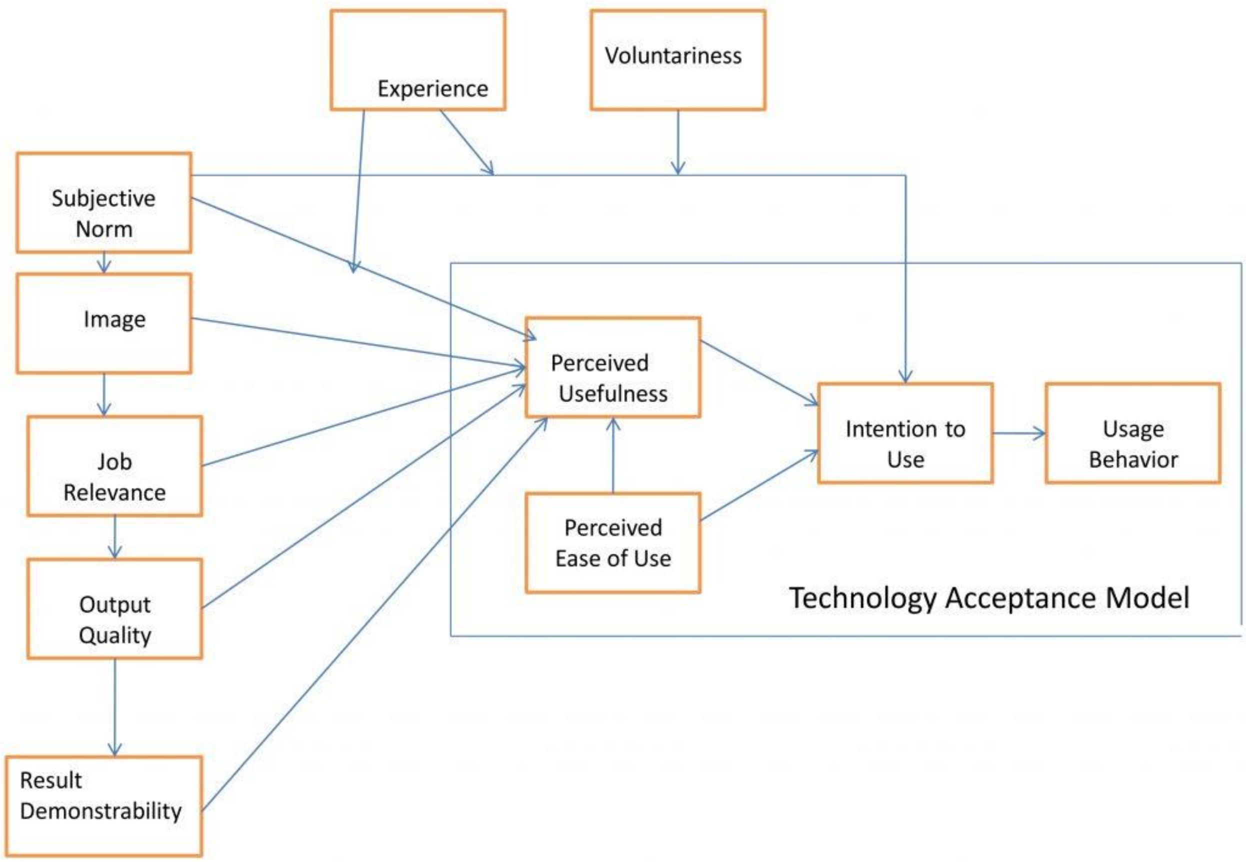

Figure 5.7: Extended TAM2 model

Construct	Definition
Image	"the degree to which use of an innovation is perceived to enhance one's . . . status in one's social system".
Job relevance	the degree to which the target system is applicable to his or her job
Output quality	Output quality measures perception of how well the system performs the job-related tasks
Result Demonstrability	The degree to which the results or benefits of using the innovation are apparent.
Voluntariness	Voluntariness is the extent to which potential adopters perceive the adoption decision to be non-mandatory.

Table 5.2: Table for Extended TAM2 model

The Model of PC Utilization (Thompson et. al. 1991)

According to this theory "Behavior is determined by what people would like to do (attitudes), what they think they should do (social norms), what they have usually done (habits), and by the expected consequences of their behavior.

This theory mainly deals with extent of utilization of a PC by a worker where the use is not mandated by the organization but is dependent on the option of the user.

This theory proposes that the worker is likely to be influenced by several factor for the for the use of computer such as predominant social norms regarding use of PC at the workplace, his feelings toward using PCs, consequences expected by the user by using the PC , general habits related to use of the computer, and extent of conditions that are present at the work place for facilitating use of PC.

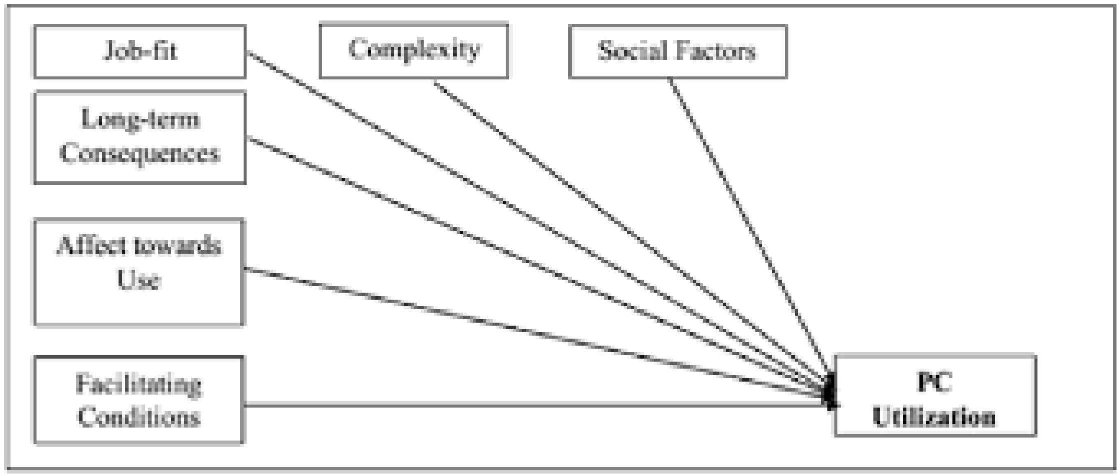

Figure 5.8: The Model of PC Utilization

<u>Contribution of research to theoretical Premises:</u>

As researcher is identifying barriers and motivating factors from literature review, semi structured interview and thereafter by survey and comparing the variable obtained from literature review and Semi structured interview with the survey result. The comparison may valid for the variables obtained from LR and semi structured interview or result in addition, updating and reduction of some variables. In all the case research is contributing to theoretical premise in context to adoption of E car.

Chapter 6

Research Gaps, Problem, questions, objectives

Research Gap:

A number of studies have been conducted on adoption of e vehicles and the barriers to its adoption. However, researcher did not come across any such study in Indian context. Moreover, the focus of existing studies has been on the environmental aspects and socio-economic aspects. The researcher did not come across any study relating in which the views of consumer and other stakeholders have been studied together. Present study is an attempt to fulfill these gaps.

Research Problem:

This proposed research is an attempt to explore the factors & measures for the adoption of E- cars by consumers in Delhi.

Research Questions:

1-What are the enablers for adoption of an E car by consumer?

2-What are the barriers for adoption of E car by consumer?

3-What measures needs to be taken for enhancing E car adoption?

Research Objectives:

1-To find the Enablers & barriers for the adoption of E- Car by consumer in Delhi.

2-To identify the measures for enhancing adoption of E- car.

Chapter 7

Research Design

It is a blueprint for the conduction of research. Research design is the overall structure of the research study. Research design provides a short plan of your future research. It is a plan to answer your research questions. It sets the basis for conducting the research.

Research design are generally divided into exploratory research and conclusive research. Conclusive research is again divided in to descriptive and casual research. In exploratory research generally deal with qualitative studies while in conclusive research deal with quantitative studies. In this research, both these research design have been adopted by researcher to some degree. Exploratory research design was used during qualitative study and for identification of variables while descriptive research design was used during quantitative study.

Exploratory Research design

Exploratory research is used when problems are in a primary stage. It is preferred when the problem or topic is new and data is tough to collect. It is flexible in nature and can help in resolving the all types of research questions starting from why what, how. It is like investigating or exploring something with interest. Researcher should also use their instincts to discover hints and venture into new problem in search of information

The basis for descriptive research is set by exploratory research. Exploratory research is performed using tools like secondary information (literature review), Personal interview and Focus group

Descriptive research Design:

As the name suggest descriptive research is used to describe something thus it is used to describe the characteristics of a population or phenomenon being studied. It is extensively used in behavioral sciences. Descriptive research can be either quantitative or qualitative.

There are three types of descriptive methods: 1- Survey methods 2-Observational methods 3- Case study methods.

Survey method is the most common which include personal interviews, questionnaire and phone survey. The purpose of descriptive research is simply to describe, explain or validate some hypothesis or objectives.

Exploratory sequential mixed method design was found to be most suitable for the research by the researcher. Exploratory sequential mixed method design is the reverse of explanatory sequential design. In the exploratory sequential research approach both qualitative as well as quantitative study is applied. The researcher first starts with qualitative study to explore participants view then analyzed data is used to conduct quantitative study.

Research approach/Research Flow Diagram

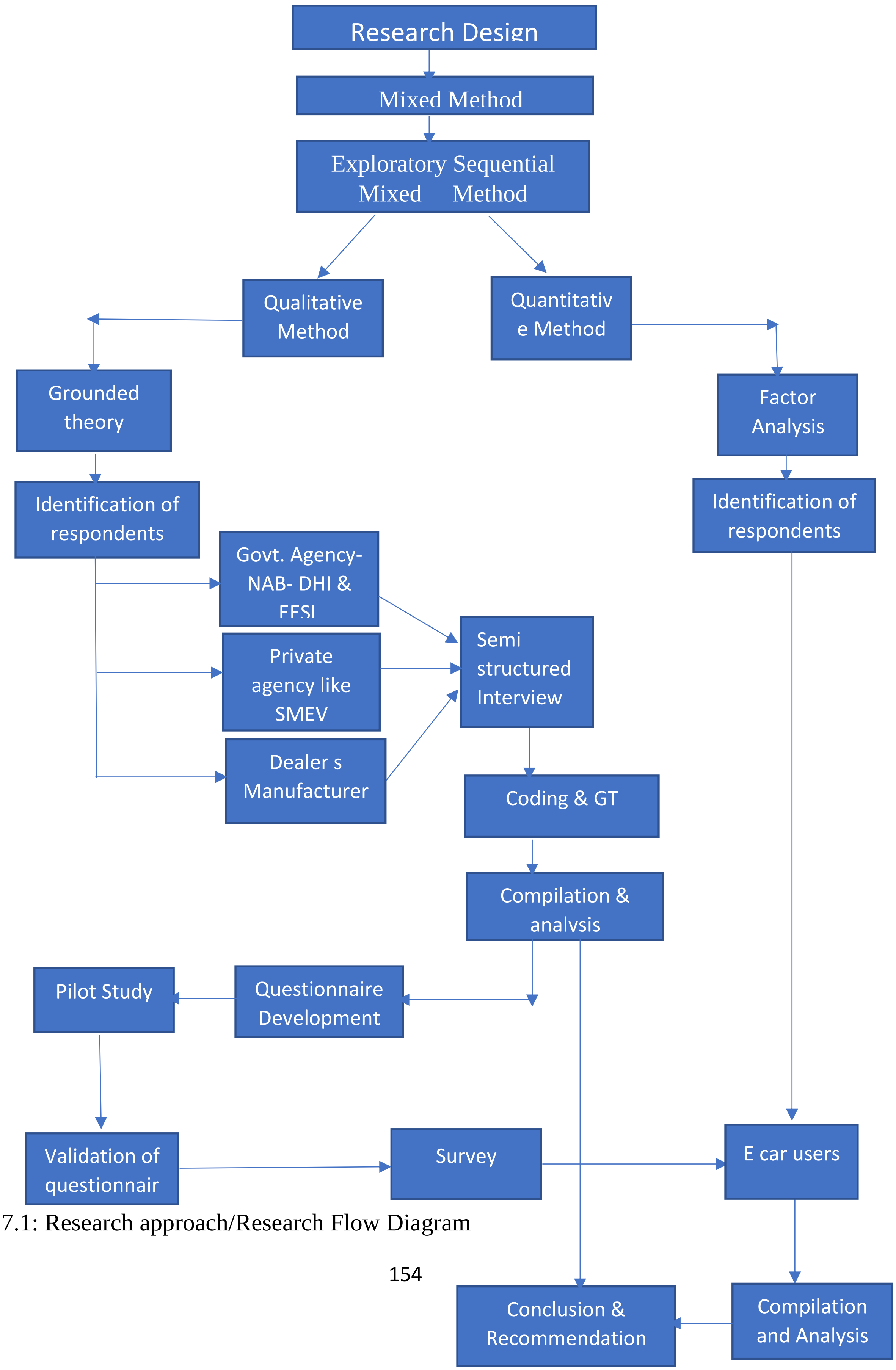

Figure 7.1: Research approach/Research Flow Diagram

<u>Research objectives:</u>

Objective 1: To find the enablers & barriers for the adoption of E Car by consumer (Users of E car) in Delhi?

Objective 2: To identify the measures for enhancing adoption of e cars.

Research Methodology

In this chapter research methodology is described for the study. The chapter focuses on the research objectives and an appropriate methodology to accomplish those objectives. The researcher outlines the research flow diagram/research plan/research design, research approach/methods/tools, the selection of respondents, selection of the sample size, sources of data, the methods of data collection, the research process and the tools of data analysis. There were two objective of this study number one was "to find enablers and barriers for the adoption of E car in Delhi" and number two was "to identify the measures for the adoption of e cars in Delhi." The research methodology used was mixed method i.e. qualitative and quantitative both in order to minimize errors in data collection and analysis. Exploratory sequential mixed method design was found to be most suitable for the research by the researcher. Exploratory sequential mixed method design is the reverse of explanatory sequential design. In the exploratory sequential research approach both qualitative as well as quantitative study is applied. The researcher first starts with qualitative study to explore participants view then analyzed data is used to conduct quantitative study.

The research methodology has to be vital owing to this, various methodologies namely survey & semi structured interview were chosen for data collection.

Within qualitative research methods coding methods and Grounded theory was used and within quantitative research methods factor analysis method was used.

The qualitative study used semi structured interview (questions based on parameters collected from literature review) method to collect the data from various stakeholders like govt. agency, Private agency, semi govt. agency, dealers, manufactures etc. and then coding methods and Grounded theory is used to accomplish the first objective as data is coded to identify emerging categories and then to generate substantive theory.

The quantitative study used questionnaire method for collecting the data from real consumers i.e. e car users. The questionnaire was prepared from the result obtained from objective 1. Necessary quantitative research methods were applied on the collected data from e car users for the quantitative analysis purpose.

The blueprint of Research methodology was to use qualitative methods -Coding and Grounded theory for the first objective and to use quantitative methods –Factor analysis for second objective. For the first objective, research carried out by interviewing various stakeholders of e car to identify the real opinion of the stakeholders about the subject and generated a theory using grounded theory method. Then based on the outcome of the first objective a questionnaire was developed to conduct a survey on the E cars users and to validate the outcome of the first objective against the real consumers i.e. e car users which in turn help to accomplish the second objective.

Respondents

To satisfy the objectives of research the correct identification of respondents was necessary. So, for the research respondents identified were of four categories

1-Government Agency

2-Private and semi govt. agency

3- Manufactures/ Dealers

4-Electric car users

Govt. Agency: Govt. of India is keen to introduce electric vehicles in India and has already running NEMMP. **National Electric** Mobility **Mission Plan** (NEMMP) **2020**. The main objective of the scheme is deal with national fuel security by encouraging BEVs and HEVs in nation. It was launched in year 2013 by UPA government.

FAME: FAME India is a part of **National Electric** Mobility **Mission Plan** (NEMMP) **2020**. FAME (Faster adoption and manufacturing of electric vehicles) has been launched under the Ministry of Heavy industry and public enterprises in 2015 to incentivize the production and promotion of electric vehicles. Main thrust of FAME is to promote BEVs with the help of subsidies.

In govt agency national Automotive Board under the department of heavy industry- FAME India was selected as respondents.

NAB: It is an independent society under the department of heavy industry, Ministry of heavy industry and public enterprises. The main objective of NAB is to steer, coordinate and synergize all efforts of the government in important ongoing and new initiatives for automotive sector specially in the area of electric mobility, intelligent transport system, automotive testing, collaborative R & D and for the implementation of recommendation of automotive mission plan 2006-2016.It works as the nerve center of organizational interaction between the govt., industry and academia under DHI is function as repository of automotive domain experts.

EESL:

EESL Energy efficiency services limited was selected as respondent. Electric vehicles are procured and organized by EESL in Government offices across the country. Organizations can also buy E vehicles from EESL.

EESL is a joint venture of four National Public Sector Enterprises – Power Finance Corporation, National Thermal Power Corporation Limited, POWERGRID and Rural Electrification Corporation. To ease execution of energy efficiency projects it was set up under Ministry of Power. EESL is a Super Energy Service Company.

Private Agency:

SMEV:

In private agency SMEV was selected as respondent.

SMEV is the registered association representing Indian manufacturers of electric vehicles (EV) and electric vehicle components. The main job of SMEV is to support the formulation of policies and processes supporting the EV ecosystem. SMEV works closely with the central and state governments. For the promotion of EV through the NEMMP-2020 and FAME policy in the country SMEV has contributed significantly. To enhance the diffusion of EVs an active role is played by SMEV in the discussion of the issues faced by the EV industry and practical aspects towards meeting the goals of our nation.

Manufacturers/Dealers:

Mahindra Electric mobility limited and its dealers in Delhi has been identified as respondents. It has three dealers in Delhi for e car.

Electric car users:

E car users fall in consumer category. All the electric car user in Delhi has been identified as respondents.

Sample selection:

As the researcher is using qualitative as well as quantitative research. The method of sample selection for qualitative study and for quantitative study has been done separately.

Qualitative sample selection:

Theoretical sampling method was used for the qualitative sampling. Theoretical sampling starts as the data collection progresses. The sample members have been selected in a way that they have a special relationship with subject under examination, appropriate & adequate work experience in the field and active involvement and understating of e car industry.

Sample Size: The justification of the sample size of multiple stake holders is use of Theoretical sampling. It is an integral part of the grounded theory approach as it leads the researcher what to collect next. Researcher identifies a small handful of people to interview based on a set of criteria (much like in purposeful sampling). Then, researcher interview those people. Following these initial interviews, the researcher will analyze these data and based on the results, the researcher will identify more people to interview. The researcher will conduct interviews with those newly selected participants and then analyze the data. Theoretical sampling continues like this, moving back and forth between sampling, data collection, and analysis, until the researcher reaches data saturation, or the point at which the researcher fails to collect new information with subsequent interviews. Which define the sample size? The bureaucrats of Govt. Agency, Semi govt. agency, private agency, manufactures, and dealerships were interviewed.

1-Govt. Agency - NAB (Director – National Automotive Board)

2-Semi Govt. Agency- EESL- (Consultant -Energy efficiency services limited)

3-Private Agency -SMEV- (Manager- Society of manufacturer of electric vehicles)

4-Manufacturer- (Regional manager-Mahindra electric limited)

5-Dealer1- (Team Leader & Senior sales consultant)

6-Dealer2- (Team leader & Experience Executive)

7-Dealer 3- (Corporate manager & Experience executive)

Quantitative sample selection

The target population for the research is total number of e car sold in Delhi since the inception of e car till 11th July 2018.

Sample Size:

The portion of the population that is studied is called sample. For some study population may small enough to include all of them in the study. But for some study population may be large enough and cannot be studied as a whole so sample is taken. Calculation of sample size from a population for a study has been shown in many books e.g. and Singh and Chaudhury (1985), Cochran (1977) and Mark (2005). An adequate sample size is required which can represent the whole population and results can be estimated with precision. With the help of sample, inferences are drawn about the population which can be generalized. So, sample should be representative of population or in other words sample should confirm the certain criteria. A question may be asked that what is a representative sample and how one can select such a sample from population. In statistical study the calculation of adequate sample size is very important steps in statistical study. The sample size should be appropriate because if the sample size is not appropriate for a study then the inference drawn from the sample will not be reliable and it might lead to some wrong conclusions. In this case the researcher uses Yamane formula technique to calculate the sample size.

Many methods are used for calculating the sample size. The elementary factors for the calculation of suitable sample size the confidence level desired, level of precision required by users and degree of variability.

1-Level of Precision:

The level of precision is also called sampling error or margin of error. Sampling error is defined as the difference between the population parameter and sample statistics. In other words, it can be understood as risk that the researcher agrees to take while using the data to make decision. Degree of precision is termed as the margin of permissible error between the population value and the estimated value. Suppose 80 % unit in the sample attribute some criteria and if the margin of error or sampling error is ±10%, then 70% to 90% of units in the population have attributed that criteria. Bigger sample sizes are required to achieve high level of precision and thus high cost to obtain bigger sample.

2) Confidence level desired:

The confidence level tells that out of N sample how many of them will be within the precision limit set by investigator. Thus, it tells the confidence of the investigator for the error acceptance as per the planned precision. Two known degrees of confidence are 95% and 99% of probability. 95% confidence level means if an investigator takes 100 independent samples from the same population, then 95 out of the 100 samples will provide an estimate within the precision set by him. Again, if the level of confidence is 99%, then it means out of 100 samples 99 cases will be within the error of tolerances specified by the precision.

3) Degree of variability:

The extent of variability in the characteristics refers to the spreading of characteristics in the population. To obtain a given level of precision the large sample size is required if the population is more heterogeneous. Smaller sample sizes work nicely for less variable (more homogeneous) population. Note that a proportion of 20% or 80%. Indicate lesser level of variability as compare to 50% which indicates a greater level of variability. This is because 20% and 80% indicate that a large majority do not or do, respectively.

Source:(Determination of appropriate Sample Size, Hemanta Kr. Sarmah, B Bora Hazarika chapter 2)

There are different methods available for the determination of appropriate sample sizes like Cochran and Yamane. The researcher should select the formula as per his needs and convenience. Among available formulas researcher has selected **Yamane formula**. While selecting the Yamane formula various factors like time limit, nature of the study, budget, desired level of precision, confidence level and variability within the population researcher has been taken into consideration by the researcher. The Yamane formula is extensively used in research. It is best suitable if researcher is working with a finite population and if the population size is known,

This sample size is based on the Yamane formula. (Note: The population size is total number of e car sold in Delhi in the last five years.)

An alternative to Cochran's formula has been suggested by Yamane (1967) for calculation of sample size from a population. As per him, at 95% confidence level and p = 0.5, size of the sample should be

$$n = \frac{N}{1 + N(e)^2}$$

where, N is the population size and e are the level of precision or margin of error.

N= 676 E cars sold in Delhi till 11th July 2018

N=Sample size

e= error of 5 % point = .05

N: E cars sold in Delhi till 11th July 2018	n (Sample Size)	e: Sampling error
676	251	0.05

Table 7.1: Sampling size table

Total number of e cars sold in Delhi till 11th July 2018 has been taken as a universe and same has been consider as population. Total number of e car users (Consumers) are assumed to be equal to total number of e cars sold in Delhi.

Research Tools

As the research methodology used is mixed one i.e. qualitative as well as quantitative so keeping this in mind the research tools have been selected separately for qualitative and quantitative study

Researcher would be using two research tools and these are

1- Questionnaire for quantitative study
2- Semi structured Interview for qualitative study

For qualitative research researcher has decided to use semi structure interview because in this type of interview both interviewer and respondents engage in a formal interview. In semi structured interview, some questions are preplanned and ask to all respondents, while other arises naturally in during discussion that help in gathering more appropriate and enough data. Thus, it helps in collecting the information of predetermine questions as well as information from spontaneously arise questions from all the respondents.

For quantitative research researcher has decided to use questionnaire because it is mainly used to obtain information from samples as it is consist of formalized set of questions .As researcher has already collected the information from literature review and qualitative study thus a formalized instrument was requiring to collect the information and questionnaire was best fit for that.

Questionnaire:

A questionnaire is also called an interview form, schedule or measuring instruments. Questionnaire is formed with a set of questions to get information from respondents. The predetermined questions are arranged in formal way in the questionnaire to obtain information from respondents. Questionnaire are of two types qualitative as well as quantitative . Questionnaire was invented by the Statistical Society of London in 1838. *(Naresh K. Malhotra)*.

Type of questionnaire

Questionnaires can be either structured or free flow.

Structured questionnaire: Structured questionnaires collect quantitative data. A structured technique for data collection that consist of a series of questions, written or verbal, that a respondent answer. *(Naresh K. Malhotra)*.

Unstructured questionnaire:

Unstructured questionnaires collect qualitative data. In these questionnaires the questions are open ended. The benefits of open-ended questions are that respondent reply in his own words. It is also called as free response or free answer questions.

Unstructured questionnaires are very useful in exploratory research as they have a less biasing effect on response as compare to structured questions as respondents feel free to provide any views. Thus, researcher may get rich insight by respondents' comments and explanations.

High Interviewer bias is the main disadvantage. For exact reporting one should use tape recorder. coding of responses is another disadvantage as it is very time consuming and costly. Some of the disadvantage of unstructured question can be controlled by precoding . *(Naresh K. Malhotra)*

Types of Questions in a Questionnaire

There could be multiple question types in a questionnaire. Some of the widely used types of questions are:

- **Open-Ended Questions:** Open-ended questions help collect qualitative data in a questionnaire where the respondent can answer in a free form with little to no restrictions.

- **Dichotomous Questions:** The dichotomous question is generally a "yes/no" close-ended question. This question is generally used in case of the need of basic validation. It is the easiest form of a questionnaire.

- **Multiple-Choice Questions:** Multiple-choice questions are a close-ended question type in which a respondent has to select one (single select multiple choice question) or many (multiselect multiple choice question) responses from a given list of options. The multiple-choice question is consisted of an incomplete stem (question), right answer or answers, incorrect answers, close alternatives and distractors. Not all questions would have all of the above and these guidelines can be used as deemed fit or that best matches the expected outcome of the question.

- **Scaling Questions:** Another question type that is widely used in a questionnaire are scaling questions. These questions are based on the principles of the 4 measurement scales – nominal, ordinal, interval and ratio. Some question types that utilize the fundamental properties of these scales are rank order questions, Likert scale questions, semantic differential scale questions and staple scale questions.

- **Pictorial Questions:** This question type is the 2nd easiest type of a questionnaire question. Respondents are given the option from certain images limiting their response to the options in the question but increasing the number of responses

Source: www.questionpro.com

<u>Types of Questionnaires based on Distribution</u>

Questionnaires can be administered or distributed in the following forms:

- **Computer Questionnaire:** In this type, respondents are sent the questionnaire via email or other online mediums and the respondent is required to complete this questionnaire. The advantages of this method are that is cost-effective and time efficient. Respondents can also answer at free time and since they are not pressured, responses could be even more accurate. The disadvantage, however is that respondents can easily ignore these questionnaires.

- **Telephone Questionnaire:** In this questionnaire type, a researcher makes a phone call to a respondent to collect responses. The advantages of this method are that responses are quick once the respondent is on call and willing to speak. But the disadvantage is that a lot of times the respondents are hesitant to give out much information over the phone. It is also an expensive way of conducting a questionnaire.

- **In-House Questionnaire:** This type of questionnaire is conducted by a researcher that visits the home or workplace of the respondent. The advantage of this type of questionnaire is that the respondent is in a comfortable and natural environment and in-depth data can be collected. The disadvantage though is that it is expensive

- **Mail Questionnaire:** Mail questionnaires are now turning obsolete but are still being used in some market research studies. This method involves a researcher sending a physical questionnaire request to a respondent that can be filled in and sent back. The advantage of this methods is that respondents can complete this at leisure and hence answer truthfully and entirely. The disadvantage though is that this method is expensive and time consuming. There is also a high risk of the not being able to collect enough number of responses.

Source: www.questionpro.com , *(Naresh K. Malhotra)*

<u>Interview Techniques: Semi structured Interview:</u>

Semi structured interview is a type of interview technique. There are three type of interview techniques.

1-Structured Interview

2-Unstructured Interview

3-Semi Structured Interview

Before explaining the semi structured interview let us first understand the structured and unstructured interview.

<u>Structured Interview</u>

A ***structured interview*** is a type of interview in which interviewer asks a particular set of predetermined questions. In structured interview questions are planned and created in advance which means all respondents were asked the same questions in the same order.

It is also known as standardized interviews, Patterned interview, Planned interviews or formal interviews.

<u>Unstructured Interview</u>

An **un**-***structured interview*** is a type of interview in which interviewer asks questions which are not planned in advance.

In an unstructured interview questions arises spontaneously in a free-flowing conversation, which means different respondents are asked different questions. It is also called informal interview, free flowing interview or casual interview.

<u>Semi-structured interview</u>

A ***semi-structured interview*** is a type of interview in which interviewer asks only a few predetermined questions while the rest of the questions are not planned in advance. In semi structured interview, some questions are predetermined and ask to all candidates, while other arises spontaneously in a free-flowing conversation. It is also known as combined interview, hybrid interview and moderately interview.

Source: www.talentlyft.com, *(Naresh K. Malhotra)*

Characteristics of Semi-structured interviews

- The interviewer and respondents engage in a formal interview.
- The interviewer develops and uses an 'interview guide.' This is a list of questions and topics that need to be covered during the conversation, usually in a particular order.

- The interviewer follows the guide, but is able to follow contemporary trajectories in the conversation that may lost from the guide when he or she feels this is appropriate.

Recording Semi-Structured interviews

Typically, the interviewer has a paper-based interview guide that he or she follows. Since semi-structured interviews often contain open-ended questions and discussions may diverge from the interview guide, it is generally best to tape-record interviews and later transcript these tapes for analysis.

While it is possible to try to jot notes to capture respondents' answers, it is difficult to focus on conducting an interview and jotting notes. This approach will result in poor notes and also diminish for the development of rapport between interviewer and interviewee. Development of rapport and dialogue is essential in unstructured interviews.

Benefits

Many researchers like to use semi-structured interviews because questions can be prepared ahead of time. This allows the interviewer to be prepared and appear competent during the interview. Semi-structured interviews also allow informants the freedom to express their views in their own terms. Semi-structure interviews can provide reliable, comparable qualitative data. If tape-recording an interview is out of the question, consider having a note-taker present during the interview. (Source: http://www.qualres.org/HomeSemi-3629) *(Naresh K. Malhotra)*

<u>Measurement & Scaling:</u>

In research the measurement means actually measuring the characteristics of objects like attitude, perception, preferences etc. and according to certain agreed rule assigning numbers or other symbols to them. Note that we measure the characteristics of object not the object. Thus, we measure only the consumer’s perceptions, attitude, preference or other relevant characteristics. Not the consumers. One of the important aspects of measurement is the description of rules for assigning numbers to the characteristics.

Scaling is considered as an extension of measurement. Scaling involve creating a continuum (a continuous sequence in which adjacent elements are not noticeably different from each other, but the extreme is quite distinct) upon which measured objects are located.

Note: Operations applied to various variables from the questionnaire in SPSS depends on scale assigned variables. Assigning a proper scale to variable is important because that determine mathematical operations need to applied to the variable. Assigning a scale of measurement depends on the numerical properties of variables.

Primary scale of measurement:

There are four primary scale of measurement:

1-Nominal

2-Ordinal

3-Interval

4-Ratio

Nominal:

In nominal scale numbers are used only as labels for identifying or classifying objects thus also termed as labeling scheme. Applied to objects that can be separated into categories without having any order. The numbers used as a level only in nominal scale they do not denotes the characteristics of the objects.

Ordinal:

When responses have an order but the distance between the responses is not necessary the same for example rank in cycle race. Therefore, focus is on gross order not on relative positional distance. Thus, ordinal scale is a ranking scale with which one can determine that whether an object has more or less of a characteristic then some other object but not how much more or less.

Interval Scale:

Here distance between the responses is same for example Celsius temperature because difference between each value is same i.e. difference between 40 degree and 50 degree is 10 degrees is same as the difference between 60 degree and 70 degree. All the information of an ordinal scale is contained by Interval scale and it also permits to compare the difference between objects. The problem with interval scale is they don't have a true zero. For example, there is no such thing as no temperature. In the case of interval scale, zero doesn't mean absence of value, (there is no such thing no temperature) but is actually another number used on scale, like 0 degree Celsius. Without a true zero it is difficult to compute ratio. With interval data we can add, subtract but cannot multiply and divide. Ex. 10 degree C + 10 degree C = 20 degree C but 20 degree C is not twice as hot as 10 degree as there is no such thing as no temperature in Celsius scale.

A normal survey rating scale in which it is asked to rate satisfaction level with a training programme on a scale of point 5 from strongly agree, agree, neutral, disagree to strongly disagree and the magnitude between them is same is an interval scale.

Ratio Scale:

The highest scale. All the properties of the nominal, ordinal and interval scales are contained in ratio scale and in addition it also enjoys an absolute zero point. Ratio scale tell us about the order, they tell us exact value between units and they also have an absolute zero. Ratio scale have a clear definition of zero.

Scaling Techniques:

1-Comparative scale

2-Non-comparative scale

Comparative scale:

Direct comparison of stimulus objects is done using this scale. For example, respondents may be asked whether they prefer Pepsi or Coke. The foremost advantage of this scaling is that small differences between stimulus items can be noticed. As they compare the stimulus objects respondents are forced to choose between them. The major disadvantage of this technique is its inability to generalize beyond the stimulus objects scaled. For instance, RC Cola to Coke and Pepsi, the researcher would have to do a new study. Comparative scale includes paired comparison, rank order, constant sum scale, Q sort and other procedures.

Non-Comparative scales:

In this type of scale each item is scaled individualistically of the others in the stimulus set. Only one object is evaluated by them at a time. Like, respondents are required to evaluate Pepsi on a 1-5 preference scale. Same evaluation would be obtained for Coke and RC Cola. Continuous and itemized rating scale are the techniques of Non-comparative scales.

Likert Scale:

Renis Likert developed this scale. It is extensively used rating scale. Respondents are required to display a degree of disagreement or agreement with individually statements about the object. Individually scale item has five respondents' classes, ranging from "strongly agree" to "strongly disagree". It has numerous benefits like easy to construct and administer. The scale is easily understood by respondents which make it suitable for telephone, mail, or personal interviews. (Naresh.k. Malhotra)

INSTRUMENTATION

Instrumentation refers to the research tools or means by which investigators attempt to measure variables or items of interest in the data-collection process. Thus, the instrument is the device used by investigators for collecting data. They include questionnaire, Interview and observations. Instrument should be valid and reliable.

Semi structure Interview for qualitative study and survey methods for quantitative study were extensively used for effective and faultless data collection. Survey method is the most widely used technique for data collection, and provide important information for behavioral science, while interviews are an appropriate method to use due to the qualitative nature of the information. Thus, these two methods are used to get the relevant information which in turn help in better analysis of data.

In order to efficiently use semi structure interview, researcher designed a semi structured interview, few questions were prepared based on literature review while rest of the questions were not planned in advance as they arise during the conversation with respondent. The manufacturer, dealers, SMEV, NAB and EESL were interviewed.

In order to efficiently use the survey method researcher designed a questionnaire. Questionnaire was developed on the basis of the outcome of the first objective. The questionnaire was designed to rate the various parameters responsible for the adoption of e car in Delhi.

The questionnaire has two parts.

In part 1 the respondents (e car users) were asked to rate the influential parameters while purchasing a car. There are a number of influential parameters while purchasing a car thus researcher has tried to include all parameters that a customer may consider while purchasing a car.

In part 2 respondents (e car users) were asked to rate the same parameters with respect to their e car.

Basically, the two parts are based on the notion that what parameters are important for a customer look while purchases a car and where those parameters stand in case of e car.

The questionnaire part 1 was structured in the Likert style, on a 5 – point scale, ranging from “Highly Influential” (HI), through “Influential” (I), “Neutral” (N), Non-Influential” (NI) to Highly Non-Influential (HNI). Respondents were then instructed to reply to their degree of agreement with the questions contained in the Questionnaire.

The questionnaire part 2 was also structured in the Likert style, on a 5 – point scale, ranging “Highly Satisfactory” (HS), through “Satisfactory” (S), “Neutral” (N), Non-Satisfactory” (NS) to Highly Non-Satisfactory (HNS). Respondents were then instructed to reply to their degree of agreement with the questions contained in the Questionnaire.

<u>Scale Evaluation:</u>

A multi item scale should be assessed for accuracy and applicability. This involve an assessment of validity, reliability and generalizability of the scale. Before understanding validity and reliability we should know the accuracy as it is basic to scale evaluation.

<u>Measurement Error</u>

A measurement is an observation of characteristics of interest not the true value of it. Measurement error is caused by a variety of factors, which results in the true score being different from measurement or observed score of the characteristic being measured. The true score model offers a basis to understand the accuracy of measurement. According to this model

Xo= Xt+Xs+Xr

Xo= the observed score of measurement

Xt=true score of characteristics

Xs=Systematic error

Xr=Random error

Thus, total measurement error includes systematic error Xs and random error Xr.

Systematic error disturbs the measurement in a constant way. It denotes the stable factors that affects the observed score in same way whenever the measurement is made.

Random error is not constant. It disturbs the measurement in different way. It denotes transient factors that disturb the observed score in dissimilar way each time the measurement is made such as situational factors. The difference between systematic error and random error was necessary to understand the validity and reliability. (Naresh.k. Malhotra)

Reliability:

The extent to which a scale produces steady results if recurring measurements are made on the characteristics. If a study and its results are reliable, it means that the same results would be obtained if the study were to be replicated by other researchers using the same method.

Systematic source of errors affects the measurement in a constant way and do not lead to inconsistency and thus do not have an adverse impact on reliability. In contrast, random error produces inconsistency, leading to lower reliability. Thus, reliability can be defined as the degree to which measures are free from random error, Xr. If Xr=0 the measure is perfectly reliable. (Naresh.k. Malhotra)

Validity:

"Validity refers to the degree to which an instrument measures what it is supposed to be measuring". Perfect validity requires that there are no measurement errors (Xo=Tx, Xr=0, Xs=0)

Relationship between Reliability and validity:

It can be understood in terms of true score model. If a measure is perfectly valid it is also perfectly reliable. In this Xo=Xt and Xr=0, Xs=0). Thus, perfect valid implies perfect reliable.

If a measure is unreliable, it cannot be perfectly valid, because at a minimum Xo=Xt+Xr (Xs may also be present i.e. Xs is not equal to zero). Thus, unreliability implies invalidity.

If a measure is perfectly reliable, it may or may not be perfectly valid because systematic error may also be present (Xo=Xt+Xs). Although lack of reliability constitutes negative evidence for validity, reliability does not in itself imply validity.

Reliability is a necessary, but not sufficient condition for validity.

Cronbach's Alpha:

Cronbach's alpha is a convenient test use to estimate the reliability, or internal consistency of a composite score. Cronbach's alpha gives the simple way to measure whether or not a score is reliable. Theoretically Cronbach's alpha results should give you a number from 0 to 1, but you can get negative number as well. A negative number indicates that something is wrong with your data. The general rule of thumb is that a Cronbach alpha test of .70 and above is good,.80 and above is better, and .90 and above is best. (Naresh. k. Malhotra)

PILOT STUDY

The pilot study formed the platform for the quantitative research. It was conducted on 20 E car users of Delhi in the month of June 2018 for questionnaire part 1 and part 2. They were asked to rate the various parameter while purchasing a car and where their e car stands with respect to same parameters. Based on the findings of this pilot study, the survey instrument was designed.

To test the Reliability of the instrument, Reliability test was done to check for the reliability and usability of the instrument. Cronbach alpha test was conducted. Cronbach alpha was calculated to measure the internal consistency or reliability of the instrument. If the value of Cronbach's alpha is greater than 0.7 then the instrument is considered reliable.

<u>Cronbach's Alpha test for Questionnaire part 1:</u>

<u>Tests of Reliability of the Questionnaire1</u>

Case Processing Summary

		N	%
Cases	Valid	13	65.0
	Excluded	7	35.0
	Total	20	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.973	51

Table 7.2: Tests of Reliability of the Questionnaire part1 Cronbach's alpha test

<u>Cronbach's Alpha test for Questionnaire part 2:</u>

<u>Tests of Reliability of the Questionnaire 2</u>

Case Processing Summary

		N	%
Cases	Valid	17	81.0
	Excluded[a]	4	19.0
	Total	21	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	N of Items
.969	45

Table 7.3: Tests of Reliability of the Questionnaire1 Cronbach's alpha test

The value of Cronbach alpha came as .973 for Part 1 and .969 for Part 2; thus, the instrument was considered the best reliable for the study.

Validity test:

Validity simply means that a test or instrument is accurately measuring what it's supposed to measure. There are two types of validity.

1-Construct validity -Content related validity

a-Face validity

b-Content validity

3-Construct validity -Criterion related validity

a- Predictive
b- Concurrent
c- Convergent
d- Discriminant

Researchers has covered construct validity -content related validity i.e. face validity and content validity as a part of quality of research however the Construct validity -Criteria related validity i.e. Predictive validity & Concurrent validity does not require by the research and the justification of the same are as follows.

Predictive validity is concerned with the predictive capacity of a test. It indicates the effectiveness of a test in forecasting or predicting future outcomes in a specific area. As research is not intended to do any type of prediction thus predictive validly is not required.

The term 'concurrent validity' is used to indicate the process of validating a new test by correlating its scores with some existing or available source of information (criterion) which might have been obtained shortly before or shortly after the new test is given. As the research is new and unique and no other similar kind of test is available thus concurrent validity is also not required.

Face Validity:

If a test measures what the test author desires to measure, we say that the test has face validity. Thus, face validity refers not to what the test measures, but what the test 'appears to measure Face validity is one of the most basic form of validity estimated which involves seeking the opinion of some respondents, whether the instrument looks complete and valid. Face validity requires a personal judgment, such as asking participants whether they thought that a test was well constructed and useful. Most researcher do not consider face validity an adequate measure of proof of the validity of the instrument, even though face validity is easier to complete as a test. and it can be used as a first step in validating the test. This questionnaire was given to the respondents of E car industry and their confirmation of their understanding of questionnaire help in establishing the face validity of the instrument. Moreover, this method helps a test maker to revise the test items to suit to the purpose

<u>Content Validity</u>:

While there are several types of validity, the most important type for most certification and licensure programs is probably that of content validity. It is also called as Rational Validity or Logical Validity or Curricular Validity or Internal Validity or Intrinsic Valid. Content validity refers to the degree or extent to which a test consists items representing the behaviors that the test maker wants to measure. The extent to which the items of a test are true representative of the whole content. Content validity is also a subjective measure but a much-improved measure when compared to face validity. In content validity, who has knowledge of the subject is given the instrument to seek their opinion on whether the instruments measures everything it needs to measure and whether everything that it is not intended to measure is excluded from the questionnaire. Content validity is related to face validity, but differs wildly in how it is evaluated. Face validity requires a personal judgment, such as asking participants whether they thought that a test was well constructed and useful. Content validity arrives at the same answers, but uses an approach based in statistics, ensuring that it is regarded as a strong type of validity. For surveys and tests, each question is given to a panel of expert analysts, and they rate it. They give their opinion about whether the question is essential, useful or irrelevant to measuring the construct under study. Their results are statistically analyzed and the test modified to improve the rational validity.

In this thesis 20 stakeholders administrated the questionnaire in pilot stage to seek their inputs on the clarity and completeness of the instrument. Their positive validation of questionnaire proved the validity of the instrument used in the research.

Predictive validity: Predictive Validity the extent to which test predicts the future performance of a subject. Predictive validity is concerned with the predictive capacity of a test. It indicates the effectiveness of a test in forecasting or predicting future outcomes in a specific area.

Concurrent Validity:

Concurrent validity refers to the extent to which the test scores matches to already established or accepted performance, known as criterion. To know the validity of a newly constructed test, it is correlated or compared with some available information. Thus, a test is validated against some concurrently available information. The scores obtained from a newly constructed test are correlated with pre-established test performance.

The dictionary meaning of the term 'concurrent' is 'existing' or 'done at the same time'. Thus, the term 'concurrent validity' is used to indicate the process of validating a new test by correlating its scores with some existing or available source of information (criterion) which might have been obtained shortly before or shortly after the new test is given.

Convergent & Divergent Validity:

Convergent Validity is a sub-type of construct validity. Construct validity means that a test designed to measure a particular construct (i.e. intelligence) is actually measuring that construct. Convergent validity takes two measures that are supposed to be measuring the same construct and shows that they are related. Conversely, discriminant validity shows that two measures that are not supposed to be related are in fact, unrelated. Both types of validity are a requirement for excellent construct validity.

The important thing to recognize is that they work together. But neither one is only sufficient to establish construct validity.

Convergent validity tests that constructs that are expected to be related are, in fact, related. Divergent validity (or divergent validity) tests that constructs that should have no relationship do, in fact, not have any relationship.

Let’s say you were researching depression in college students. In order to measure depression (the construct), you use two measurements: a survey and participant observation. If the scores from your two measurements are close enough (i.e. they converge), this demonstrates that they are measuring the same construct. If they don’t converge, this could indicate they are measuring different constructs (for example, anger and depression or self-worth and depression. Source:https://www.statisticshowto.datasciencecentral.com/convergent-validity/

Convergent validity is usually accomplished by demonstrating a correlation between the two measures, although it’s rare that any two measures will be perfectly convergent. In the case of discriminant validity, you could show that there is no correlation at all.

Research Methodology for Objective 1:

Objective 1: To find the enablers & barriers for the adoption of E Car by consumer in Delhi?

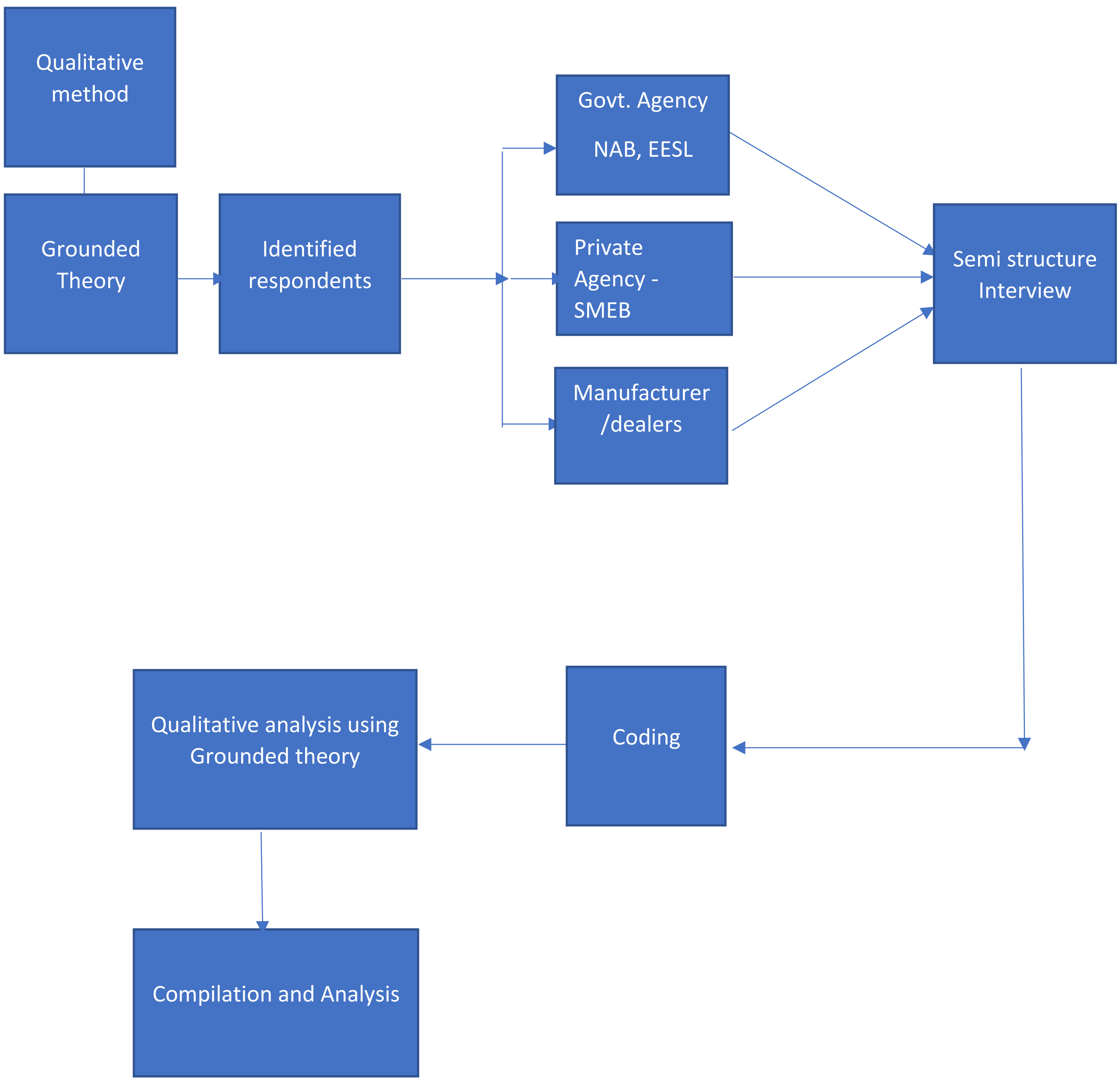

Figure 7.2: Research Methodology for Objective 1

<u>Following Variables have been identified from the literature review</u>

Barriers	Enablers
1- Technical	1-Motivation
a- Range Constraint	a-Positive Environmental Impact
b- Cost of Car	
c- Battery Cost	b-Scarcity of crude oil
d- Charging Infrastructure	c-Increased crude oil prices
e- Recharge time	d-Very low running cost
f- Recharge locations	e-Very Low Maintenance
g- Fast charging	d-Driving satisfaction
h- Top Speed	
I-Carrying Capacity	
j- Vehicle Power	
2- Psychological	2-Technical
a- Consumer range anxiety	
b- Consumer Anxiety	a-Latest Technology
c-Awareness	b-Performance
d- Image status	c-Reliability
e- Lack of knowledge	d-Brand
f- Recharge Convenience	e-Govt policy & regulation
g-resale	f-Design
	g-Vehicle Power
3- Financial	h-Pick up
a- Cost of Car	i-Automatic Transmission
b- Subsidy & Incentives	
c- Tariff for charging	
d- Tax	
e- Costly Replacement part	

4- Regulatory a- Govt policy b- Limited Choice c- Lack of manufacturer	

Some Parameters applicable to foreign country only identified from literature review. 1- No Toll road Charge 2- Free parking 3- Registration Free 4- Driving privilege for licenses 5- Access to Bus Taxi lane 6- Bonus for scraping an old car 7- EV supply equipment financing 8- Free charging 9- Emission testing exemption 10-Public charger availability 11-Insurance discount

Table 7.4: Following Variables have been identified from the literature review

Research Methodology for Objective 2:

Objective 2: To identify the measures for enhancing adoption of e cars.

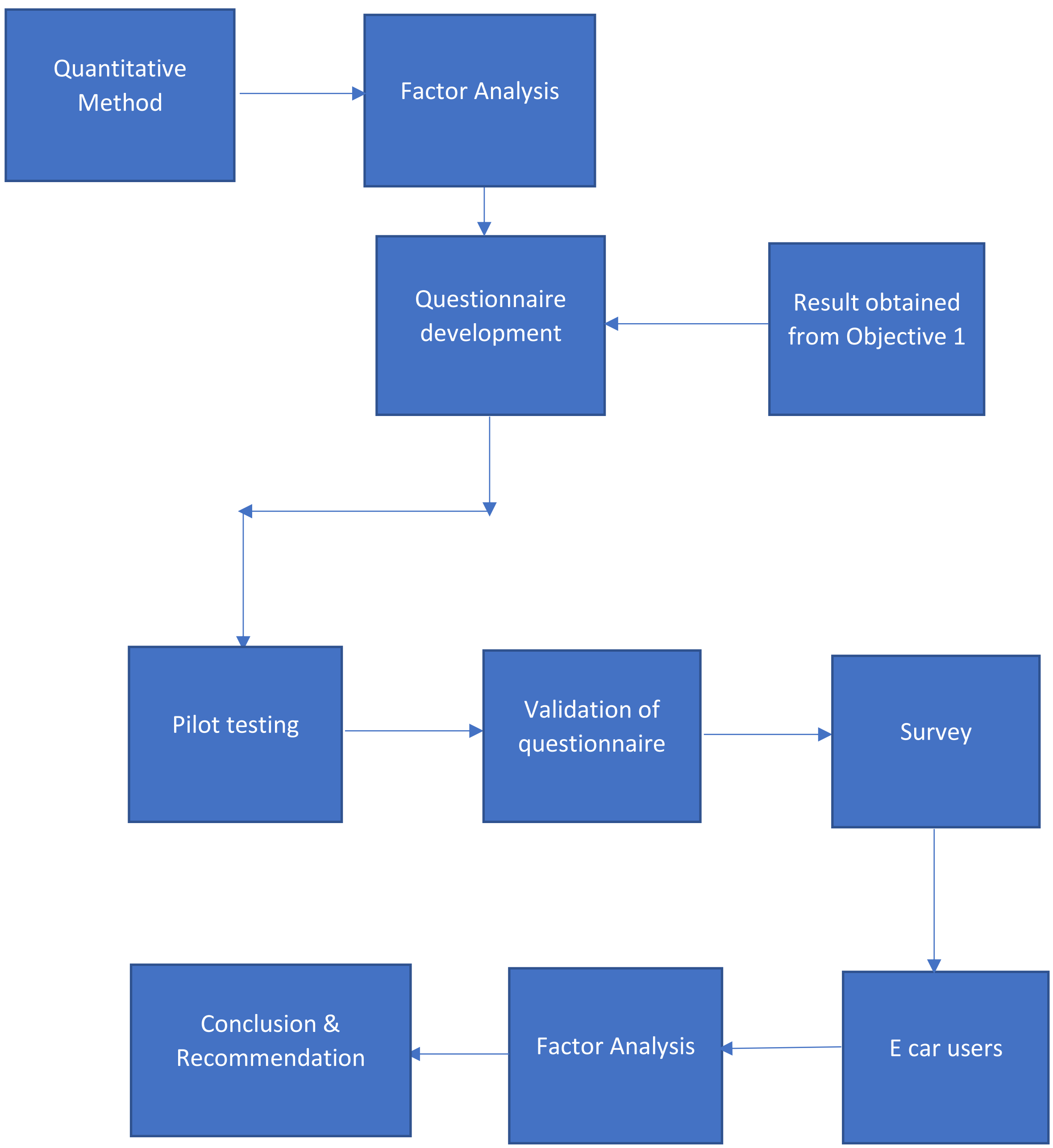

Figure 7.3: Research Methodology for Objective 2

Sources of Data

Data is immensely necessary to conduct the research. Data is the fact and figures from which conclusion can be drawn. There has been a proper process of gathering the data. Gathering data can be completed through a primary source (researcher is the first person to obtain the data) or a secondary source (the researcher obtains the data that has already been collected by other sources. (Mesly, 2015).

There are two kinds of methods in research to gather the data Primary method and Secondary method. (Douglas, 2015). Primary data is one which is collected for the first time by the researcher while secondary data is the data already existing data collected or produced by individuals, investigator agencies or organizations. Primary data is real time data while secondary data is relating to the past.

Primary data sources include surveys, observations, questionnaires, personal interview, experiments etc. Secondary data collection sources are websites, journals, publications, reports, books, internal records etc.

In our case, both primary data as well as secondary data has been collected.

Primary data sources for objective 1 was personal interview of various stake holders such as National Automotive Board- Ministry of Heavy Industry & public enterprises, Society of manufacturer of Electric Vehicles, Energy efficiency services limited, Manufacturer and Dealers.

Primary data sources for objective 2 was survey & questionnaires & filled by e car Consumers.

Secondary Data: Secondary data has been used from various sources like government and industry reports, Journals articles, websites, books etc.

Ethical Consideration of data & Research:

Ethical consideration is one of the most important part of research. So, all precautions have been taken while conducting the research so that participants should not be exposed to ill-treatment by any mean. Respect for the dignity of the research participants has been prioritized. Prior consent has been obtained from participants. They have been informed about the voluntary participants. If some participants do not want to disclose their identity in that case their identity has been kept confidential.

Data Collection

Data collection has been done for qualitative study for objective 1 as well as for quantitative study for objective 2.

For qualitative study for data collection various related organizations of India -Delhi such as such as National Automotive Board- Ministry of Heavy Industry & public enterprises, Society of manufacturer of Electric Vehicles, Energy efficiency services limited, Manufacturer and Dealers and their officials through purposive sampling were selected for semi structure interview. The invitation letters have been sent to bureaucrats via e mail and they have been also contacted via phone for the personal interview. The bureaucrats have been approached after or during office hours and was informed regarding the nature and rationale of the research. First reminder was sent after 07 days of the first email followed by second reminder with the gap of 15 days meanwhile contact on phone was made with a gap of 03 days. The appointment for the interview has been booked via e mail and telephone. Some of the organizations & bureaucrats were very helpful for granting the appointment for the interview while for others emails and telephone was extensively used to make them understand the purpose of the research and assure them that the data so provided will be used only for academic research to take the appointment for interview. The privacy and secrecy of the data and results were guaranteed. In-depth, open ended, semi structure interviews and face to face interview were planned by the researcher for conducting a grounded theory approach for objective 1. Because the researcher has better chance to get the respondents opinions, views and experiences in detail in these types of interviews.

A deeply observation of the participant for any non-verbal communication is possible in face-to-face interview and it also allows to clarify the ambiguities and necessary points to both the interviewer and the interviewee (participant). No specific time duration was mentioned by researcher but can last for 30-to 45 minutes however, this time was only a guess for the interview meetings; the participant's responses defines the actual interview time and duration and it can extend and prolong the interviews sessions. To determine an accurate account of the interview the interviews were audio-taped with due permission of the participant which can be replayed for investigative purposes. Almost all the bureaucrats were interviewed face to face except two who were interviewed via telephone. Regional managers, Managers, Directors, Consultants and Team leader of some of the organizations were interviewed.

For quantitative study, questionnaires were used to obtain data relevant to the study's objective 2. The purpose of study was to identify measures for enhancing the adoption of e car in Delhi. The researcher has approached the e car user in Delhi to participate in the study. Every e car user who has been approached to participate received a letter with information about the study and a questionnaire After completion of pilot study and all necessary modifications the questionnaire were directly administrated to chosen sample for the study. Survey questionnaire was administrated in three modes. 1- Electronic media -Google doc 2- Telephone Interview 3- Personal Interview

A total of 563 questionnaires were sent to e car users in Delhi via electronic media with a request to get these filled. First reminder was sent after 02 days of the first message followed by second reminder with the gap of 04 days meanwhile, they were also contacted on phone on daily basis. Some of the e car users were very helpful for filling the questionnaire while for others repeated reminder messages and telephone was extensively used to make them ready to fill the questionnaire and to make them understand the purpose of the research and assure them that the data so provided will be used only for academic research to fill the questionnaires.

Only 194 (34.4%) filled in questionnaires were received after so many requesting repeated electronic reminder and requesting phone calls out of which only 182(32.32%) were found to be fully filled in, the rest 12 were discarded due to major incomplete information. To complete the sample size the remaining 69 respondents were approached on phone and personally to filled the questionnaire. Researcher was successful to get the questionnaire filled by 47 more respondents out of remaining 69 respondents on phone. For the remaining 22 respondent's researchers met personally on the service center of e car to get the questionnaire filled.

Thus, Information was finally gathered through google doc, telephonic interview and personal interview.

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Tools of Analysis

Researcher has used three types of tools for analysis of objectives 1 & 2.

1- Grounded Theory
2- Correlation
3- Factor Analysis

Grounded Theory

Glaser and Strauss introduced the term grounded theory in The Discovery of Grounded Theory (1967) as “the discovery of theory from data—systematically obtained and analyzed in social research”. In the place of authentication of existing theories, Glaser and Strauss announced a investigation method to arrive at a “theory appropriate to its supposed uses. There are two school of thoughts Glaser’s version (Glaser 1978,1992) and Strauss and Corbin’s (1990,1998) Version. According to Strauss and Corbin (1994) it is “a general methodology, a way of thinking about and theorizing data.

Grounded theory is all about data collection and analysis. In this approach the aim is to construct a theory that is grounded in the data (Glaser, 1978, 1992; Glaser & Strauss, 1967, 2009; Strauss, 1987).

Glacer, one of the founders of grounded theory also run The Grounded Theory Institute, the institute defined it as follows:

As per the Grounded theory institute 2013 Grounded Theory is a general method. However, many sounds it a qualitative method. It is the systematic generation of theory from systematic research. GT is all about severe research procedures which ultimately lead to the development of conceptual categories. GT can be used with any of quantitative or qualitative data.

Theory is generated only from the data collected in the study not come from other sources (i.e. text books. researcher opinions). Why it is called Grounded theory because theory is grounded in (i.e. Founded from and comes from) the data collected in the study.

Grounded theory which is not a theory by itself but play an important role in developing and building a theory from data

Grounded theory involves the “use of an intensive, open-ended, and iterative process that simultaneously involves data collection, coding (data analysis), and memo-writing (theory building)” (Groat & Wang, 2002).

Study using GT is likely to begin with the questions or even just with the collection of qualitative data. As the researcher review the collected data repetitive ideas, concepts and elements will become apparent. The code is extracted from the data collected, as enough data are collected then calculated codes can be grouped in to categories and then into concepts. These concepts then become the basis for new theory. In old style model of research, researcher uses an existing theory to show that whether the theory does or does not apply the phenomenon under study and only for this researcher collects the data while in grounded theory data is collected to generate a theory.

Elementary principles of grounded theory are that GT involves the identification and integration of categories from data. GT is the process of category identification and integration (as method) and its product (as theory). GT as method guide us for identification of categories, to make links between categories and how to establish relationships between them. Grounded theory as theory is the end-product of this process; it provides us with an explanatory framework with which to understand the phenomenon under investigation. To identify, refine and integrate categories, and ultimately to develop theory, grounded theory researchers use a number of key strategies, including constant comparative analysis, theoretical sampling and theoretical coding. Let us take a closer look at the major analytical constructs, or building blocks, of the grounded theory method.

Unique Characteristics:

Theoretical Sampling:

Theoretical sampling is an integral part of the grounded theory approach as it leads the researcher what to collect next. In this regard, the important definition of the theoretical sampling presented by Glaser and Strauss (1967) that what theoretical sampling is and what is its role in grounded theory approach. According to them, theoretical sampling is ‘The process of data collection for generating theory whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges'.

In grounded theory studies, theoretical sampling occurs as the data collection progresses. After the researcher identifies the research topic and question, they identify a small handful of people to interview based on a set of criteria (much like in purposeful sampling). Then, they interview those people. Following these initial interviews in a grounded theory study, the researcher will analyze these data. Based on the results from this round of data analysis, the researcher will identify more people to interview. These might be people who will confirm what the researcher has already found, but the researcher will also purposefully look for participants who can disconfirm the previous findings. The researcher will conduct interviews with those newly selected participants and then analyze them. Theoretical sampling continues like this, moving back and forth between sampling, data collection, and analysis, until the researcher reaches data saturation, or the point at which the researcher fails to collect new information with subsequent interviews. *(https://www.statisticssolutions.com/theoretical-sampling-in-grounded-theory/)*

Constant Comparison analysis:

One of the fundamental features of grounded theory pertains to constant comparative. Constant comparison is the data-analytic process whereby each interpretation and finding are compared with existing findings as it emerges from the data analysis. To begin data analysis researcher does not wait until data are totally collected; in its place, analysis and data collection occur concurrently so that the analyzed data guides subsequent data collection. (The qualitative report)

A Core Category:

The core category (or central category) portrays the main theme of a study (Strauss & Corbin, 1990). Several criteria for choosing the core category have been pointed out by Strauss (1987) like: (i) the core category can be related to other major categories, (ii) it should emerge frequently in the data.

General Steps in Grounded Theory Design Research

Step 1: Decide whether a Grounded Theory Design Suits the Research Problem.

A new theory can be generated by Grounded theory or it can be used to adjust an existing theory. It provides a clearer description to a studied process it also helps in finding general perception actions and interactions among human being. GT is also appropriate to produce that theory which has been overlooked in the literature or receives only a little attention in previous studies it is viewed by Goulding (1999).

Step 2: **Plan a Feasible Process to Study.**

The aim of GT research is to produce a theory in reality for the topic of interest. To achieve the objective, it is necessary to researchers to identify a tentative process in the early stage. The benefit of identifying a tentative process is that it can be changed when needed.

Step3: **Seek Approval and Access.** It is necessary to the researcher to get the approval from the required number of respondents i.e. various institutions and interviewees for the conduction of the study**.** The researcher should provide the details of the study to respondents, including objective of the study, observation guides and interview questions to get access to the participants.

Step 4: **Theoretical Sampling**. A very fundamental and important aspect of grounded theory is theoretical sampling. In theoretical sampling researcher continuously collect the data to develop the categories until categories get saturated and a clear theory is developed.

Step 5: **Code the Data**. Data need to be coded during the data collection process. The process of data coding helps the researcher to determine what data to collect next. The collected data need to be compared by the researcher the data should be grouped to generate corresponding categories based on their commonalities. Generally 10 categories are assumed to be enough for the grounded theory research but it also depends on the difficulty of the studied phenomenon. .

Step6: **Use Selective Coding and Develop the Theory**. During this step, the relationship between categories according to the coding pattern logically developed by researcher. And then finally a conceptual model or a theory of the studied phenomenon is generated

Source: April 30, 2015 *An Overview of Grounded Theory Design in Educational Research*

Code and Coding

Code: A code is **a word or short phrase** in qualitative analysis which is representative of a portion of qualitative data.

Coding: In social science, **coding** is an analytical process in which data, in both quantitative form (such as questionnaires results) or **qualitative** (such as interview transcripts) is categorized to facilitate analysis. **Coding** means the transformation of data for computer software.

Coding is the process of organizing and sorting your data. Codes serve as a way to label, compile and organize your data. They also allow you to summarize and synthesize what is happening in your data. In linking data collection and interpreting the data, coding becomes the basis for developing the analysis.

The codes are given meaningful names that gives an indication of the idea or concept that supports the theme or category.

Coding allows you to generate categories or families which share some characteristics by organizing and grouping similarly coded data and this led to the beginning of a pattern. It is not just labeling. Coding vigorously helps in generation of categories. Codes are grouped as per the similarity and regularity (a pattern). (Saldana2013)

Why Coding?

All researcher collects data of some sort. In order to make sense of data, it must be analyzed. Analysis begins with the labeling of data as to its source, how it was collected, the information it contains etc.

Working with original data, however, can be very bulky, whether it is hundreds of mailed questionnaires, figures on yearly accident rates for the fifty states, or observations of classroom behavior of school children. For this reason, data are often coded.

Coding allow the researcher to reduce large quantities of information into a form than can be more easily handled, especially by computer programs. Not all data need to be coded.

From codes and categories to theory

Richards and Morse (2007) clarify that categorizing is basically giving shape to huge diversify data. Themes and concepts are evolved after analyzing the categories. Now interconnection of these theme and concepts leads to the development of theory. (Corbin & Strauss,2008)

Coding Process

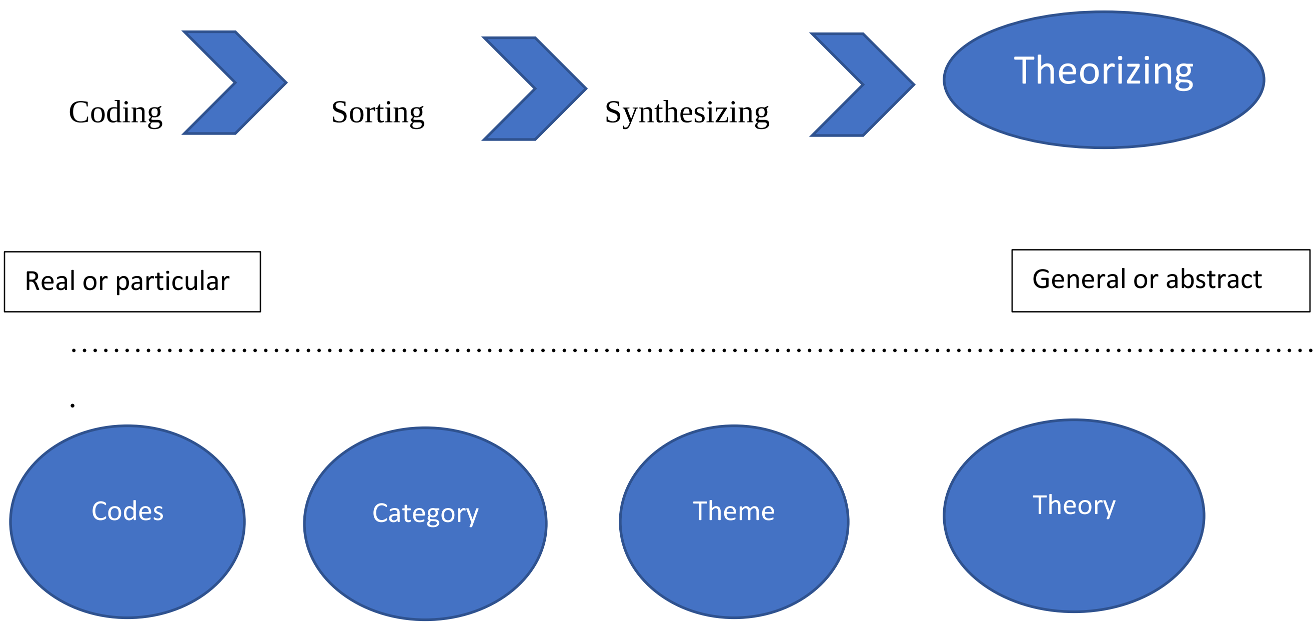

Figure 7.4: Coding Process

Source:Saldan,2013

Coding Strategies/Methods

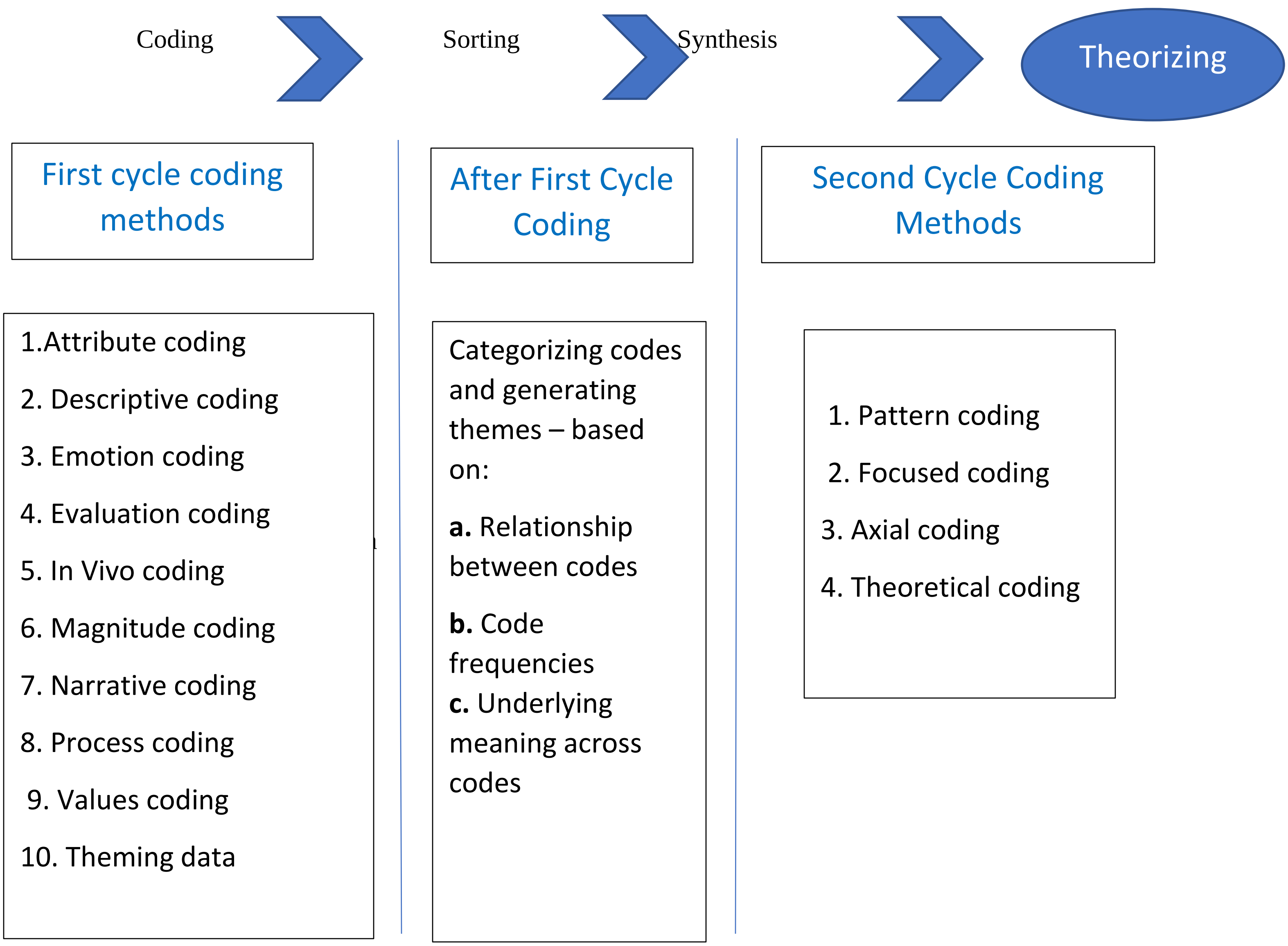

Figure 7.5: Coding Strategies/Methods

Source:(Saldana, 2013)

Choosing appropriate coding methods

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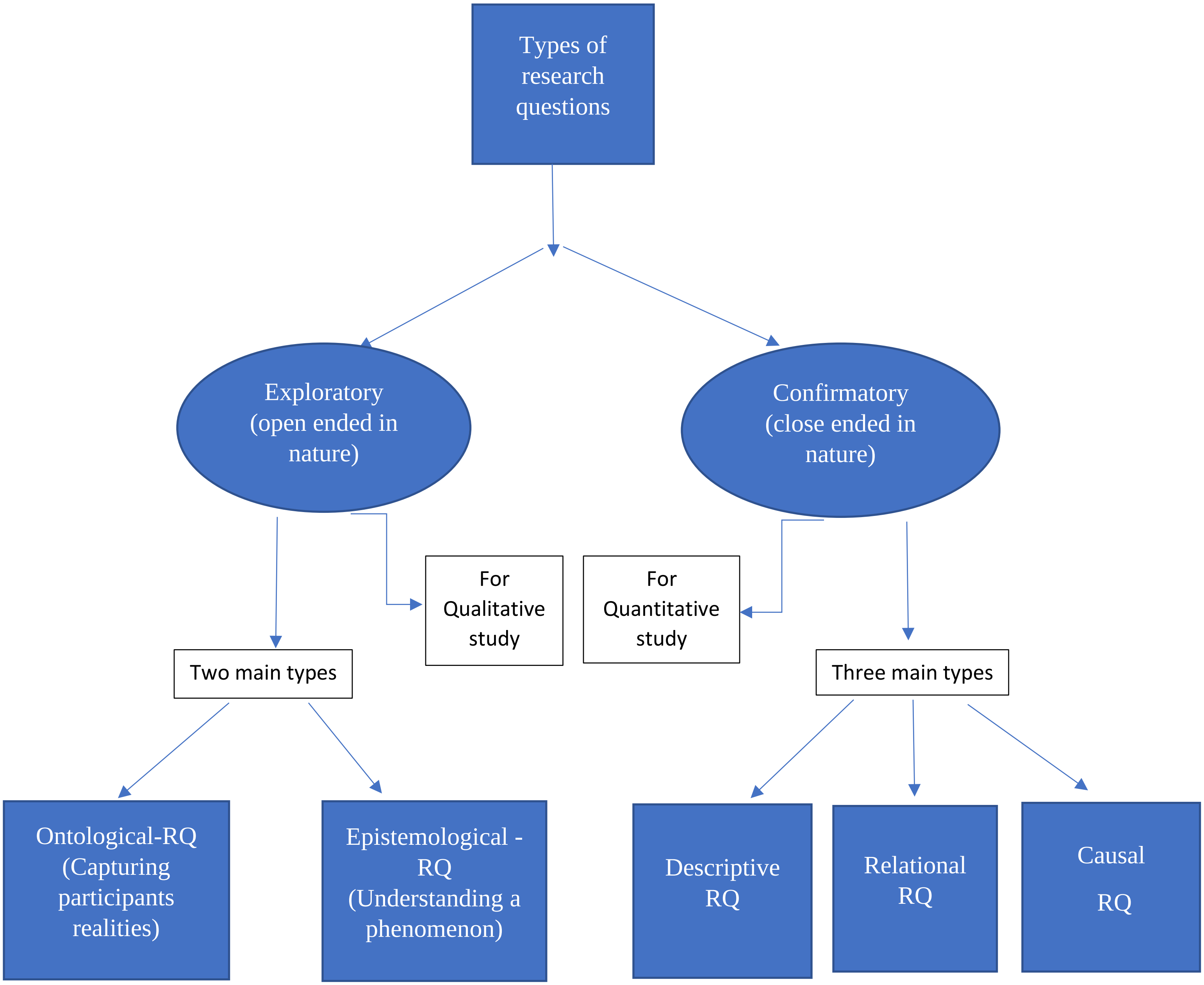


Figure 7.6: Choosing appropriate coding methods

Source:(Saldana, 2013; Trochim, 2006)

<u>Choosing coding methods based on Research question</u>

Types of Research question	Meaning	Coding method First cycle coding
Ontological research question	Related to studying the nature of participants realities (Capturing participants realities)	Attribute Emotion In Vivo Value Narrative Process Theming
Epistemological research question	Related to knowing and understanding a phenomenon (Understanding Phenomenon)	Description Evaluation Magnitude Narrative Process Theming

Table 7.5: Choosing coding methods based on Research question

Source:(Saldana, 2013, p.61)

Out of the available first cycle coding methods we have used In Vivo coding method as its best fit for our research work.

<u>In vivo coding method:</u> Coding by using participants' own words. it is the practice of assigning a label to a section of data, such as an interview transcript, using a word or short phrase taken from that section of data.

Out of available Second cycle coding methods we have used Axial Coding.

Pattern Coding:

Examining initial codes • Identifying trends, patterns, relationships • Assigning labels (they could be categories or themes)

Pattern codes not only organize the corpus but attempt to attribute meaning to that organization.

Note: Focused Coding, Axial Coding and theoretical coding are the latter stages towards developing grounded theory- the former stages being In vivo process and Initial coding.

Focused Coding:

Focused coding is appropriate for virtually all qualitative studies, but particularly for studies employing grounded theory methodology and the development of major categories or theme from data.

Focused coding categorizes coded data based on thematic or conceptual similarity.

• Identifying "the most frequent or significant initial codes" looking for: code frequencies, codes relationships, and central codes

• Building categories around them

Axial Coding:

Axial coding forms the theory. Researcher uses codes and memos to show how categories relate to each other.

Researcher look for the category that may be the core phenomenon and connects these categories to each other.

Researcher shows these connections through a coding paradigm /logic diagram visual model to explain how the process work.

Identifying core category ("Core phenomenon") and related categories

Examining the features and dimensions of categories

Theoretical Coding or Selective coding:

It is an overall explanation of the theory. Researcher writes a story about how the theory explains the core process.

Theoretical coding progress towards discovering the central/ core category that identifies the primary theme of the research.

• Connecting the core category and related categories to create a storyline • The narrative (proposition/theory) should explain a phenomenon.

From Coding to Theorizing

A social science theory has three main characteristics: it predicts and controls action through an if-then logic; explains how and/or why something happens by stating its cause(s); and provides insights and guidance for improving social life.

FORMAT

Text	Coding	Sorting/Categorizing codes and generating themes	Synthesis	Theorization
--	Code Code Code Code Code	Category --------Theme Category--------Theme Category--------Theme		

Table 7.6: FORMAT

Why Grounded Theory: Protocol: Rationale choice: Justification

1-Grounded theory is best suitable in areas in which little research has been done. Little or no research has been conducted.

2- When a particular phenomenon has not been explained effectively in the literature, and that researcher study was designed to fill this gap.

3-Researcher may identify a recent social phenomenon that has not been investigated.

4-There may be a large research literature about the phenomenon but none of the studies reported asked the type of question that the researcher wants to ask about it. This is often the case when most of the studies reported have used quantitative methods (Japhet Lawrence1 and Usman)

5- The aim of Grounded Theory is to discover theory: ‘grounded theorists want to know what is going on.

The use of grounded theory has spread to other many disciplines. (Yazan Mansourian)The most notable use of grounded theory in IS research is that by Orlikowski (1993) in which she presents findings of a study into the adoption and use of CASE tools.

Similarly, in our case - Adoption of e car in Delhi a little or no research has been conducted in Indian context.

Grounded theory is chosen for collecting and analyzing the data, with the aim of generating a theory of the adoption of e car in Delhi.

This generative approach seems particularly useful here given the objective of the study is the measure for enhancing the adoption of E car (discovery of theory) that explains the adoption of E car in Delhi.

Turner (1981) suggests that GT is mainly best suited to deal with qualitative data of the kind collected from respondents observation, from the observation of face-to-face interaction, from unstructured interviews or semi-structured , documentary sources or from case-study material .

Most of all Grounded Theory allows researchers to get into the field, and quickly acquire an empirically grounded understanding of social phenomena, and to evaluate the phenomena without reliance on extant theory.

Some other Points: **Grounded theory re-checked:**

As it has been declared in the paper (Adoption of grounded theory in LIS research, Research gate), GT is a general research methodology which can be applied in different areas of study including LIS. Glaser (1992, p. 18) states:

Allan (2003, p. 9) advocates using GT in LIS research and declares:

In conclusion, the Grounded Theory method is recommended as a powerful way to collect and analyses data and draw meaningful conclusions. This recommendation applies to any researcher in the hard sciences as well as the social sciences.

Grounded theory can be used successfully by people in many disciplines, it is a general methodology. What counts are that grounded theory methods are not bound by either discipline or data collection.

Basically, the important thing is to remember is that researcher do not begin with a theory and then attempt to prove it but rather researcher begin with an area of study and then what is relevant is allowed to emerge from his research. it is wise to remember, too, that the aim is not to discover the theory, but a theory that aids understanding and action in the area under investigation.

Correlation:

Correlation is a statistical measure that define the degree of relationship between two variables or the degree to which two or more variables fluctuate together.

One may find a relationship between two variables which is just a coincidence f or example, there is a departure of migrating birds from a sanctuary, you may find a fall in wedding ceremonies in the country. Such relationship is meaningless. Only those relationships are to be treated as correlations which offer some meaningful conclusion for example change in price leads to change in quantity demanded.

Types of correlation: Correlation can be positive, negative or no correlation

Positive correlation: When two variables move in the same direction, that is when one variable increases other also increases or when one decreases other also decreases, such a relation is called positive correlation. For example, relationship between price and supply.

Negative Correlation: When two variables move in the opposite direction, that is when one variable increases other decreases or when one decreases other increases, such a relation is called negative correlation. For example, relationship between price and demand.

No correlation: There is no correlation among the variables.

Correlation coefficient:

The degree of association is measured by a correlation coefficient, denoted by r. It is sometimes called Pearson's correlation coefficient after its originator. It only measures the linear relationship between the variables. The correlation coefficient cannot capture nonlinear relationships between two variables. If a curved line is needed to express the relationship, other and more complicated measures of the correlation must be used.

The best method of measuring the association between variables of interest is the correlation coefficient because it is based on the method of covariance. The magnitude of the association, or correlation, as well as the direction of the relationship can be obtained from this.

Degree of correlation:

The correlation coefficient is measured on a scale that varies from + 1 through 0 to - 1. Complete correlation between two variables is expressed by either + 1 or -1.where -1 indicates a perfect negative relationship and +1 indicates a perfect positive relationship and a 0 indicates no relationship exists.

Limited Degree of Correlation:

Between perfect correlation and absence of correlation there is a situation of limited degree of correlation. In real life one mostly finds limited degree of correlation.

Degree of correlation	Positive	Negative
Perfect	+1	-1
High	Between +.75 & + 1	Between -.75 & -1
Moderate	Between +.25 & +.75	Between -.25 & -.75
Low	Between 0 & + .25	Between 0 & - .25
Zero	0	0

Table 7.7: Correlation table

Assumptions:

Independent of case: Cases should be independent to each other.

Linear relationship: Two variables should be linearly related to each other. This can be assessed with a scatterplot: plot the value of variables on a scatter diagram, and check if the plot yields a relatively straight line.

Methods of measuring correlation:

Correlation between 2 variables can be measured by graphic methods and algebraic methods.

I Graphic Methods:

1)Scatter Diagram
2)Correlation graph

II Algebraic methods :(Mathematical methods or statistical methods or Co-efficient of correlation methods):
1)Karl Pearson's Co-efficient of correlation
2)Spearman's Rank correlation method
3)Concurrent deviation method

<u>Factor Analysis:</u>

<u>Factor:</u>

In general, a factor is a variable but it has a different meaning in factor analysis. In factor analysis, a factor is a latent (unmeasured) variable that expresses itself through its relationship with other measured variables.

Take for example a variable like leadership. We may want to measure a person's or an organization's leadership style, but this is the kind of construct that would be impossible to measure using a single variable. It's just too nonconcrete and complex, although it does represent a single concept.

So instead, you may have to develop the scale with many items, each of which measures some more measurable part of leadership. The idea would be that there is an underlying unmeasurable factor, leadership, that causes people to respond in certain patterns on the many items on the scale. The purpose of factor analysis is to analyze these patterns of response as a way of getting at this underlying factor.

Source: https://www.theanalysisfactor.com/confusing-statistical-term-6-factor/

Factor analysis is a general name mainly it is used to reduce and summarize the data. During research, a huge number of variables which may have some correlation are reduced to lesser numbers to manage them. Thus few factors are created to represent the sets of various interrelated variables (Naresh.k. Malhotra)

<u>Objective of Factor analysis:</u>

1-Data Reduction: It will reduce the number of variables in to lesser number of variables.

2-Data Summarization: Same nature of questions which will be highly corelated to each other will be club to make a factor**.**

Types of Factor Analysis:

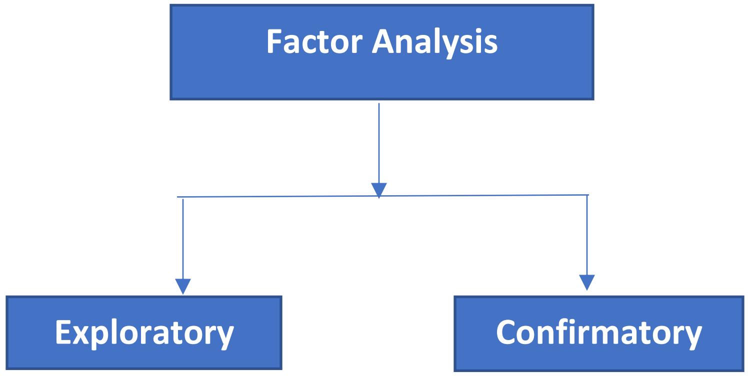


Figure 7.7: Types of Factor Analysis

Exploratory factor analysis: EFA attempts to discover the nature of the constructs influencing a set of responses.

Confirmatory Factor analysis: CFA tests whether a specified set of constructs is influencing responses in a predicted way.

When to use Exploratory Factor analysis: If the type of study is exploratory. If do not have any prior knowledge and no review exist in that case, we apply exploratory factor analysis.

When to use Confirmatory Factor analysis: If we already have a model and review exists and we want to check that then we have to apply confirmatory factor analysis.

Principal component analysis: If the purpose is to make factors which are totally un correlated use principal component analysis.

Principal access factoring: If the purpose is to find out the commonality factor among all the constructs then we should use principle access factoring.

Assumption in factor analysis:

a-Metric Data (Interval)

b- Conceptually valid

c- Multi collinearity must be present i.e. correlation among variable

d-Bartlett test of sphericity (Sign >.05)

e-Measure of sampling adequacy (>.50)

Driving factors and assessing overall fit- Number of factors extracted:

a-Latent root criteria

b-Prior criteria

c-Percentage of variance criteria

d-Scree test criteria

Interpreting factors:

a-Factor Loading: factor loading is the correlation between variables and factors. It should be greater than .6. It also depends on sample size. if sample size is large enough then the value can be .5.

b-Varimax rotation: The problem of cross loading can be removed using varimax rotation. (**Cross loading:** One variable is showing high correlation with more than one factor is called cross loading**)**

C-Label the factors: After extraction whatever number of variables come, we have to summarize them it is called labeling the factor.

Chapter 8

Qualitative Data Analysis

Objective: To find the enablers and barriers for the adoption of e cars in Delhi

The analysis of this objective was done using qualitative methods. Grounded theory one of the qualitative data analysis technique has been used to encounter the objective. Coding methods were extensively used for the analysis purpose. Primary data has been used for the for the application of coding methods. Primary data has been collected by semi structure interview of various respondents. Secondary data has also been used to prepare the semi structured interview questionnaire.

Sources of Data

Primary data sources include surveys, observations, questionnaires, personal interview, experiments etc. Secondary data collection sources are websites, journals, publications, reports, books, internal records etc.

In our case, both primary data as well as secondary data has been collected.

Primary data sources for objective 1 was semi structure interview of various stake holders such as National Automotive Board- Ministry of Heavy Industry & public enterprises, Society of manufacturer of Electric Vehicles, Energy efficiency services limited, Manufacturer and Dealers.

Secondary Data: Secondary data has been used from various sources like government and industry reports, Journals articles, websites, books etc.

Data Collection

For qualitative study for data collection various related organizations of India -Delhi such as such as National Automotive Board- Ministry of Heavy Industry & public enterprises, Society of manufacturer of Electric Vehicles, Energy efficiency services limited, Manufacturer and Dealers and their officials through purposive sampling were selected for semi structure interview. The invitation letters have been sent to bureaucrats via e mail and they have been also contacted via phone for the personal interview. The bureaucrats have been approached after or during office hours and was informed regarding the nature and rationale of the research. First reminder was sent after 07 days of the first email followed by second reminder with the gap of 15 days meanwhile contact on phone was made with a gap of 03 days. The appointment for the interview has been booked via e mail and telephone. Some of the organizations & bureaucrats were very helpful for granting the appointment for the interview while for others emails and telephone was extensively used to make them understand the purpose of the research and assure them that the data so provided will be used only for academic research to take the appointment for interview. The respondents should be guaranteed of the privacy and secrecy of the data and results. For conducting a grounded theory approach for objective 1 researcher had planned to conduct face to face, in-depth, open ended and semi structure interviews. In these types of interviews, the researcher has better chance to get their opinions, views and experiences in detail. The pattern of semi-structured interviews allows and enable the researcher to have prepared a topic guide or relevant questions to be covered with each participant in one setting (Polit & Beck, 2008).

Further the face-to-face interview allows the researcher to deeply observe the participant for any non-verbal communication but also allows both the interviewer and the interviewee (participant) to clarify the ambiguities and necessary points. No specific time duration was mentioned by researcher but can last for 30-to 45 minutes however, this time was only a guess for the interview meetings; the actual interview time and duration depends upon the participant's responses which can extend and prolong the interviews sessions. The interviews were audio-taped with permission from the participant to determine an accurate account of the interview which can be replayed for investigative purposes. Almost all the bureaucrats were interviewed face to face except two who were interviewed via telephone. Regional managers, Managers, Directors, Consultants and Team leader of some of the organizations were interviewed.

Data Analysis Procedure for Qualitative data for objective 1

First of all, identification of respondents was carried out. The main respondents identified for qualitative study were Government agency, manufacturers, dealers, private and semi govt. agency. Then all the main respondents were interviewed using semi structured interview methods. After interviewing the respondents, a script of all the interviews were prepared to keep the exact record of all the interviews.

Once the interviewing process finishes, the coding process start with in vivo coding. Codes are identified from the script and after that first level coding is done. On completion of the first level coding all code generated during first level coding are kept together for the finalization of first level coding thereafter similar codes are grouped together to identified various categories.

After identification of various categories, a model is developed mentioning the enablers and barriers for the adoption of e car in Delhi.

The detailed description of all the stake holders who have been interviewed are given in Annexure.

Description of all the stake holders	**Reference: Annexure**
Semi Structure Interview questionnaire	**Reference: Annexure**
Transcript of interviews of all stake holders	**Reference: Annexure**
Memo:	**Reference: Annexure**

Interpretation and Analysis:

First Cycle Coding

In vivo Coding

Questions asked	Raw data	In Vivo Codes	
	SMEV	**Mr. Alok**	
Q1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per the discussion held during semi structured interview with Mr. Alok as per his opinion major factors are Price even after subsidy. There is huge difference between quality and performance of Ice and e car at the same price like Low speed charging, Range limit, Technically issue, price issue. There is a problem in Government observation also as Indian component market is one of the best in world. Government does not want to do anything which leads to unemployment for number of people.	Price Subsidy, Quality Performance Low speed charging, Range limit, Technical issues, Govt. observation, Indian component market Unemployment, Industry cannot reduce cost Margins of Dealers	

	Industry cannot reduce the cost because of margin of dealers.		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	Infrastructure if customer will see the chargers will definitely purchase the car. e car saves money and in 5-6 years car will be free. While Ice car run on Rs 70 km per liter petrol /Diesel. Battery Cost will be reduced after 5- 6 years so battery would not be an issue. 2- Government Bulk buying (One tender of 10000 car by government has given birth to one more car company other than Mahindra i.e. TATA. 3-If Industry and Society will see the Infrastructure then condition will be improved.	Infrastructure, Chargers Saves Money Rs.70 km per liter Petrol/diesel Battery cost Govt. Bulk buying Birth to one more car company TATA Industry Society	
Q3- Does Delhi have an adequate awareness for	Awareness almost zero. Urgent need of awareness to people like	Urgent need of Awareness Save smoke Save petrol &Diesel	

electric Car If yes then How? If No then Why?	Sawacha Bharat, LED bulb,ujjala etc. Electric car on roads not only save your smoke but petrol and diesel too and ultimately less import and save money to import petrol/Diesel. Causes of awareness is that Government is not focusing. It is not an issue for government. Even FAME does not have an advertisement budget SMEV requested so many times but they did not listen. There is no Industry only Mahindra for the last five years he is running R & D. So, industry cannot be blamed.	less Import Save money to import Govt. not focusing FAME Advertisement Budget Advertisement R & D	
Q4-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for	Yes, limited choice (Models) and competition is a major issue.	limited choice (Models) Competition	

Competitive price, range and charging infrastructure. If No Then Why?			
Q5 Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?	Subsidy is not enough. At least we require three times subsidy for car. Car is a dream for first time buyer and their car budget lies generally within 4-5 lacs so they will not purchase a headache by purchasing e car at the same price if compare with Ice.	Subsidy First time buyer Dream Car Budget	
Q6-Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking	From industry point of view there is no profitable model of business. From government point there is a strong lobby of ICE car manufacturer who control the government. So, intentions are not positive.	Profitable model, Strong Lobby Control Govt. Intentions	
Q7- Do you think that at the price of	Yes. At the price of current electric car, the ICE car is a better option.	ICE car better than E car at same price	

current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?	It is more than two times better.		
Q8What Infrastructure and resources are required to support mass adoption?	Easy availability of Charging stations. Easy way of doing business in charging Till the date Resale of electricity is not yet allowed. One has to go through discom only. RTO-every state has different policy One has to go through cabinet. There is a need of law. There should be Law for resale of electricity. There should be law for no registration requirement for e vehicles. There should be amendment in central motor act.	Resale of electricity Discom Business in Charging Policy RTO Cabinet Law Registration Amendment Central Motor Act	
9- Additional Information	Car battery is taxed at 28 % which is a major part	Battery Tax Car Tax	

	of e car and constitute 60% cost of car. Car is taxed at 12 %. So, for an 8 lacs car you have to pay approximate 1 lac tax. and subsidy by central govt is 1.24 lacs. So compare and see.	Battery .	
	NAB- Director	**Mr. Pravin Agarwal**	
Q1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per the discussion held during semi structured interview with Shri Pravin Agarwal the major factor is non-availability of models from industry point of view which leads to low adoption. Government job is to promote and that we are doing promotion. Ice car has developed because of availability of model's efficient models, cost effective models, good models in the market, If there will be products in the market it will be sell. As ICE cars various models available which	Non-availability of models Adoption Promotion Efficient Cost effective	

	cost effective so people purchase them similarly if E cars models will be available people will start purchase them too. Same from society point of view i.e. non-availability of models		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	It depends on the quality of the products. There are some deciding parameters for purchasing a car like Speed, Comfort, acceleration, leg space etc until customer will not satisfy with these he will not purchase e car. Thus, e car should be as par with the ICE car only then customer will purchase.	Speed Comfort Acceleration Leg space Satisfaction E Car as par ICE Car	
Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?	No need of awareness. If we do the awareness and then customer will go market to purchase the car and there is no or very	No need of awareness Very less cars in the market Indian market 3-4 lacs car	

	less cars in the market how they will purchase. Indian market does not purchase car more than 3-4 lacs that is why other companies have not manufacturing the car. Government is trying.		
Q4-Does limited choice (Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?	Yes, limited choice (Models)- and Competition it is a major issue.		
Q5 Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?	Subsidy is enough. Not an issue.		

Q6-Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking	Limited Choices-models.		
Q7- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?	Yes, at the price of current electric car the ICE car is a better option it is.		
Q8What Infrastructure and resources are required to support mass adoption?	Technology, R & D, Charging infrastructure in offices and Malls, Indian manufacturing	Technology Charging Infrastructure in offices & Malls Indian manufacturing	
9- Additional Information			
	EESL	**Mr. Sambit Patil (Consultant)**	
Q1-What are the major barriers for the low adoption of E Car by consumer	People are not aware about e car. Range anxiety from society point of view. People believe car is very costly	Range Anxiety	

in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	and it is really. But overall life time cost is considered then e car is better. Even government entities and educated people are not aware. Because they have never seen e cars on the road. Options are limited. Cost is another factor. So, when manufacturer will know that there is a tender for 10000 car they can think that this is also one of the area to enter and manufacturer can optimize cost. It does not make a financial sense to manufacturer to invest in a technology and redevelop their assembly line. Manufacturer confidence to invest is less. Government is seriously looking for a transition to Indian mobility. There are lot of enabling policy, couple of question on Charging Infrastructure, how it will be set up, who	Life time cost Educated people not aware Govt. Entities not aware E cars on road Manufacturer can Optimize cost Manufacturer Confidence to invest Set up Tariff Necessary volume	

	will own the charging infrastructure, what should be tariff. Necessary Volume is one of the barriers for getting confidence to manufacturers.		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	Positive government policy and direction from the industry point of view as well from government point of view Operating cost of EV is cheaper from society point of view	Positive government Policy & Direction Operating Cost	
Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?	Need of awareness.		
Q4-Does limited choice(Models)-	No it is not a major issue for his tender.		

and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?	But it is.		
Q5 Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?	Subsidy is enough. Not an issue.		
Q6-Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking	Cost must reach at optimum Cost.	Optimum cost.	
Q7- Do you think that at the price of	No. If you consider the life cycle of car.	Life cycle of Car	

current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?			
Q8What Infrastructure and resources are required to support mass adoption?	Charging Infrastructure, EVSE infrastructure.	EVSE infrastructure.	
9- Additional Information			
	Dealer	**Koncept Auto mobile**	
Q1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per the discussion held during semi structured interview with Mr. Gaurav Chaudhary and as per his opinion people are saying there should be charging stations at the road and duration of charging should be decreased from six hours otherwise car is great. It is fatigue free, easy to drive and low maintenance car. As per him government is happy and ordering	Decreased charging time Fatigue free Easy to Drive Low Maintenance Intelligent customer liking car Low Advertising	

	fatigue free and Zero maintenance car. From society point of view he says some of the customer is very much intelligent and they are liking and heading towards e car and avoiding diesel car. Inadequate awareness is one of the major barrier from society point of view. Low Advertising and promotional activities is another barrier.		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per their opinion pollution is one of the major enabler other enablers are noise free, Good Mileage, Maintenance free, automatic car, good technology, car is worth paying it's cost as compare to ICE car as in ten years diesel /Petrol and maintenance cost will double the price of ICE car. Small compact	Good Mileage Maintenance Free Worth paying it's cost for long run Good technology 10-12 units only to full Charge	

	car. It takes 10-12 units only to full charge i.e. to run 100 km.		
Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?	No.		
Q4-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?	Yes limited choice(Models)- and Competition is a barrier. When there will be competition more advertising and promotion by competitors		
Q5 Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then	Govt has to play more role in this. Sales is less only because of government. huge registration charges of 60-70 k this is Public feedback. If government	Registration charges	

why? If No then Why?	wants to protect the environment why government charges huge registration charges		
Q6Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?	No promotional and awareness program me by government	No awareness program me by govt.	
Q7- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?	Yes, as per the customer. Price is so high and that is because of government at this price customer can switch to a big ICE car or CNG car without range anxiety with good power. First of all one should build the base i.e. charging station. So every 10 -15 km there should be some charging station. Charging time should reduce.	Charging time	
Q8What Infrastructure and	First of all u have to built up the base first promote	Build up the base	

resources are required to support mass adoption?	the power charging station. You are promoting car not charging station. This is the best car , There should be no comparison with ICE car. This is the future. If I stuck some where in jam first thing will come where should I charge this car.so if every 10-15 km there will be charging station you will completely feel free wherever you want to drive. Charging time should reduce.	Charging point at every 10-15 km.	
9- Additional Information	If this car will be launch in the range of 3-4- lacs the sales will be boost like anything and a morale booster for dealers also to promote the car. In India if people are not ready to purchase 100km range car how they will purchase 300 km range car as price will increase.	range 3-4 lacs Sales boost Morale booster for dealer	

	Dealer	**Shri Druga**	
Q1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per the discussion held during semi structured interview with them the major barriers are Cost and Range. First time buyer generally purchases small car. So, price and limited Range does not suit him whatever his uses. Fiber body is also one of the factor. So, customer hesitates to buy. From manufacturer point of view Battery cost is high. From government point of view Subsidy for battery making or for importing. No support for manufacturer by Govt. Customer Awareness is one of the factor. From society point of view range is a major issue. Charging is secondary issue as no one has that much of time in	Fiber Body No support for manufacturer First time buyer Small car Subsidy for battery making or importing No support for manufacturer by Govt Range is a major issue. Charging is secondary issue. Designer Spacious Comfortable Buyers of e car generally Educated Second time buyer	

	life to charge for 3 -4 hours during 200 km journey. Customer is not taking initiative for environment. Car is small but at that range one can buy a bigger car. Ice car has a option of go any way within 5-7 lacs. At the same range one can purchase Designer, spacious, stylish, Comfortable car. Buyer's of e car have different thought generally they are educated.		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view	It's Buyers have different thinking. People should take initiatives for environment protection People thinking should be changed in India as in India people thoughts are to purchase a bigger car as compare to others. Mostly buyer's are educated. Mostly,	People should take Initiatives Environment protection People thinking should be changed Better Speed	

c-From Society point of view	Doctors, engineers, Professors, Better speed, Better range, Reduced charging time.		
Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?	Need awareness 15-20 % only		
Q4-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?	Yes it is . When there will be competition the more options available to customer		
Q5 Do you think that the current electric car Subsidy	Subsidy is enough.		

is enough to meet the NEMM target in Delhi If yes then why? If No then Why?			
Q6-Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking	Range, Price and No promotional and awareness programme by government		
Q7- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?	Yes ICE car is better.		
Q8What Infrastructure and resources are required to support mass adoption?	Quick charge options should be there.		
9- Additional Information	Industry should think for first time car buyer.	Price bracket	

	Industry should think for price bracket in which first time car buyers can be fit. In today's time the customer who is purchasing E Car generally already have one or two car.		
Dealer	**Genesis Motors**		
Q1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per the discussion held during semi structured interview with Mr. Sunil, Mr. Rana and Mr. Ankit - as per their opinion range is one of the major barriers from industry and society point of view. Price is another major barrier as at comparatively low cost (3-4 lacs) other companies are offering better features. So customer mentality is that e car must come in this price range. So why to pay 8-10 lacs and then wait for subsidy return. Another major po ints are Safety , looks- style and	Better features Safety Looks Status Less Aggressive Govt.	

	status .As per them government is less aggressive.		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	As per their opinion pollution is one of the major enabler other enablers are noise free, low running cost, Low maintenance cost, good technology Dealers are also waiting for government to announce that we are fully ready to adopt the car so that dealer and manufacturer will start investing in E Car.	Pollution Noise Free Low running cost	
Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?	Need awareness, Government is not fully prepared for e- car		
Q4-Does limited choice(Models)- and Competition (one-two manufacturer only)	Yes limited choice(Models)- and less Competition (one-two manufacturer only) - (Major one only) of		

-(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?	electric car is a major barrier. When there will be competition only then customer visit for comparison and dealer also have some point to differentiate.		
Q5 Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?	Subsidy is enough but customer is not believing on electric. Government may think to increase subsidy if customer will show interest in E- Car. Hardly 2-3 e cars sold in a month as very few customers enquire. So we do not have a range of customer to analyze data about subsidy. Those who visit are almost satisfied with subsidy. But if subsidy will increase then more customer may purchase.	Customer not believing on electric	
Q6-Even after formulation of NEMMP the sales of E car is not picking up as	limited choice(Models)-and Competition. Subsidy is enough but customer is not believing on electric. Government		

desired. Where are the Industry and government lacking	may think to increase subsidy if customer will show interest in E- Car range is one of the major barriers from industry and society point of view . Price is another major barrier as at comparatively low cost (3-4 lacs)other companies are offering better features. So customer mentality is that e car must come in this price range. So why to pay 8-10 lacs and then wait for subsidy return		
Q7- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?	Yes . ICE car is better at the same price.. As you are getting better design, better safety , big size ,better feeling and of course no range anxiety.		
Q8- What Infrastructure and resources are	Range should increase by any means, Some charging point should be there on petrol pumps,	Features and looks as per the new generation	

required to support mass adoption?	Subsidy and price range should be reasonable 5- 6 lacs, Look ,status and features should match as per today's generation , Safety is almost nil. So almost many features needs improvement.		
Q9--Additional Information	Mostly 45 -60 age group person are showing interest in E- Car whose daily running is mostly around 60-70 km. Corporates are showing interest for their employees whose daily running is mostly around 60-70 km. This car is basically for city drive . Other consumer are wives and school and college going children. Car is costly as there is no coemption so Competition is must.	45-60 Age group shown interest 60-70 km daily running people shown interest	
Mahindra	**Mr. Rachit Khanna**		

Q1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	No issue from industry. People are purchasing it gradually. Govt is also doing his job. More Govt Initiatives may help.		
Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion? a-From Industry Point of view b-From Government Point of view c-From Society point of view	Pollution free, Low maintenance cost, Low running cost, Less Life time cost, subsidy by government, easy to drive		
Q3- Does Delhi have an adequate awareness for electric Car If yes	No		

then How? If No then Why?			
Q4-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?	Yes it is an issue.		
Q5 Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?	Subsidy is enough		
Q6-Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are	Charging Infra & lack of models.		

the Industry and government lacking			
Q7- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?	No		
Q8What Infrastructure and resources are required to support mass adoption?	Charging Infrastructure and low-priced battery.		
9- Additional Information			

Table 8.1: First Cycle Coding

First level Coding:

	In Vivo Coding
SMEV- **Mr. Alok - Manager**	Price Subsidy, Quality Performance Low speed charging, Range limit, Technical issues, Govt. observation, Indian component market Unemployment, Industry cannot reduce cost Margins of Dealers Infrastructure, Chargers Saves Money Rs.70 km per liter Petrol/diesel Battery cost Govt. Bulk buying Birth to one more car company TATA Industry Society Urgent need of Aware people Save smoke Save petrol &Diesel Save Import Save money to import

	Govt. not focusing FAME Advertisement Budget Advertisement R & D limited choice (Models) Competition First time buyer Dream Car Budget Profitable model, Strong Lobby Control Govt. Intentions ICE car better than E car at same price Resale of electricity Discom Business in Charging Policy RTO Cabinet Law Registration Amendment Central Motor Act Battery Tax Car Tax
DHI - Director-	Non-availability of models Adoption Promotion

Mr. Pravin Agarwal	Efficient Cost effective Speed Comfort Acceleration Leg space Satisfaction E Car as par ICE Car No need of awareness Very less cars in the market Indian market 3-4 lacs car Technology Charging Infrastructure in offices & Malls Indian manufacturing
EESL - Mr. Sambit Patil (Consultant)	Range Anxiety Life time cost Educated people not aware Govt. Entities not aware E cars on road Manufacturer can Optimize cost Manufacturer Confidence to invest Set up Tariff Necessary volume Positive government Policy & Direc tion Operating Cost Optimum cost. Life cycle of Car

	EVSE infrastructure.
Dealer Koncept Auto mobile	Decreased charging time Fatigue free Easy to Drive Low Maintenance Intelligent customer liking car Low Advertising Good Mileage Worth paying it's cost for long run Good technology 10-12 units only to full Charge Registration charges No awareness program me by govt. Build up the base Charging point at every 10-15 km. range 3-4 lacs Sales boost Morale booster for dealer
Dealer Shri Druga	Fiber Body No support for manufacturer First time buyer Small car Subsidy for battery making or importing No support for manufacturer by Govt Range is a major issue. Charging is secondary issue. Designer Spacious

	Comfortable Buyers of e car generally Educated People should take Initiatives Environment protection People thinking should be changed Better Speed Price bracket Second time buyer
Dealer Genesis Motors	Safety Looks Status Zero Pollution Noise Free Better features Low running cost Less Aggressive Govt Customer not believing on electric Features and looks as per the new generation 45-60 Age group shown interest 60-70 km daily running people shown interest
Mahindra - Mr. Rachit Khanna- Regional Manager	

Table 8.2: First level Coding

First Level Coding Final

Price Subsidy, Quality Performance Low speed charging, Range limit, Technical issues, Govt. observation, Indian component market Unemployment, Industry cannot reduce cost Margins of Dealers Infrastructure, Chargers Saves Money Rs.70 km per liter Petrol/diesel Battery cost Govt. Bulk buying Birth to one more car company TATA Industry Society Urgent need of Aware people Save smoke Save petrol &Diesel Save Import Save money to import Govt. not focusing FAME Advertisement Budget	

Advertisement R & D limited choice (Models) Competition First time buyer Dream Car Budget Profitable model, Strong Lobby Control Govt. Intentions ICE car better than E car at same price Resale of electricity Discom Business in Charging Policy RTO Cabinet Law Registration Amendment Central Motor Act Battery Tax Car Tax Non-availability of models Adoption Promotion Efficient Cost effective Speed	

Comfort Acceleration Leg space Satisfaction E Car as par ICE Car No need of awareness Very less cars in the market Indian market 3-4 lacs car Technology Charging Infrastructure in offices & Malls Indian manufacturing Range Anxiety Life time cost Educated people not aware Govt. Entities not aware E cars on road Manufacturer can Optimize cost Manufacturer Confidence to invest Set up Tariff Necessary volume Positive government Policy & Direction Operating Cost Optimum cost. Life cycle of Car EVSE infrastructure. Decreased charging time Fatigue free Easy to Drive Low Maintenance	

Intelligent customer liking car Low Advertising Good Mileage Worth paying it's cost for long run Good technology 10-12 units only to full Charge Registration charges No awareness program me by govt. Build up the base Charging point at every 10-15 km. range 3-4 lacs Sales boost Morale booster for dealer Fiber Body No support for manufacturer First time buyer Small car Subsidy for battery making or importing No support for manufacturer by Govt Range is a major issue. Charging is secondary issue. Designer Spacious Comfortable Buyers of e car generally Educated People should take Initiatives Environment protection People thinking should be changed Better Speed Price bracket Safety	

Looks Status Zero Pollution Noise Free Better features Low running cost Less Aggressive Govt Customer not believing on electric Features and looks as per the new generation 45-60 Age group shown interest 60-70 km daily running people shown interest	

Table 8.3: First Level Coding Final

After First Cycle coding -Sorting

Category Identification:

In the grounded theory process next step is the category identification. The following categories are emerged with the help of memo out of all available codes. Memos have been integrated with the process of arriving at categories. The process has been explained.

Process of category identification with the help of Memo

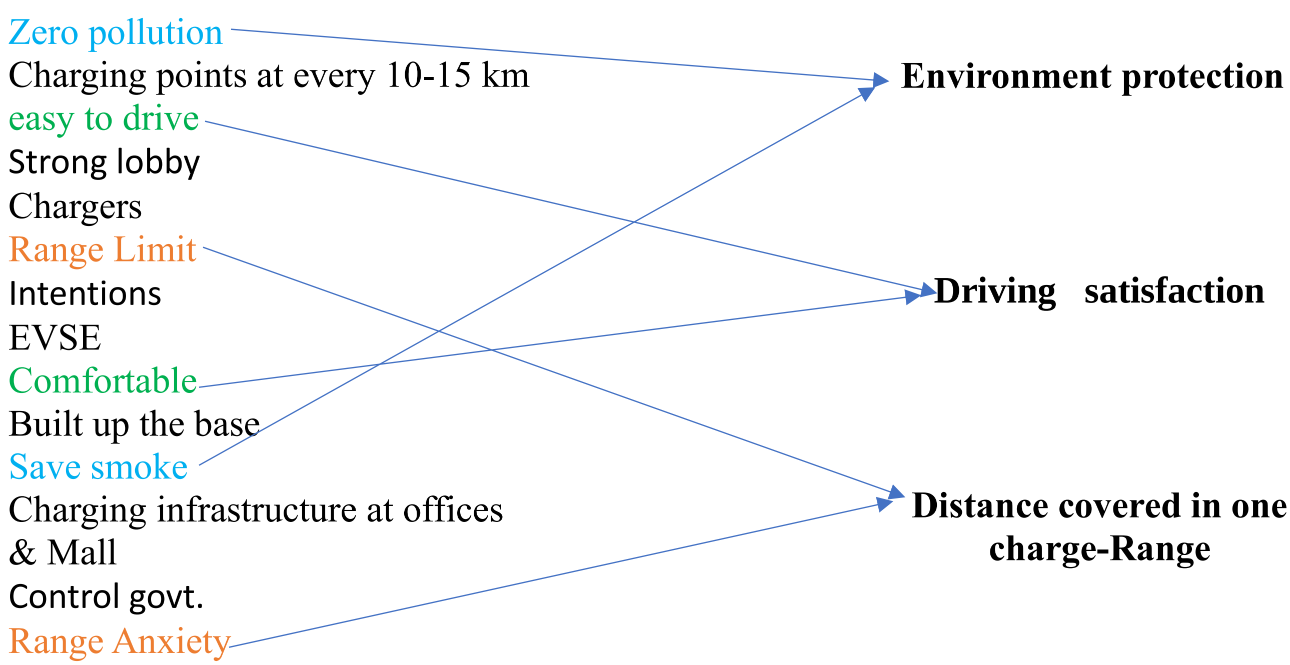


Figure 8.1: Process of category identification with the help of Memo

Emerged Categories

1- **Environment protection**: It emerges from the following codes

   a- Save smoke

   b-Zero pollution

2- **Economy of car:** It emerges from the following codes

   a-Save petrol & diesel

   b-Save money to Import

   c-Low maintenance

   d-Low running cost

   e-cost effective

   f-operating cost

   g-efficient

   h-Total cost of ownership

3-**Quality (Design/Features & safety):** It emerges from the following codes

a-Looks

b-Fiber body

c-Spacious

d-Leg space

e-Features and looks as per the new generation

f- Safety

g-Brand

h- Performance

i-Designer

4-Law & Policy

It emerges from the following codes

a-Policy

b-Amendment

c-Central motor act

d-Law

e-Govt. Observation

f-Indian component market

g-Unemployment

h-cabinet

I-Positive Govt.policy and direction

5-ICE car manufacturers Intentions: It emerges from the following codes

a-Strong lobby

b-Control govt.

c-Intentions

6-**Business in charging:** It emerges from the following codes

a- Discom
b- Resale of electricity
c- Set up
d- Tariff

7-Driving Satisfaction: It emerges from the following codes

a-Comfortable

b-easy to drive

c-Fatigue free

8-Pickup & Speed: It emerges from the following codes

a-Acceleration/Pick up

b-speed

c-new generation

d-top speed

9-Distance covered in one charge: It emerges from the following codes

a-Range Anxiety

b-Range Limit

10-Image Status: It emerges from the following codes

a- Status

11-Infrastructure: It emerges from the following codes

a-Built up the base

b-Chargers

c-Charging points at every 10-15 km

d-Charging infrastructure at offices & Mall

e-EVSE

12-Government Action: It emerges from the following codes

a-Subsidy

b-Govt. Bulk buying

c-Govt. Not focusing

d-FAME

e-R&D

13- **Promotional activity &awareness:** It emerges from the following codes

a-Urgent need to aware people

b-Advertisement budget

c-Advertisement

d-Promotion

e-No need of awareness

d-Govt. entities not aware

e-Educated people are not aware

14-**Type of customer:** It emerges from the following codes

a- Intelligent customers liking the car
b- Buyers of e car generally educated
c- People thinking should be changed
d- People should take initiative
e- 45-60 age group show interest
f- 60-70 km daily running customer shown interest
g- First time buyer's
h- Second time buyer's

15- Car Budget: It emerges from the following codes

a-Price bracket

b-Small car

c-First time buyer

d-Dream

e-ICE car better than E car

f-Cost effective

g-E car as per ICE car

h-Indian market

I-3-4 lacs car

J-Price

16-<u>Taxing:</u> It emerges from the following codes

a-Battery tax

b-Registration tax

c-Road Tax

d-RTO

17-Charging Time: It emerges from the following codes

a-decreased charging time

b-quick charging

c-technical issue

d-E car as par ICE car

18**-Profitable model:** It emerges from the following codes

a-Price

b-Margin of dealer

c-Industry cannot reduce cost

d-E cars on road

e-Manufacturer can optimize cost

f-Manufacturer confidence to invest

g-Indian manufacturing

h-necessary volume

i-Life time cost

j-optimum cost

k-worth paying it’s cost for long run

l-10-12 units only to full charge

m-No support for manufacturer

19- Battery: It emerges from the following codes

a-Battery cost

b-Battery tax

20-Non-availability of models: It emerges from the following codes

a- Limited choices (models)
b- Competition
c- Very less cars in the market

<u>Second Cycle Coding Method- Synthesis</u>: <u>Model for enablers and barriers</u>

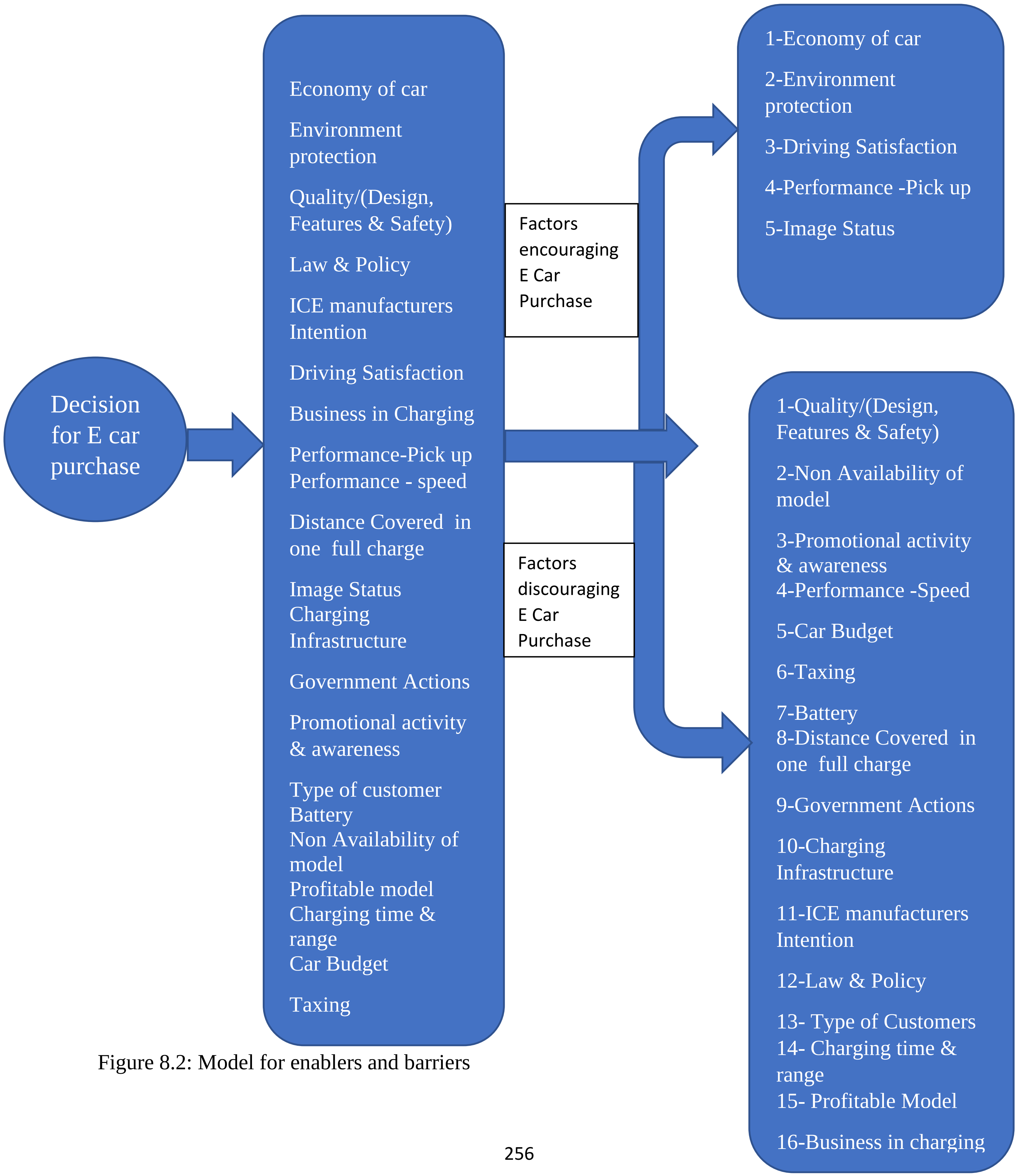


Figure 8.2: Model for enablers and barriers

In this chapter the qualitative data collection and qualitative data analysis has been presented. Use of semi structure interview has been extensively used for qualitative data collection. The grounded theory has been applied using coding methods. The model for objective 1 is also highlighted.

Link between outcome of objective 1 and objective 2

Objective 1 outcome are enablers and barriers identified from various stake holders (Govt agencies, private agencies, dealers, manufacturers etc.) except consumers however to incorporate the consumers view also the consumers have been surveyed on the basis of output obtained from objective 1 to find the significant enablers and barriers and to explain the measures for enhancing the adoption of e car. Therefore, the objective 2 outcomes are the factors identified from e car users which are actually significant enablers and barriers that certainly represents the link between the outcome of objective 1 and objective 2.

Chapter 9

Quantitative Data Analysis

The analysis of this objective was done using quantitative methods. Factor analysis one of the quantitative data analysis technique has been used to encounter the objective. Primary data has been used for the application of Factor analysis. Primary data has been collected using questionnaire from e car respondents. Secondary data & output of objective 1 have been used to prepare the questionnaire.

Sources of data:

Primary data sources include surveys, observations, questionnaires, personal interview, experiments etc. Secondary data collection sources are websites, journals, publications, reports, books, internal records etc.

In our case, both primary data as well as secondary data has been collected. Primary data source for objective 2 was questionnaire method. A survey of e car users has been conducted to collect the primary data.

Secondary Data: Secondary data has been used from various sources like government and industry reports, Journals articles, websites, books & from objective 1 to make the questionnaire.

Data Collection:

For this study, questionnaires were used to obtain data relevant to the study's objective 2. The purpose of study was to identify measures for enhancing the adoption of e car in Delhi. The researcher has approached the e car user in Delhi to participate in the study. Every e car user who has been approached to participate received a letter with information about the study and a questionnaire After completion of pilot study and all necessary modifications the questionnaire were directly administrated to chosen sample for the study. Survey questionnaire was administrated in three modes. 1- Electronic media -Google doc 2- Telephone Interview 3- Personal Interview

A total of 563 questionnaires were sent to e car users in Delhi via electronic media with a request to get these filled. First reminder was sent after 02 days of the first message followed by second reminder with the gap of 04 days meanwhile, they were also contacted on phone on daily basis. Some of the e car users were very helpful for filling the questionnaire while for others repeated reminder messages and telephone was extensively used to make them ready to fill the questionnaire and to make them understand the purpose of the research and assure them that the data so provided will be used only for academic research to fill the questionnaires.

Only 194 (34.4%) filled in questionnaires were received after so many requesting repeated electronic reminder and requesting phone calls out of which only 182(32.32%) were found to be fully filled in, the rest 12 were discarded due to major incomplete information. To complete the sample size the remaining 69 respondents were approached on phone and personally to filled the questionnaire. Researcher was successful to get the questionnaire filled by 47 more respondents out of remaining 69 respondents on phone. For the remaining 22 respondent's researchers met personally on the service center of e car to get the questionnaire filled.

Thus, Information was finally gathered through google doc, telephonic interview and personal interview.

Data Analysis procedure for quantitative study for objective 2:

First of all, identification of respondents was carried out. The main respondents identified for quantitative study were E car users in Delhi. Then all the main respondents were requested to fill the questionnaire. Once the data have been received after filling the questionnaire by respondents the data analysis has been conducted with the help of SPSS software. Factor analysis has been applied to find the factors.

Interpretation and Analysis:

Correlation Matrix:

Researcher has set a cutoff of .8 to analyses interterm correlation. After analyzing interitem correlation in Correlation matrix table researcher has found that there are no two items whose correlation is more than .8. So, all the items are unique items & valid thus there is no need to remove any single item.

KMO & Bartlett's Test:

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.526
	Approx. Chi-Square	20689.684
Bartlett's Test of Sphericity	Df	1326
	Sig.	.000

Table 9.1: KMO & Bartlett's Test

Kaiser-Meyer-Olkin (KMO) and Bartlett’s Test of Sphericity is a test to assess the appropriateness and suitability of the data for Factor Analysis. The KMO measures the sample adequacy (Which determine if the responses given with the sample are adequate or not).

Table states KMO value to be 0.526 which shows that the data is suitable for Factor Analysis. And Bartlett’s value is 0.000 which shows that the data is multivariate normal and acceptable for data analysis.

Note: Majority of the papers employed Kaiser-MeyerOlkin (KMO) measure of sampling adequacy to assess the suitability of the sample for PCA. While almost 43% of the reviewed papers did not report the KMO value, the remaining 57% papers reported KMO values greater than 0.5 which is acceptable (Hair et al., 1998).

Source:(Reenu MASKEY, Jiangang-31st may 2018, Use of Exploratory Factor Analysis in Maritime Research, The Asian Journal of Shipping and Logistics, ELSEVIER)

Communalities: The next item from the output is a table of communalities. The communality value should be more than 0.5 to be considered for further analysis else these variables are to be removed from further steps factor analysis.

Communalities

	Initial	Extraction
Price_Economy	1.000	.823
Low_running_cost_Economy	1.000	.798
Low_maintenance_Economy	1.000	.875
Low_cost_of_ownership_Economy	1.000	.877
Cost_effective	1.000	.792
Less_Pollution_Enviormental_Protection	1.000	.636
Pick_up_Quality	1.000	.777
Topspeed_Quality	1.000	.848
Vehiclepower_Quality	1.000	.885
Appereance_Quality	1.000	.788
Saftey_Quality	1.000	.876

Perception_Quality	1.000	.784
Reliabilty_Quality	1.000	.842
Durability_Quality	1.000	.881
Serviciabilty_Quality	1.000	.742
Comfortable_Driving_satisfaction	1.000	.847
Easy_to_drive_Driving_satisfaction	1.000	.849
Fatigue_free_Driving_Satisfaction	1.000	.805
Distance_Covered_one_fully_tank	1.000	.849
Image_status_Esteem	1.000	.713
Refuelling_Infrastructure	1.000	.824
Refuelling_location	1.000	.889
Refuelling_cost	1.000	.852
Refuelling_Convenience	1.000	.871
Refueling_time	1.000	.782
Increased_fuel_price	1.000	.859
Scarcity_of_fuel	1.000	.782
Free_refueling	1.000	.784

Non_availability_of_models	1.000	.739	
Awarness	1.000	.940	
Promotional_activity	1.000	.937	
Law	1.000	.781	
Road_tax	1.000	.829	
Registration_tax	1.000	.830	
Subsidy_Government_Policy	1.000	.882	
Favorable_policy_Govt_Policy	1.000	.863	
Spacious	1.000	.855	
Size	1.000	.831	
Technological_features	1.000	.757	
Cheap_car_insurance	1.000	.816	
High_resale_value	1.000	.710	
Latest_Technology	1.000	.813	
Good_return_on_Investment	1.000	.809	
Carrying_Capacity	1.000	.716	
Costly_replacement_part	1.000	.799	
Automatic_transmission	1.000	.807	

Bonus_for_scaraping_an_old_car	1.000	.824
Free_Parking	1.000	.879
Emission_testing_exemption	1.000	.820
Insurance_discount	1.000	.857
No_tollroad_charges	1.000	.855
Conversion_ICE_Ecar	1.000	.736

Table 9.2: Communalities

All the extraction values are greater than .5 so which signifies that all the items are valid.

<u>Total Variance Explained:</u>

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	19.657	37.801	37.801	19.657	37.801	37.801	8.330	16.020	16.020
2	3.860	7.424	45.225	3.860	7.424	45.225	5.597	10.764	26.784
3	3.423	6.583	51.808	3.423	6.583	51.808	4.255	8.183	34.967
4	2.754	5.296	57.103	2.754	5.296	57.103	4.131	7.945	42.912
5	2.240	4.307	61.410	2.240	4.307	61.410	3.974	7.643	50.554
6	1.995	3.837	65.248	1.995	3.837	65.248	2.908	5.593	56.147
7	1.896	3.645	68.893	1.896	3.645	68.893	2.894	5.566	61.713
8	1.719	3.305	72.198	1.719	3.305	72.198	2.850	5.480	67.193
9	1.460	2.808	75.006	1.460	2.808	75.006	2.363	4.544	71.737
10	1.363	2.621	77.627	1.363	2.621	77.627	1.952	3.755	75.491

11	1.161	2.232	79.859	1.161	2.232	79.859	1.803	3.468	78.959
12	1.084	2.085	81.945	1.084	2.085	81.945	1.553	2.986	81.945
13	.932	1.793	83.737						
14	.902	1.736	85.473						
15	.794	1.528	87.000						
16	.719	1.382	88.382						
17	.671	1.291	89.673						
18	.592	1.138	90.811						
19	.548	1.055	91.866						
20	.469	.901	92.767						
21	.441	.848	93.615						
22	.392	.753	94.368						
23	.368	.708	95.075						
24	.317	.610	95.685						
25	.262	.505	96.190						

26	.244	.470	96.660						
27	.214	.411	97.071						
28	.193	.372	97.443						
29	.163	.314	97.756						
30	.144	.277	98.034						
31	.133	.255	98.289						
32	.122	.234	98.523						
33	.106	.203	98.727						
34	.100	.193	98.919						
35	.089	.171	99.091						
36	.076	.146	99.237						
37	.065	.124	99.361						
38	.060	.116	99.477						
39	.053	.102	99.578						
40	.046	.088	99.666						
41	.039	.075	99.741						

42	.034	.066	99.807							
43	.029	.055	99.862							
44	.020	.039	99.901							
45	.013	.026	99.926							
46	.013	.025	99.951							
47	.008	.016	99.968							
48	.008	.014	99.982							
49	.004	.008	99.990							
50	.002	.005	99.995							
51	.002	.004	99.999							
52	.001	.001	100.000							

Table 9.3: Total Variance Explained

After analyzing the total variance table researcher has found that there are total twelve components whose eigen value are more than 1. The cumulative variance is 81.945 % which signifies that more than 80% items are unique means they are different. All the factors in table accounted for 81.945% of the variance. Total variance explained (81.945%) exceeds the 60 % threshold commonly used in social sciences. (Hair, 2006)

Rotated Component Matrix

Rotated Component Matrix

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
Refuelling_location	.866											
Scarcity_of_fuel	.785											
Refuelling_Convenience	.779											
Refuelling_Infrastructure	.774											
Refueling_time	.773											
Increased_fuel_price	.701											
Refuelling_cost	.696											
Costly_replacement_part	.655											
Distance_Covered_one_fully_tank	.613											

Free refueling	.599											
Serviciabilty_Quality	.588											
High_resale_value	.554											
Non_availability_of_models												
Free Parking		.749										
Technological_features		.723										
Insurance_discount		.700										
No_tollroad_charges		.671										
Bonus_for_scaraping_an_old_car		.669										

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
Cheap_car_insurance		.594										

Spacious		.564			.560								
Latest_Technology		.549											
Low_cost_of_ownership_Economy		.	.845										
Low_maintenance_Economy			.810										
Low_running_cost_Economy			.790										
Cost_effective			.751										
Less_Pollution_Envi ormental_Protection													
Registration_tax				.719									
Road_tax				.708									
Subsidy_Government_Policy				.674									
Favorable_policy_Govt_Policy				.649									

Price_Economy				.522								
Vehiclepower_Quality					.892							
Topspeed_Quality					.876							
Pick_up_Quality					.767							

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12
Size		.510			.540							
Promotional activity						.867						
Awareness						.857						
Law				.502		.540						
Saftey_Quality							.717					
Durability_Quality							.700					
Reliabilty_Quality							.607					

Comfortable_Driving_satisfaction								.766				
Fatigue_free_Driving_Satisfaction								.761				
Easy_to_drive_Driving_satisfaction								.676				
Emission_testing_exemption									.842			
Automatic transmission									.712			
Carrying Capacity												
Appereance_Quality										.726		
Perception Quality											.585	
Image_status_Esteem											.541	

	Component											
	1	2	3	4	5	6	7	8	9	10	11	12

Conversion_ICE_Ecar												.800
Good_return_on_Investment												

Table 9.4: Rotated Component Matrix

The extraction technique used over here is principal component analysis available in SPSS software.

Rotated component matrix table shows only those values which are greater than 0.5. Researcher has not considered four items whose factor loading are less than 0.5 for all the component. These four items are Non-availability of models, less pollution, carrying capacity & Good return on investment.

Cross loading was found between factor 2 (.564) & factor 5(.560) for item Spacious. So, researcher decided to retain loading for factor 2 and removing loading for factor 5.

Similarly, cross loading was found between factor 2 (.510) & factor 5(.540) for item Size. So, researcher decided to retain loading for factor 5 and removing loading for factor 2.

Cross loading was also found between factor 4 (.502) & factor 6 (.540) for item Law. So, researcher decided to retain loading for factor 4 and removing loading for factor 6. Now there is no cross loading in matrix and we have reached to a clean matrix. Thus, all the items are valid and unique. Hence data is suitable for factor analysis.

Factors:

Refuelling_Infrastructure	.774	Factor1	Free Parking	.749	Factor 2
Refuelling_location	.866		Insurance discount	.700	
Refuelling_Convenience	.779		No_tollroad_charges	.671	
Refueling time	.773		Bonus_for_scaraping_an_old_car	.669	
Refuelling_cost	.696		Cheap_car_insurance	.594	
Scarcity_of_fuel	.785		Spacious	.564	
Increased_fuel_price	.701		Latest Technology	.549	
Free refueling	.599		Technological features	.723	
Serviciabilty_Quality	.588				
High_resale_value	.554				
Costly_replacement_part	.655				
Distance_Covered_one_fully_tank	.613				

Low_cost_of_ownership_Economy	.845	Factor 3	Registration tax	.719	Factor 4
Low_maintenance_Economy	.810		Road tax	.708	
Low_running_cost_Economy	.790		Subsidy_Government_Policy	.674	
Cost-effective	.751		Favorable_policy_Govt_Policy	.649	
			Price_Economy	.522	
			Law	.502	

Vehiclepower_Quality	.892	Factor 5	Promotional activity	.867	Factor 6
Topspeed_Quality	.876		Awareness	.857	
Pick_up_Quality	.767				
Size	.540				

Saftey_Quality	.717	Factor 7	Comfortable_Driving_satisfaction	.766	Factor 8
Durability Quality	.700		Fatigue_free_Driving_Satisfaction	.761	
Reliabilty_Quality	.607		Easy_to_drive_Driving_satisfaction	.676	

Emission_testing_exemption	.842	Factor 9	Appereance_Quality	.726	Factor 10
Automatic transmission	.712				

Perception _Quality	.585	Factor 11	Conversion_ICE_Ecar	.800	Factor 12
Image_status_Esteem	.541				

Table 9.5: Factors

Researchers inquired about 52 items in the questionnaire. Out of 52 items four items has been rejected by SPSS. The remaining 48 items has been segregated in twelve components/factors by the spss. Researcher has named those factors accordingly. As per the researcher opinion few items segregated by SPSS is not relevant in that particular factor instead, they must belong to a different factor thus researcher has made corrective action to make the output more logical and appropriate. Similarly, after analyzing the items for the factor 9, researcher finds that these items are already related to an existing factor i.e. non-financial Incentive & technology. So, researcher decided to merge the factor 9 into factor 2. Thus total factors has became now eleven.

The detail of corrective action for concern factors are as follows.

Factor 1 – Refueling & Range: For this particular component /factor spss has segregated 12 items. These 12 items are shown in the table below. After analyzing these items researcher found that the majority of items was related to refueling & one item was related to range. But out of 12 items three items serviceability, High resale value and Costly replacement part seems to be odd. Thus, researcher decide to eliminate these three items from factor 1 and name the factor as Refueling & Range. The eliminated three items has been transferred to some other factors where they are relevant.

Refuelling_Infrastructure	.774	Factor 1	Refuelling_Infrastructure	.774	Refueling & Range
Refuelling_location	.866		Refuelling_location	.866	
Refuelling_Convenience	.779		Refuelling_Convenience	.779	
Refueling time	.773		Refueling time	.773	
Refuelling_cost	.696		Refuelling_cost	.696	
Scarcity_of_fuel	.785		Scarcity_of_fuel	.785	
Increased_fuel_price	.701		Increased_fuel_price	.701	
Free refueling	.599		Free refueling	.599	
Distance_Covered_one_fully_tank	.613		Distance_Covered_one_fully_tank	.613	

Serviciabilty_Quality	.588				
High_resale_value	.554				
Costly_replacement_part	.655				

Table 9.6: Refueling & Range

Factor 2- Non-financial Incentives & Technology:

For this particular component /factor spss has segregated 08 items. These 08 items are shown in the table below. After analyzing these items researcher finds that the majority of items are related to Non-financial Incentives & others are related to Technology. Thus, researcher decided to name the factor Non-financial Incentives & Technology. Similarly, for the factor 9, spss has segregated 02 items. These 02 items are Emission testing exemption & automatic transmission. After analyzing these two items researcher finds that these two items are again related to non-financial Incentive & technology. So researcher decided to merge the factor 9 into factor 2.

Free Parking	.749	Factor 2	Free Parking	.749	
Insurance discount	.700		Insurance discount	.700	
No_tollroad_charges	.671		No_tollroad_charges	.671	
Bonus_for_scaraping_an_old_car	.669		Bonus_for_scaraping_an_old_car	.669	
Cheap_car_insurance	.594		Cheap_car_insurance	.594	

Spacious	.564		Spacious	.564	Non-financial Incentives & Technology
Latest Technology	.549		Latest Technology	.549	
Technological features	.723		Technological features	.723	
			Emission testing exemption	.842	
			Automatic transmission	.712	

Table 9.7: Non-financial Incentives & Technology

Factor 3 – Economy of car:

For this particular component /factor spss has segregated 04 items. These 04 items are shown in the table below. After analyzing these items researcher finds that the majority of items are related to Economy of car. Thus, researcher decided to name the factor Economy of car.

Low_cost_of_ownership_Economy	.845	Factor3	Low_cost_of_ownership_Economy	.845	**Economy of car**
Low_maintenance_Economy	.810		Low_maintenance_Economy	.810	
Low_running_cost_Economy	.790		Low_running_cost_Economy	.790	
Cost-effective	.751		Cost-effective	.751	

Table 9.8: Economy of car

Factor 4- Financial Incentive, Law, Policy & Taxes

For this particular component /factor spss has segregated 06 items. These 06 items are shown in the table below. After analyzing these items researcher finds that the majority of items are related to Financial incentive, Law, policy & taxes. Thus, researcher decided to name the factor Financial Incentive, Law, Policy & Taxes.

Registration tax	.719	Factor 4	Registration tax	.719	**Financial Incentive, Law, Policy & Taxes**
Road tax	.708		Road tax	.708	
Subsidy_Government_Policy	.674		Subsidy_Government_Policy	.674	
Favorable_policy_Govt_Policy	.649		Favorable_policy_Govt_Policy	.649	
Price_ Economy	.522		Price_ Economy	.522	
Law	.502		Law	.502	

Table 9.9: Financial Incentive, Law, Policy & Taxes

Factor 5: Performance

For this particular component /factor spss has segregated 04 items. These 04 items are shown in the table below. After analyzing these items researcher finds that the majority of items are related to performance. But out of 04 items one item size seems to be odd. Thus, researcher decide to eliminate this item from factor 5 and name the factor performance. The eliminated item has been transferred to some other factors (Appearance & Design) where they are relevant.

Vehiclepower_Quality	.892	Factor 5	Vehiclepower_Quality	.892	Performance
Topspeed_Quality	.876		Topspeed_Quality	.876	
Pick_up_Quality	.767		Pick_up_Quality	.767	
Size	.540				

Table 9.10: Performance

Factor 6: Promotional activity & awareness

For this particular component /factor spss has segregated 02 items. These 02 items are shown in the table below. After analyzing these items researcher finds that the both items are related to Promotional activity & awareness**.** Thus, researcher decided to name the factor Promotional activity & awareness.

Promotional activity	.867	Factor 6	Promotional activity	.867	Promotional activity & awareness
Awareness	.857		Awareness	.857	

Table 9.11: Promotional activity & awareness

Factor 7: Quality

For this particular component /factor spss has segregated 03 items. These 03 items are shown in the table below. After analyzing these items researcher finds that all three items are related to Quality**.** Thus, researcher decided to name the factor Quality. One item - Serviceability that is segregated by spss in factor 1 found to be irrelevant in that factor but relevant in factor 7- quality. Thus, researcher has decided to include serviceability from factor 1 to factor 7.

Saftey_Quality	.717	Factor 7	Saftey_Quality	.717	Quality
Durability Quality	.700		Durability Quality	.700	
Reliabilty_Quality	.607		Reliabilty_Quality	.607	
Serviciabilty_Quality	.588		Serviciabilty_Quality	.588	

Table 9.12: Quality

Factor 8- Driving Satisfaction:

For this particular component /factor spss has segregated 03 items. These 03 items are shown in the table below. After analyzing these items researcher finds that all three items are related to Driving satisfaction**.** Thus, researcher decided to name the factor Driving satisfaction.

Comfortable_Driving_satisfaction	.766	Factor 8	Comfortable_Driving_satisfaction	.766	Driving Satisfaction
Fatigue_free_Driving_Satisfaction	.761		Fatigue_free_Driving_Satisfaction	.761	
Easy_to_drive_Driving_satisfaction	.676		Easy_to_drive_Driving_satisfaction	.676	

Table 9.13: Driving Satisfaction

Factor 9 Appearance/Design:

For this particular component /factor spss has segregated 01 items. This item is shown in the table below. After analyzing these items researcher finds that item is related to Appearance/Design**.** Thus, researcher decided to name the factor Appearance/ Design. One item -Size that is segregated by spss in factor 5 found to be irrelevant in that factor but relevant in factor 10- Appearance/Design. Thus, researcher has decided to include size from factor 5 to factor 10.

Appereance_Quality	.726	Factor 10	Appereance_Quality	.726	Appearance/ Design
Size	.540		Size	.540	

Table 9.14: Appearance/Design

Factor 10 Perception & Esteem

For this particular component /factor spss has segregated 02 items. These 02 items are shown in the table below. After analyzing these items researcher finds that all two items are related to perception & esteem. Thus, researcher decided to name the factor perception & esteem. Two items -High resale value & Costly replacement part which are segregated by spss in factor 1 found to be irrelevant in that factor but relevant in factor 11- Perception & esteem. Thus, researcher has decided to include High resale value & costly replacement part from factor 1 to factor 11.

Perception _Quality	.585	Factor 11	Perception _Quality	.585	Perception & Esteem
Image_status_Esteem	.541		Image_status_Esteem	.541	
High_resale_value	.554		High_resale_value	.554	
Costly_replacement_part	.655		Costly_replacement_part	.655	

Table 9.15: Perception & Esteem

Factor 11 Conversion

For this particular component /factor spss has segregated 01 item. This item has shown in the table below. After analyzing the item researcher finds item is related to Conversion of ICE car to E car**.** Thus, researcher decided to name the factor Conversion.

Conversion_ICE_Ecar	.800	Factor 12	Conversion_ICE_to Ecar	.800	Conversion

Table 9.16: Conversion

Chapter 10

Conclusion:

The Indian automotive industry is one of the largest in the world with an annual production at 23.96 million vehicles in FY 2015-16 accounting for around 7% of the country's Gross Domestic Product (GDP). (*Source: Karunakar, April 2017)* The growth of Indian auto Industry is remarkable from its inception. There is a phenomenal growth in the number of vehicles specially in two wheelers and cars.

For instance, Delhi could have about 380 cars per 1,000 population taking the total cars in the city from 2 million in 2011 to about 10 million by 2025. With this exponential growth there are two major implications - energy security and pollution - health and both are critical. *(Source: Proliferation of Cars in Indian Cities, TERI policy brief, Issue 12 June 2014)*

In India, Delhi is one of the main impacted cities in term of energy security and Pollution - health. A city of about 20 million has almost about 10 million vehicles. As per the economic survey(2017-18) Delhi has 556 motor vehicles per one thousand people, with every second person in the city owning a vehicle.(Source :auto economics times) .The total number of registered vehicles in Delhi has crossed one crore mark 1,05,67,7129 till May 2017*(Source: Transport department)* and cars have a significant number. The total number of registered cars in Delhi are 31,72,842(*Source: Transport Department)* till may 25 2017.

Our country heavily depends on imported crude oil & petroleum products to meet the numerous energy demand. As per the data there is a huge gap between the demand and supply of oil *(Source: U.S. energy information administration 2014)* and this gap is increasing year by year. The Transport sector is the largest consumer of petroleum products at 55%, with 98% of transport fuel being petroleum products and electricity accounting for the remaining 2% (*TERI 2012).* As per the data 70% of Diesel and 99.6 % of Petrol consumed by Transport sector. *(Ministry of Petroleum & Natural Gas,2014).* Within transport sector Road transport is one of the major consumers of crude oil & petroleum product. *(Source: Petroleum Conservation Research Association).* Road transport consumes more than 90% of the energy with road passenger transport consuming about 65%, and road freight transport about 35. *(Source: Proliferation of Cars in Indian Cities,2014 TERI).* Within road transport**,** cars consumed 34.33 % of Petrol and 13.15% of Diesel**.** *(Ministry of Petroleum & NaturalGas,2014).*

As world is already facing the challenge of oil scarcity *(Source: BP research)* there is a huge need of energy efficient road transport vehicles specially in country like India where oil import is too high *(Source: U.S. energy information administration 2014)*. In India the number of vehicles are maximum in Delhi *(Source: data.gov.in)* thus a huge demand for oil too.

Road transport is one of the major contributors of pollution *(Source: System of Air Quality and Weather Forecasting and Research (SAFAR))* it is mainly because of increased number of vehicles however other sources of pollution are also exist. As per the findings of the study, Heavy Commercial Vehicles (HCVs), commercial and privately-owned four-wheeler (4W) segment has emerged as one of the major polluting sources in Delhi.

Growth in the number of personal vehicles also leads to increasing levels of vehicular pollution in cities. It has been found that cities with high car-ownership levels have PM10 concentrations above the standards set by the World Health Organization (WHO).*(Source: Proliferation of Cars in Indian Cities, TERI policy brief, Issue 12 June 2014).*

Delhi has been declared the most polluted city of the world *(Source: WHO report, live mint*).

Thus, in this context, the Electric - Car being energy efficient & zero pollutant have the potential to deliver benefits for energy security and local environment. Thus, Delhi has lot to gain by converting its ICE cars to E cars at the earliest.

A study conducted by **(Ishrar Ahmad and KK Dewan Electric vehicle: a futuristic approach to reduce pollution -A case study of Delhi)** on a sample of 500 respondent in year 2006 reveals that 95.6% people are of the opinion that Delhi should be less polluted while 93 % people believe that EVs will reduce the pollution.

Thus, in this context this study has presented the enablers, barriers & measures for the adoption of e car in Delhi.

As per the report by **net scribes Automotive and Logistics Industry Series- Electric vehicle markets for India** (Global market intelligence and content management firm,2014) the drivers for e vehicles adoption are Government Initiatives, Rise in Fuel Costs, Low Operating and Maintenance Cost, Foreign Dependence for Crude Oil, Environment Friendly. While major barriers for the same are Low Vehicle Performance, Inefficient Battery, Price Constraint, Power Shortage, Lack of Infrastructure

A study conducted by **(Ishrar Ahmad and KK Dewan Electric vehicle: a futuristic approach to reduce pollution,2006 -A case study of Delhi)** on a sample of 500 respondent in year 2006 reveals that 85.8 % of respondents are willing to shift EVs if batteries could be charged easily and in lesser time and they also want the recharge facilities available at petrol pumps. Presently, 24.8% petrol and 1.8% diesel car owners are interested in shifting their vehicle to Electric. However, 73.4% people are not interested in shifting to EVs due to high initial costs and various other factors like electric problems, easy availability of petrol, seating capacity and mileage on a single charge.

As per the (Electric Vehicles in India A GERMI White paper,2014) The key challenges are, Cost, A negligible charging infrastructure, Lack of awareness, Lack of, manufactures, Long-term policy clarity, Subsidy is essential.

As per the study (Electric Vehicles in India: Market Analysis with Consumer Perspective, Policies and Issues, Pritam K. Gujarathi1, Varsha A. Shah) EV and PHEV will have promising future in India, however, its current growth will be limited and the limit is decided by policies and awareness creation.

As per the report **(Study on Electric Mobility in India by Amit Garg Indian Institute of Management**, Ahmedabad, Srinivas Cherla Sustain Impact) lack of clear government policies, lack of vehicle standards and wait and watch attitude of large auto makers meant that Indian EV sales are a mere 0.02% of total auto sales in 2016

In the context of this research, factors encouraging the purchase of e car and factors discouraging the purchase of e car in Delhi have been found by taking interviews of various stakeholder and applying grounded theory. The **enablers** are **Economy of car (Low running cost, Low maintenance), Environmental protection, driving satisfaction, Performance-pick up & image status**. Economy of car and Environmental protection performance-pickup & driving satisfaction have been identified as encouraging factors for the adoption of e car in earlier literature too **however image status, has been found a new enabler** as researcher has not found this factor as enabler in earlier studies**.**

As far as the factors discouraging the adoption of e car is concerned these are numerous. These are Quality (Design, features & safety), Non-availability of models, promotional activity, awareness, performance-top speed, Car budget, Taxing, Battery, government actions, charging infrastructure, Charging time, ICE car manufacturing intentions, law & policy, type of customers, range, profitable model, business in charging.

Out of these barriers ICE car manufacturer intentions, Type of customers, profitable model, Business in charging, Quality (Design, features & safety) & law have been found **as new barriers** as researcher has not found these barriers in earlier literature. However**,** policy, Promotional activity, awareness, distance covered in one full charge(range), government actions, charging infrastructure**,** Non-availability of models**,** Taxing, Battery, charging time**, have been identified as barriers in case of Delhi too.**

In objective 1 only the stated stakeholders but not consumers have been interviewed to find factors encouraging and discouraging the adoption of e car however consumer perception affecting the adoption of e car has been identified in 2nd objective to validate the data obtained from government, industry & others agencies.

The factors which are affecting the consumer's inclination towards e car are

Refueling & Range: Refueling (Refueling Infrastructure, Refueling Location, Refueling Convenience, refueling time, refueling cost, free refueling, Increased fuel charges, scarcity of fuel,) & Range (Distance covered in one fully tank).

Non-financial Incentives & Technology: Non-financial incentives (Free parking, Insurance discount, no toll road charges, bonus for scraping an old car, cheap car insurance) & technology (latest technology, Technical features, Spacious)

Economy of Car: (Low maintenance, low running cost, low cost of ownership, Cost effective)

Financial incentives, Law, policy & Taxes: (registration taxes, road tax, subsidy, favorable policy, price economy & law)

Performance: vehicle power, top speed, pickup

Promotional activity & awareness: promotional activity, awareness

Quality: (Safety, durability, reliability & serviceability)

Driving Satisfaction: Comfortable, fatigue free, easy to drive

Non-financial incentives & technology or Flexibility: Emission testing exemption, Automatic transmission

Appearance /Design: Appearance, size

Perception & Esteem: Perception, Image status, High resale value, costly replacement parts.

Conversion: ICE to E car

No doubt that encouraging factors like Economy of car, Environmental protection, driving satisfaction, Performance-pick up & image status are helpful for the acceptance of car however the discouraging factors are numerous and needs to be enhanced.

As far as the range is concern the available car have the enough range (around 100 km) for the city mobility. So, car is a good option for city mobility but seems to be impractical for more than that distance because of refueling issues & poor battery range.

As far as refueling is concerned refueling infrastructure is must and it should be available not only at residential places but also at various others locations like offices, market etc. so in case of range anxiety customer can recharge the battery. (Note: Researcher finished the research in Sep 2018 & Government has also taken action on the same in Delhi EV policy 27 Nov,2018)

Here one important point is that the while recharging the car charging time will play an extremely important role so it is advised that rather than installing normal charging station the focus should be on fast charging stations as no one would like to wait for 5-6 hours to get the car charged and almost every customer will prefer to charge at fast charging station. So, if both types of charging stations would be installed in that case customer will always prefer to charge at fast charging stations and that would be a total loss of money, time, place & energy. Slow charging station will also leave a negative impression on the psyche of customer and rather supporting the adoption it will damage the same. However slow charging stations may successful at residential place & offices. (Note: This thing has not been implemented & this recommendation may be taken in to consideration.)

Majority of customer do not want to purchase a car just for city mobility so range of the car should be increased by arranging improved & more efficient batteries & battery swapping stations. (Note: Researcher finished the research in Sep 2018 & Government has also taken action on the same in Delhi EV policy 27 Nov,2018)

Non-Financial incentives may also play an important role in boosting the sales of e cars. There should be free parking Emission testing exemption, Insurance discount, no toll road charges, bonus for scraping an old car, cheap car insurance etc. (Note: These things have not been implemented except onetime parking fee so this recommendation may be taken in to consideration).

As far as car budget is concern majority of customer who plans to buy a car first time generally has a price bracket of 3-4 lacs to maximum 5 lacs. They have a dream for it so the E Car price should be as par the ICE car price as customer does not want to pay more & take risk for a car which can go only 100 km while ICE car can go anywhere at the same price bracket. So even after paying the more price customer is not getting the range. As Indian customer is price sensitive too, so, anyhow cost of the car should be come down.

Price can be come down by providing financial incentives & by achieving economy of scale. There should be enough subsidy to make the car attractive for the buyers. The subsidy should be fairly enough so that the car price should touch near to ICE car price of the same segment as success of EV in China, Norway& other countries largely perceived to be because of subsidies. Unfortunately, as per recently launched FAME II scheme, govt. has ignored the passenger car for the benefits of subsidy. Source (Surprising that private electric cars left out from FAME II subsidy, https://www.financialexpress.com). (Note: This recommendation may be taken in to consideration)

As the battery pack is the most expensive single component in an electric car so GST on the battery pack should be minimized. It has been already reduced from 28 % to 18% which researcher think is still too much and will not help adequately in reduction of car price. This seems to be ridiculous one side govt. is focusing on the adoption of e vehicles and on the other side imposing a heavy GST on the most expensive battery pack. The Nil GST on electric battery would also boost startups and established manufacturers to make these battery packs. (Note: This recommendation may be taken in to consideration). Electric car sold with factory fitted battery are charged 12 % GST this should also be minimized. Vehicles part and components for assembly in India attracted import duty of 15-30 %. Govt has lowered the custom duty for such vehicle 10- 15 %.but These should also be minimized. (Note: Researcher finished the research in Sep 2018 & Government has also taken action on the same in Jan,2019) Import duty on battery packs should also be minimize.

As the battery pack is the most expensive single component in an electric car so to reduce the price company may sold the car and lease the battery. (Note: This recommendation may be taken in to consideration)

For initial few years or up to one lacs car the import duty on the battery pack should also be nil. So, for at least 1 lacs car the import duty should be Nil (Note: This recommendation may be taken in to consideration)

The registration tax, road tax should be nil at least for initial one lacs car. (Researcher finished the research in Sep 2018 & Government has also taken action on the same in Delhi EV policy 27 Nov,2018.)

As of now Mahindra was only manufacturer in e car segment now Tata has also entered because of government Bulk buying. Government Bulk buying is necessary as it (One tender of 10000 car by government) has given birth to one more car manufacturer other than Mahindra i.e. TATA that will also help in economy of scale. (Note: This recommendation may be taken in to consideration)

Thus, non-availability of models is also one of the major causes of low adoption of e car. The intentions of ICE car manufacturer seem to be not in favor of E car as they have a very strong inventory of ICE cars. So, keeping this view there should be a law & policy so that ICE car manufacturer would be enforced to produce the e cars. Once the competition will be there which in turn help in reduction of car price. Availability of more models will also offer a choice to customer with regard to quality, price & brand perception which will definitely boost the adoption. (Note: This recommendation may be taken in to consideration)

There are two types of customer one who is purchasing the car first time and other one who is already have a car and purchasing second car in family. There should be a law that whosoever is interested in purchasing a second car that car must be an e car. The first-time purchaser may go for any car but the Financial & Nonfinancial incentives along with quality & features of car make it so lucrative that customer may take a decision to purchase e car only. (Note: This recommendation may be taken in to consideration)

The awareness level of people is almost nil. There should be a proper focus on the promotional activity & awareness of the car like Swachh Bharat & Led bulb etc. Government should focus on awareness. There should be intensive advertising, test drives, awareness camps, awareness lectures in institutions, malls, offices and public places. (Note: This recommendation may be taken in to consideration)

Along with the demand side incentives there should be supply side incentives too to promote R & D. (Note: This recommendation may be taken in to consideration)

There is a need of ease of doing business in charging. Introduction of Feebate is necessary on ICE car as it will lead to a hike in price to collect the fund and collected fund should be used to subsidized the e car. (Researcher finished the research in Sep 2018 & Government has also taken action on the same in Delhi EV policy 27 Nov,2018.)

For Car, Company & industry:

As per the responses of the e car users the serviceability for the car is very poor as it is a new technology the serviceability should be as good as possible to satisfy the customer but company is not focusing on that and customer is facing a lot of issues.

As now a days most of the ICE cars have been equipped with safety features so safety features like air bags, strong body is also required.

In spite of being good pick up the Car's top speed is not acceptable to new generation It should be increased to attract new generation.

The focus should be on design and appearance too to make it more attractive

Customer is also looking for high resale value and secondary market needs to be created for the better resale price of the car.

The company should minimize the price of replacement part as per the survey customers were complaining about costly replacement part.

From industry point of view there is no profitable model. So, policy should be made in favor of manufacturer too.

As far as the conversion of ICE car in to e car is concerned then as per the data, 42% respondents are highly desirable, 29% respondents are desirable, 25% are neutral, 6% are undesirable and only 3 % are highly undesirable thus there is a need of developing & promoting the technology which can convert the ICE car into E car without compromising the safety and performance at a rational price. (Note: These all recommendations may be taken in to consideration.)

As per recently launched FAME II scheme, govt. has ignored the passenger car for the benefits of subsidy. Source (Surprising that private electric cars left out from FAME II subsidy, https://www.financialexpress.com).The reason for this is , the number of private electric cars plying on the roads is far too less, and hence it has decided to give cash subsidies to cab aggregators instead according to government officials.

This decision of government will make the sale of private e car almost nil as even a subsidized e car was struggling to sell for the last so many years. The new policy of government for e car hasn't made sense from a consumer point of view. This decision of the government seems to be highly unrealistic specially in case of Delhi where total number of registered cars till 31 may 2018 are 3132839. Rather than applying the policy uniformly in whole country it should be specific for different geographical & environmental locations specially those area where sale of cars & and pollution is at a higher side. The below analysis suggests that how useful it is for Delhi if all ICE cars have been replaced by E cars. The money saved in purchasing oil can be used to provide incentive to e cars and there is a reduction of pollution too.

As per the study by (**Ishrar Ahmad and KK Dewan Electric vehicle: a futuristic approach to reduce pollution,2006 -A case study of Delhi)** Around 500 respondents were interviewed personally and their viewpoints were brought into focus. The findings and observations of the respondents can be seen in the table below

1Average mileage of vehicle	15.29 Km/Lt.
2 Average distance travelled by a vehicle per day	39.78 Km
3 Average number of working days per month	24.06 days
Average CO emitted by a car	4 gm/Km
Average NOx and HC emitted by a car	2 gm/Km
Average pollution emitted by a car	(4 gm + 2 gm) = 6 gm/Km

Table 10.1: Findings and observations of the respondents by Ishrar Ahmad and KK Dewan

By taking the same values as reference lets calculate the impact on pollution and revenue

Impact on pollution:

Average distance travelled by a car per day 39.78 Km

Average no. of working days in a month 24.06 days

Average distance travelled by a car in one month =24.06 × 39.78 Km =957 Km

Average distance travelled by a car in one year= 957 × 12 =11484 Km

Average CO emitted by a car 4 gm/Km

Average NOx and HC emitted by a car 2 gm/Km

Average pollution emitted by a car (4 gm + 2 gm) = 6 gm/Km

Pollution emitted by a car per year= 0.006 Kg/Km 11484 Km= 68.9 Kg

Pollution emitted by 3132839 cars per year 3132839 × 68.9 Kg= 215852607.1 Kg= 215852.60 tones/year =2.15852 lac tones /year

If all these cars have been replaced by e cars, Delhi can save 2.15852 lac tones of pollution from cars only per year.

Impact on Oil

Average distance travelled by a car per day 39.78 Km

Average no. of working days in a month 24.06 days

Average distance travelled by a car in one month 24.06 × 39.78 Km =957 Km

Average distance travelled by a car in one year 957 × 12 =11484 Km

Average of the vehicle = 15.29 Km/Lt

oil required for a car per year = 11484/15.29 = 751.08 lt

oil required for 3132839 cars per year= 3132839 *751.08 =2353012716.08 lt

=2353012.716klt

=2.353012 lac tones

If all these cars have been replaced by e cars, Delhi can save 2.353012 lac tons of oil from cars only per year.

Impact on revenue

Average price of Oil = Rs.70 per lt

Amount required for 2353012716.08 lt = 2353012716.08 * 70=Rs.164710890125.6

= Rs.164 billion

In case of e car:

Average distance travelled by a car per day 39.78 Km

Average no. of working days in a month 24.06 days

Average distance travelled by a car in one month 24.06 × 39.78 Km =957 Km

Average distance travelled by a car in one year 957 × 12 =11484 Km

Average of e car =100 km per charge consuming 10 units means 1unit =10 km

No of units required for 11484 km = 11484/10=1148.4 units

No. of units required for 3132839 cars per year = 3132839* 1148.4 units = 3597752307.6 units

Average price of units =Rs. 6

Amount required for 3597752307.6 units per year = Rs 6*3597752307.6 = Rs. 21586513845.6= Rs. 21 .58 billion

Thus, Delhi can save Rs (164 billion- 21billion) = 143 billion in year.

Final Model:

Methodology for Model Development

The base methodology of the research is the grounded theory thus model is developed using grounded theory. Therefore, Methodology for model development is grounded theory. However, while developing the model output of objective 2 has been clubbed with output of objective 1 for the development of final model.

The process of Model development is shown in the below diagram.

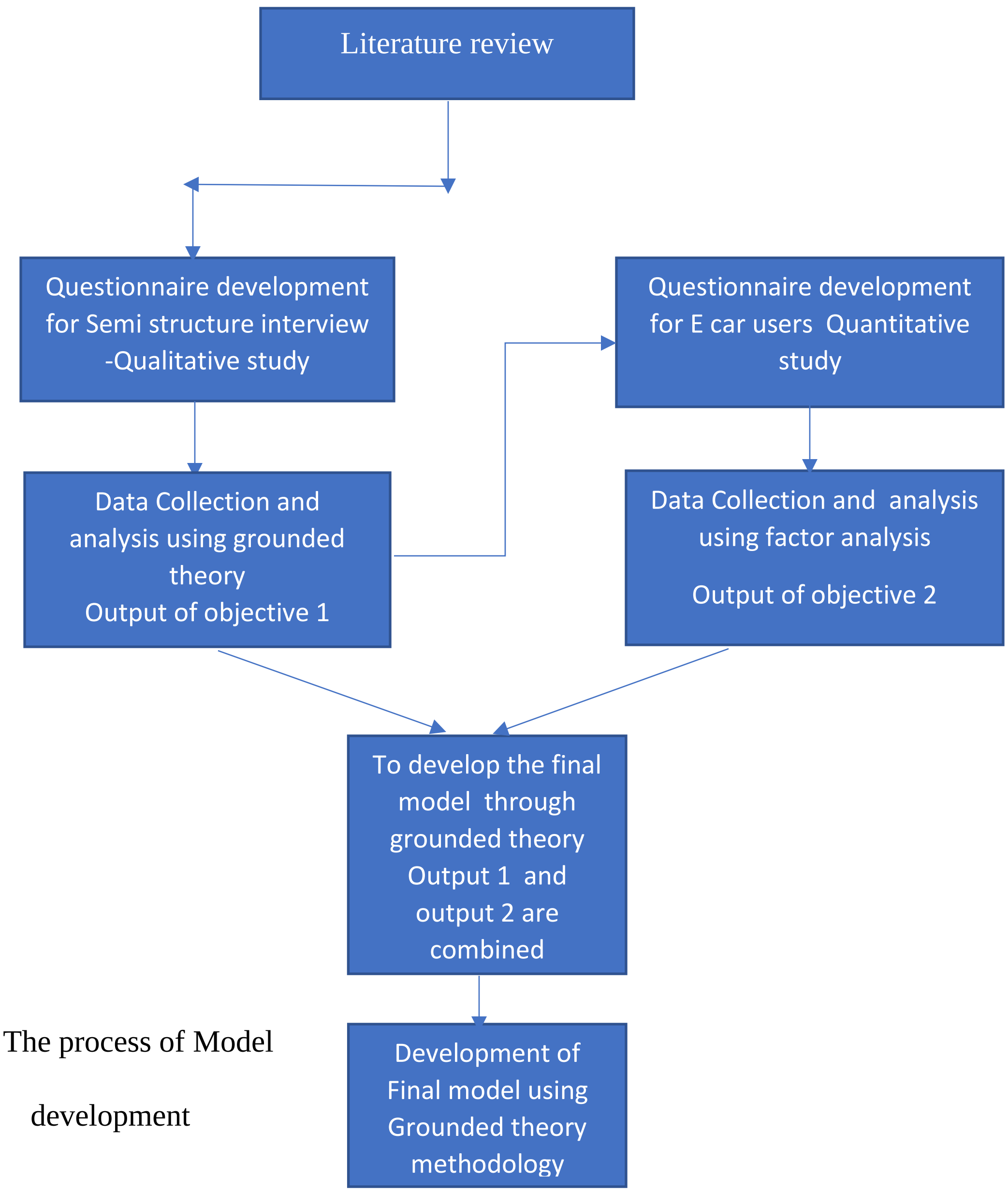
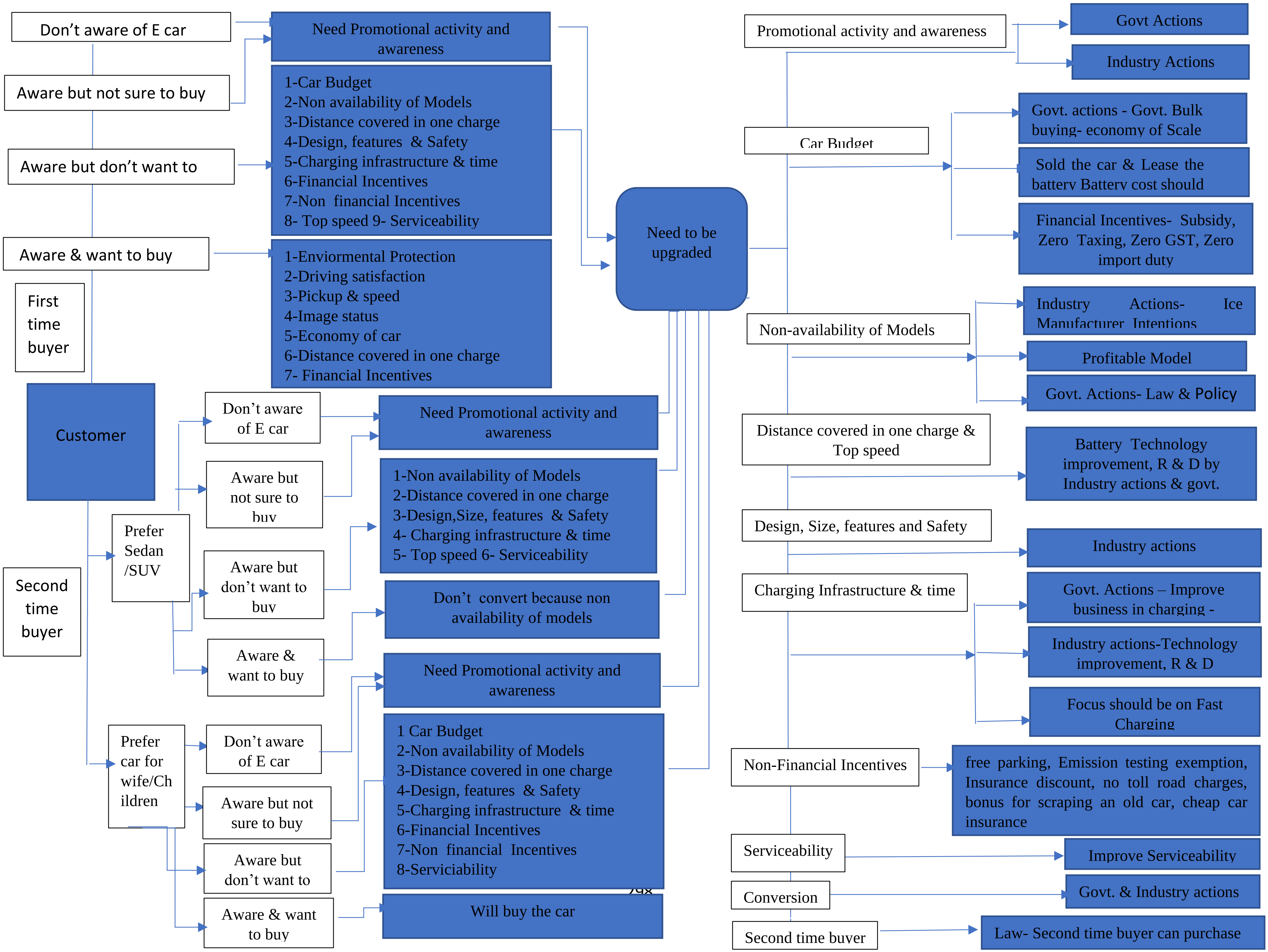


Fig. 10.1: The process of Model development


Don't aware of E car
Aware but not sure to buy
Aware but don't want to
Aware & want to buy
First time buyer
Customer
Second time buyer
Need Promotional activity and awareness
1-Car Budget
2-Non availability of Models
3-Distance covered in one charge
4-Design, features & Safety
5-Charging infrastructure & time
6-Financial Incentives
7-Non financial Incentives
8- Top speed 9- Serviceability
1-Enviormental Protection
2-Driving satisfaction
3-Pickup & speed
4-Image status
5-Economy of car
6-Distance covered in one charge
7- Financial Incentives
Prefer Sedan /SUV
Don't aware of E car
Aware but not sure to buy
Aware but don't want to buy
Aware & want to buy
Need Promotional activity and awareness
1-Non availability of Models
2-Distance covered in one charge
3-Design,Size, features & Safety
4- Charging infrastructure & time
5- Top speed 6- Serviceability
Don't convert because non availability of models
Need Promotional activity and awareness
Prefer car for wife/Children
Don't aware of E car
Aware but not sure to buy
Aware but don't want to
Aware & want to buy
1 Car Budget
2-Non availability of Models
3-Distance covered in one charge
4-Design, features & Safety
5-Charging infrastructure & time
6-Financial Incentives
7-Non financial Incentives
8-Serviciability
Will buy the car
Need to be upgraded
Promotional activity and awareness
Govt Actions
Industry Actions
Car Budget
Govt. actions - Govt. Bulk buying- economy of Scale
Sold the car & Lease the battery Battery cost should
Financial Incentives- Subsidy, Zero Taxing, Zero GST, Zero import duty
Non-availability of Models
Industry Actions- Ice Manufacturer Intentions
Profitable Model
Govt. Actions- Law & Policy
Distance covered in one charge & Top speed
Battery Technology improvement, R & D by Industry actions & govt.
Design, Size, features and Safety
Industry actions
Charging Infrastructure & time
Govt. Actions – Improve business in charging -
Industry actions-Technology improvement, R & D
Focus should be on Fast Charging
Non-Financial Incentives
free parking, Emission testing exemption, Insurance discount, no toll road charges, bonus for scraping an old car, cheap car insurance
Serviceability
Improve Serviceability
Conversion
Govt. & Industry actions
Second time buyer
Law- Second time buyer can purchase

Contribution to Theory:

Out of available models on adoption theory, three models best fit for the research.

1-Diffusion of Innovation Theory Roger (Roger, 1960)

2-Technical Adoption Model (Fred D Davis, 1989):

3-Extended TAM2 model (Venkatesh and Davis, 2000)

In the Extended TAM 2 model, Venkatesh & Davis modified TAM to include additional key determinants of TAM's perceived usefulness and usage intention constructs in their extended TAM model.

The additional constructs included social influence processes (subjective norm, voluntariness and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability and perceived ease of use)

After the research, researcher identified that in the extended TAM2 model in the additional constructs -cognitive instrumental process which contain Job relevance, output quality and result demonstrability the output quality should be replaced by overall quality. As while taking an adoption decision of an innovation or new product the adopter does not look only for output quality while it evaluates overall quality. Like in case of e car only output performance (output quality) is not a major factor for low adoption while other quality features are also important for low adoption.

Thus, the construct - quality will be a contribution to theory.

Contribution to Literature:

Based on the overall literature review including the literature review of theoretical premises researcher has come across the research gap and to address that gap work has established the contribution to literature.

The contribution to literature is mention below.

1- **Enabler:** “Image status”

2- **Barriers**-

a-ICE car manufacturer intentions

b-Type of customers

c-Profitable model

d-Business in charging

e-Quality (Design, features & safety)

f-Law

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Appendix A

Questionnaire for Semi Structured Interview

1-What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

3-- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

a-Price

b-Range What do you think the reason behind range Anxiety?

c-Power

d-Top Speed

e-Adequate Charging stations

f-Charging Time

g-Charging Convenience

h-Image status of owing an e car

I-Battery & Battery Cost

5-Does limited choice (Models)- and Competition (one-two manufacturer only) - (Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

6- Do you think that the current electric car Subsidy is enough to meet the NEMMP target in Delhi If yes then why? If No then Why?

7- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

11- What Infrastructure and resources are required to support mass adoption?

Appendix B

Detailed description of all the stake holders

Type of Agency	Agency	Name	Designation	Address and Contact
Government	1-National Automotive Board under the department of Heavy Industry - FAME India	Shri Praveen Aggarawal	Director	Room Number -117 Udyog Bhavan New Delhi Email- pravin.agrawal@nic.in Contact:011-23062182
	2-EESL- Energy Efficiency Services Limited under Ministry of Power	Mr. Sambit Patil	Consultant	Contact: 7042383283

Type of Agency	Agency	Name	Designation	Address and Contact
Private	SMEV-Society of Manufacturers of Electric Vehicles	Mr.Alok	Director-Research	CGF 3 & CGF 4 Okhla Industrial Estate Phase III New Delhi 100020 Email- alokray1986@gmail.com, Info@smev.in Contact:**011-41820055**

Type of Agency	Company	Name	Designation	Address and Contact
Manufacturer	Mahindra Electric Mobility Limited	Mr. Rachit Khanna	Regional Manager	Mahindra and Mahindra Ltd located at 2 A Mahindra Tower, New Delhi, Delhi Telephone Number 011-41220302

Type of Agency	**Dealer**	**Name**	**Designation**	**Address and Contact**
Dealers	1-Genesis Cars	Mr.Sunil Mr.Ankit Sharma Mr.Praveen Rana	Senior Sales Consultant Team Leader Senior Sales Consultant	B-1 ,A10. Mohan Cooperative Mathura Road Delhi Contact:01142187777
	2-Koncept Automobile	Mr. Gaurav Chaudhary Mr.Pushpender	Experience Executive Team Leader	24 A, Part 4, Ring Road Lajpat Nagar Near Max Hospital New Delhi, Delhi 110024 Contact: 01146787777
	3-Sri Durga Automobile	Mr.Utsav Mr. Ashu Sharma	Experience Executive Corporate Manager	Shri Durga Automobile Moti Nagar Delhi Contact: 01141103750

Appendix C

Transcript of interviews of all stake holders

1-Stakeholder: Government of India

Contact Person: Mr. Pravin Agarwal

Designation: Director (Heavy Industry Department -Ministry of Heavy Industries and Public Enterprises- Government of India)

Contact:011-23062182

Address: Room No:117, Udyog Bhawan, New Delhi-110011

Q1- What are the major barriers for the low adoption of E Car by consumers in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per the discussion held during semi structured interview with Shri Pravin Agarwal the major factor is non-availability of models from industry point of view.

Government job is to promote and that we are doing promotion. Ice car has developed because of availability of model's efficient models, cost effective models, good models in the market, If there will be products in the market it will be sell. As ICE cars various models available which cost effective so people purchase them similarly if E cars models will be available people will start purchase them too.

Same from society point of view i.e. non-availability of models

Q2-- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

It depends on the quality of the products. There are some deciding parameters for purchasing a car like Speed, Comfort, acceleration, leg space etc. until customer will not satisfy with these, he will not purchase e car. Thus, e car should be as par with the ICE car only then customer will purchase.

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

No need of awareness. If we do the awareness and then customer will go market to purchase the car and there is no or very less cars in the market how they will purchase.

Indian market does not purchase car more than 3-4 lacs that is why other companies have not manufacturing the car . Government is trying.

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why? As per them hi the answer

a-Price	A
b-Range	NA
c-Power	NA
d-Top Speed	NA
e-Adequate Charging stations	A
f-Charging Time	A
g-Charging Convenience	NA
h-Image status of owing an e car	A
I-Battery & Battery Cost	A

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

Yes it is a major issue.

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?

Subsidy is enough. Not an issue.

.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Enough. Not an issue

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No idea. MORT department.

Q9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

Lack of models.

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

Yes, it is.

Q11- What Infrastructure and resources are required to support mass adoption?

Technology, R & D, Charging infrastructure in offices and Malls, Indian manufacturing

2- Stakeholder: EESL

Contact Person: Mr. Sambit Patil

Designation: Consultant (Energy Efficiency Services limited) from PWC

Contact:

Address: EESL, Sector 1, Noida

Q1- What are the major barriers for the low adoption of E Car by consumers in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

People are not aware about e car . Range anxiety from society point of view. People beleive car is very costly and it is infect .But overall life time cost is consider then e car is better .Even government entities and educated people are not aware. Because they have never seen e cars on the road.

Options are limited. Cost is another factor. So when manufacturer will know that there is attender for 10000 car they can think that this is also one of the area to enter and they can optimize their cost. It does not make a financial sense to them to invest in a technology and redevelopment their assembly line.

Manufacturer were not getting the confidence to invest.

Government is seriously looking for a transition to Indian mobility. There are lot of enabling policy ,couple of question on Charging Infrastructure ,how it will be set up ,who will own the charging infrastructure ,what should be tariff.

Necessary Volume is one of the barriers for getting confidence to manufacturers.

Q2-- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

Positive government policy and direction from the industry point of view as well from government point of view

Operating cost of EV is cheaper from society point of view

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

Need of awareness.

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

As per them him the answer

a-Price	NA
b-Range	A
c-Power	A
d-Top Speed	A
e-Adequate Charging stations	NA
f-Charging Time	NA
g-Charging Convenience	NA
h-Image status of owing an e car	A
I-Battery & Battery Cost	No comment

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

No it is not a major issue for his tender.

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?

Subsidy is enough. Not an issue.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Can’t comment.

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No idea.

Q9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

Cost must reach at optimum level.

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

No. If you consider the life cycle of car.

Q11- What Infrastructure and resources are required to support mass adoption?

Charging Infrastructure ,EVSE infrastructure.

3-Stakeholder: Society of Manufacturing of Electric Vehicles

Contact Person: Mr. Alok Ray,

Designation : Manager -SMEV

Contact:011-41820055

Address:

Q1- What are the major barriers for the low adoption of E Car by consumers in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per the discussion held during semi structured interview with Mr. Alok as per his opinion major factors are Price even after subsidy. There is huge difference between quality and performance of Ice and e car at the same price like Low speed charging, Range limit, Technically issue, price issue .

There is a problem in Government observation also as Indian component market is one of the best in world. Government does not want to anything like which leads to unemployment for number of people.

Industry can not reduce the cost because of margin of dealers.

Q2-- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

1-Infrastructure if customer will see the chargers will definitely purchase the car. e car saves money and in 5-6 years car will be free. While Ice car run on Rs 70 km per liter petrol /Diesel.

Battery Cost will be reduce after 5- 6 years so battery would not be an issue.

2- Government Bulk buying (One tender of 10000 car by government has given birth to one more car company other than Mahindra i.e. TATA.

3-If Industry and society will see the Infrastructure then condition will be improved.

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

Nothing almost zero.Very important to aware people like sawacha bharat, Led bulb,ujjabla etc.Electric car on roads not only save your smoke but petrol and diesel too and ultimately import and thus money.

Causes of awareness is that Government is not focusing. It is not an issue for government. Even FAME does not have a budget for Advertisement. SMEV requested so many times but they did not listen.

There is no Industry only Mahindra for the last five years he is running R & D.So industry can not be blamed.

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

As per them him the answer

a-Price	NA
b-Range	NA
c-Power	A
d-Top Speed	NA
e-Adequate Charging stations	NA
f-Charging Time	NA
g-Charging Convenience	NA

h-Image status of owing an e car NA

I-Battery & Battery Cost NA

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

Yes it is a major issue.

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?

Subsidy is not enough. At least we require three times subsidy for car. Car is a dream for first time buyer and their budget lies generally within 4-5 lacs so they will not purchase a headache by purchasing e car at the same price if compare with Ice.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Only Demand incentive . Not enough .Nothing for manufacturer.

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Nothing.

Q9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

From industry point of view there is no profitable model of business. From government point there is a strong lobby of ICE car manufacturer who control the government . So intentions are not positive.

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

Yes it is. It is more than two times better.

Q11- What Infrastructure and resources are required to support mass adoption?

Easy availability of Charging stations. Easy way of doing business in charging

Till the date Resale of electricity is not yet allowed. One has to go through discom only. RTO- every state has different policy

One has to go through cabinet . There is a need of law. There should be Law for resale of electricity.

There should be law for no registration requirement for e vehicles. There should be amendment in central motor act.

Additional Information:

Car battery is taxed at 28 % which is a major part of e car and constitute 60% cost of car. Car is taxed at 12 %. So for an 8 lacs car you have to pay approximate 1 lac tax . and subsidy by central govt is 1.24 lacs. So compare and see.

4- **<u>Stakeholder: Dealer 1 Genesis</u>**

Contact Person:

1-Mr. Sunil Designation: (Senior Sales Consultant)

2-Mr. Praveen rana Designation: (Senior Sales Consultant)

3-Mr. Ankit Sharma Designation: (Team leader)

Address: Genesis, Mohan Cooperative, Delhi

Contact:011

Q1- What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per the discussion held during semi structured interview with Mr. Sunil, Mr. Rana and Mr. Ankit - as per their opinion range is one of the major barriers from industry and society point of view.

Price is another major barrier as at comparatively low cost (3-4 lacs) other companies are offering better features. So customer mentality is that e car must come in this price range. So why to pay 8-10 lacs and then wait for subsidy return.

Another major points are Safety , looks- style.

As per them government is less aggressive.

Q2-- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per their opinion pollution is one of the major enabler other enablers are noise free, low running cost, Low maintenance cost, good technology

Dealers are also waiting for government to announce that we are fully ready to adopt the car so that dealer and manufacturer will start investing in E Car.

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

Need awareness, Government is not fully prepared for e- car

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

As per them the answer

a-Price	NA
b-Range	NA
c-Power	No issue
d-Top Speed	No issue
e-Adequate Charging stations	NA
f-Charging Time	NA
g-Charging Convenience	NA
h-Image status of owing an e car	NA
I-Battery & Battery Cost	NA

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

Yes it is . When there will be competition only then customer visit for comparison and dealer also have some point to differentiate.

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?

Subsidy is enough but customer is not believing on electric. Government may think to increase subsidy if customer will show interest in E- Car. Hardly 2-3 e cars sold in a month as very few customer enquire. so we do not have a range of customer to analyze data about subsidy. Those who visit are almost satisfied with subsidy.

But if subsidy will increase then more customer may purchase.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Nothing like that for dealers.

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Nothing like that.

Q9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

Answer already giving in previous questions.

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

Yes, it is. As you are getting better design, better safety, big size, better feeling and of course no range anxiety.

Q11- What Infrastructure and resources are required to support mass adoption?

Range should increase by any means, some charging point should be there on petrol pumps, Subsidy and price range should be reasonable 5- 6 lacs, Look, status and features should match as per today's generation, Safety is almost nil

Some additional information:

Mostly 45 -60 age group person are showing interest in E- Car whose daily running is mostly around 60-70 km. Corporates are showing interest for their employees whose daily running is mostly around 60-70 km.

This car is basically for city drive . Other consumer are wives and school and college going children.

Car is costly as there is no coemption so Competition is must .

5-Stakeholder: Dealer 2

Contact Person: Gaurav Chaudhary **Contact: 9711610461**

Designation: Experience Executive **Address:**

Q1- What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per the discussion held during semi structured interview with Mr. Gaurav Chaudhary and as per his opinion people are saying there should be charging stations at the road and duration of charging should be decreased from six hours otherwise car is great. It is fatigue free and low maintenance car.

As per him government is happy and ordering fatigue free and Zero maintenance car.

From society point of view he says some of the customer is very much intelligent and they are liking and and heading towards e car and avoiding diesel car. Adequate awareness is one of the major barrier from society point of view.

Low Advertising and promotional activities is another barriers .

Q2-- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per their opinion pollution is one of the major enabler other enablers are noise free, Good Mileage , maintenance free, automatic car, good technology ,car is worth paying it's cost as compare to ICE car as in ten years diesel /Petrol and maintenance cost will double the price of ICE car. Small compact car. It takes 10-12 units only to full charge i.e. to run 100 km.

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

Need awareness

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

As per them the answer

a-Price	Acceptable
b-Range	NA
c-Power	Acceptable
d-Top Speed	Acceptable
e-Adequate Charging stations	NA
f-Charging Time	NA
g-Charging Convenience	Acceptable
h-Image status of owing an e car	Acceptable
I-Battery & Battery Cost	Acceptable

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

Yes limited choice(Models)- and Competition is a barrier . When there will be competition more advertising and promotion by competitors.

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMMP target in Delhi If yes then why? If No then Why?

Govt has to play more role in this. Sales is less only because of government .huge registration charges of 60-70 k this is Public feedback. If government wants to protect the environment why government charges huge registration charges.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No Idea

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No Idea

Q9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

No promotional and awareness programme by government

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

Yes as per the customer. Price is so high and that is because of government at this price customer can switch to a big ICE car or CNG car without range anxiety with good power. First of all one should build the base i.e. charging station. So every 10 -15 km there should be some charging station. Charging time should reduce.

Q11- What Infrastructure and resources are required to support mass adoption?

First of all u have to built up the base first promote the power charging station. You are promoting car not charging station. This is the best car , There should be no comparison with ICE car. This is the future. If I stuck some where in jam first thing will come where should I charge this car.so if every 10-15 km there will be charging station you will completely feel free wherever you want to drive. Charging time should reduce.

<u>Some additional information:</u>

If this car will be launch in the range of 3-4-5 lacs the sales will be boost like any thing and a moral booster for dealers also to promote the car.

In India if people are not ready to purchase 100km range car how they will charge 300 km range car as price will increase.

<u>6- Stakeholder: Dealer 3 Shri Durga</u>

Contact Person: Mr. Utsav Gahlot Designation: Experience Executive

Mr. Ashu Sharma Designation: Corporate Manager

Contact:9582158235

Address's Druga, Moti Nagar

Q1- What are the major barriers for the low adoption of E Car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

As per the discussion held during semi structured interview with them the major barriers are Cost and Range. First time buyer generally purchases small car. So, price and limited Range does not suits him whatever his uses. Fiber body is also one of the factor. So customer hesitates to buy.

From manufacturer point of view Battery cost is high.

From government point of view Subsidy for battery making or for importing government is not providing any support for manufacturer. Customer Awareness is one of the factor.

From society point of view range is a major issue. Charging is secondary issue as no one has that much of time in life to charge for 3 -4 hours during 200 km journey.

Customer is not taking initiative for environment. Car is small but at that range one can buy a bigger car. Ice car has a option of go any way within 5-7 lacs.

At the same range one can purchase Designer, spacious, stylish, Comfortable car .

Q2- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

It's Buyers have different thinking. People should take initiatives for environment protection People thinking should be changed in India as in India people thoughts are to purchase a bigger car as compare to others. Mostly buyer's are educated. Mostly, Doctors , engineers, Professors,.

Better speed, Better range , Reduced charging time, .

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

Need awareness 15-20 % only

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

As per them the answer

a-Price	NA
b-Range	NA
c-Power	NA
d-Top Speed	NA
e-Adequate Charging stations	NA
f-Charging Time	NA
g-Charging Convenience	NA
h-Image status of owing an e car	NA
I-Battery & Battery Cost	NA

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

Yes it is . When there will be competition the more options available to customer .

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMMP target in Delhi If yes then why? If No then Why?

Subsidy is enough.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No Idea

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No Idea

Q9- Even after formulation of NEMMP the sale of E cars is not picking up as desired. Where are the Industry and government lacking?

Range, Price and No promotional and awareness programme by government

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

Yes, ICE car is better.

Q11- What Infrastructure and resources are required to support mass adoption?

Quick charge options should be there.

<u>Some additional information:</u>

Industry should think for first time car buyer. Industry should think for price bracket in which first time car buyers can be fit. In today's time the customer who is purchasing E Car generally already have one or two car.

<u>Stakeholder 7-: Mahindra Electric Pvt. Ltd</u>

Contact Person: Mr. Rachit Khanna

Designation: Regional Manager (Mahindra Electric Pvt. Ltd.)

Contact:

Address:

Q1- What are the major barriers for the low adoption of E Car by consumers in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

No issue from industry point of view. Government may take some more initiatives. People are adopting it gradually.

Q2-- What are the major enablers for the adoption of E car by consumer in Delhi in your opinion?

a-From Industry Point of view

b-From Government Point of view

c-From Society point of view

Pollution free, Low maintenance cost, Low running cost, Life time cost is less, subsidy by government, easy to drive

Q3- Does Delhi have an adequate awareness for electric Car If yes then How? If No then Why?

No

Q4-Do you think that given below parameters of current electric car is acceptable in Delhi If yes then How? If no then Why?

As per them him the answer

a-Price	A
b-Range	A
c-Power	A
d-Top Speed	A
e-Adequate Charging stations	A
f-Charging Time	A
g-Charging Convenience	A
h-Image status of owing an e car	A
I-Battery & Battery Cost	NA

Q5-Does limited choice(Models)- and Competition (one-two manufacturer only) -(Major one only) of electric car is a major barrier for Competitive price, range and charging infrastructure. If No Then Why?

Yes it is an issue.

Q6- Do you think that the current electric car Subsidy is enough to meet the NEMM target in Delhi If yes then why? If No then Why?

Subsidy is enough.

Q7-- What are the current financial incentives that government offers to promote the vehicle? Do you think that the current financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

Can’t comment

Q8- What are the current Non-financial incentive that government offers to promote the vehicle? Do you think that the current Non-financial incentives for electric car is enough to promote the vehicle and to meet the NEMMP target in Delhi If yes then why? If No then Why?

No idea.

Q9- Even after formulation of NEMMP the sales of E car is not picking up as desired. Where are the Industry and government lacking?

Charging Infra & lack of models.

Q10- Do you think that at the price of current electric car the ICE car is a better option in Delhi If yes then why? If No then Why?

No

Q11- What Infrastructure and resources are required to support mass adoption?

Charging infrastructure and low-priced battery.

Appendix D

Questionnaire-Purchasing of Car

Dear Respondents,

How influential are the following parameters when purchasing a car? Please give your response. The data collected through this questionnaire will not be used for any purpose other than research. The data findings would be presented in aggregate and no identification whatsoever would be made with any of the respondents. Thus, you are requested to share accurate and honest response.

Q 1- How influential are the following factors when purchasing a car?

Factors	**Very Influential**	**Influential**	**Neutral**	**Non-influential**	**Very Non-Influential**
Economy of car					
Price					
Low running cost/good Mileage					
Low maintenance					
Low cost of ownership (Purchase price + Cost of operations)					
Cost effective (effective or productive in relation to its cost)					
Environment protection					
Less pollution/Save smoke					
Quality:					
1-Performance (How well does the product perform with respect to its intended use? elementary functioning					

characteristics of a product; how well a car is handled.)					
1a- Pick up					
1b- Top Speed					
1c- Vehicle power					
2-Apperance/looks (How pleasant is the outward look, smell, taste, feel, or sound of the product to the customers?)					
3-Safety (How much care the company has taken to make the product safe for users before, during & after use? It's a kind of declaration that product will not harm the customer; a particularly significant consideration for automobiles)					
4-Perceptions/Brand (Individual insights based on brand name, advertising)					
5- Reliability (Likelihood that a product will function appropriately within an expected time frame)					
6-Durability (– How long can the product perform before needing any repair or replacement of parts?)					
7-Serviceability (– How easily, cheaply, and speedily can the product be repaired and serviced?)					
Driving Satisfaction					

1- Comfortable					
2-Easy to drive					
3-Fatigue free					
Running capacity in one fully filled Tank.					
Distance covered in one fully filled tank.					
Image status					
Image status/Esteem					
Refueling Infrastructure					
Refueling Infrastructure					
Refueling Infrastructure location					
Refueling Cost					
Refueling Convenience					
Refueling time					
Increased fuel price					
Scarcity of Fuel					
Free Refueling					
Non-Availability of model					
Limited choice for selection /purchasing of car					
Promotional activity & awareness					
How awareness influences car purchasing decision?					
How Promotional activity influences car purchasing decision?					
Law & Policy					

How may law influence car purchase decision?					
Tax					
Road tax					
Registration Tax					
Government Policy					
Subsidy					
Favorable policy					
Some other Factors					
Spacious					
Size/Hatchback/SUV/Sedan					
Technological features					
Cheap car insurance					
High resale value					
Latest Technology					
Good return on investment					
Carrying Capacity					
Costly replacement part					
Automatic transmission					
Bonus for scraping an old car					
Free parking					
Emission testing exemption					
Insurance discount					
No toll road charges					

Appendix E

Questionnaire - E Car

Q- Where your e car stands with respect to following parameter?

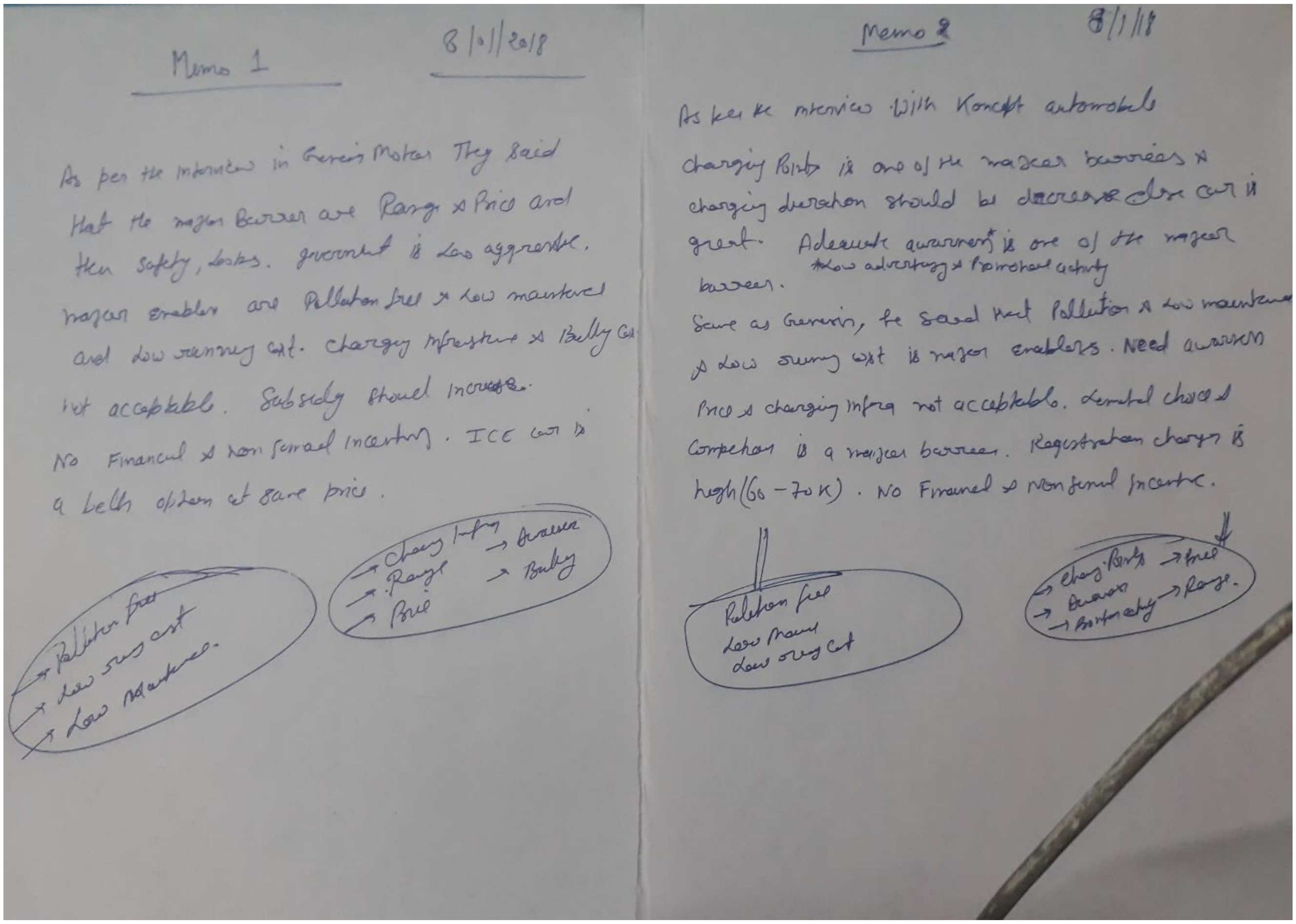
Factors	Very Influential	Influential	Neutral	Non-influential	Very Non-Influential
Economy of car					
1-Price					
2-Low running cost/good Mileage					
3-Low maintenance					
4-Low cost of ownership (Purchase price + Cost of operations)					
5-Cost effective					
Environment protection					
1-Less pollution/Save smoke					
Quality:					
1-Performance (How well does the product perform with respect to its intended use? elementary functioning characteristics of a product; how well a car is handled.)					
1a- Pick up					
1b- Top Speed					
1c- Vehicle power					
2-Apperance/looks (How pleasant is the outward look, smell, taste,					

feel, or sound of the product to the customers?)					
3-Safety (How much care the company has taken to make the product safe for users before, during & after use? It's a kind of declaration that product will not harm the customer; a particularly significant consideration for automobiles)					
4-Perceptions/Brand (individual insights based on brand name, advertising.					
5- Reliability (Likelihood that a product will function appropriately within an expected time frame)					
6- Durability (– How long can the product perform before needing any repair or replacement of parts?)					
7-Serviceability (– How easily, cheaply, and speedily can the product be repaired and serviced?)					
Driving Satisfaction					
1- Comfortable					
2-Esy to drive					
3-Fatigue free					
Running capacity in one fully charged battery/ filled Tank.					

1-Distance covered in one fully filled tank.					
Image status					
1-Image status/Esteem					
Refueling /Charging Infrastructure					
1-Refueling/Charging Infrastructure					
2-Refueling /charging Infrastructure location					
3-Refueling/ Charging Cost					
4-Refueling /Charging Convenience					
5-Refueling /charging time					
6-Increased fuel price					
7-Scarcity of fuel					
8-Free Refueling/Charging					
Non-Availability of model					
1-Limited choice for selection /purchasing of car					
Promotional activity & awareness					
1-How Promotional activity influences car purchasing decision?					
2-How awareness influences car purchasing decision?					
Law					

1-How may law influence car purchase decision?					
Tax					
1-Road tax					
2-Registration Tax					
Government Policy					
1-Subsidy					
2-Favorable Policy					
Some other Factors					
1-Spacious					
2-Size/Hatchback/SUV/Sedan					
3-Technological features					
4-Cheap car insurance					
5-High resale value					
6-Latest Technology					
7-Good return on investment					
8-Carrying Capacity					
9-Costly replacement part					
10-Automatic transmission					
11-Bonus for scraping an old car					
12-Free parking					
13-Emission testing exemption					
14-Insurance discount					
15-No toll road charges					
Conversion	**Highly Desirable**	**Desirable**	**Neutral**	**Non-Desirable**	**Highly Non-Desirable**
1-Would you prefer to convert your Petrol/Diesel car into E car at rational price rather than buying it?					

Appendix F: Memos



Memo 1 8/01/2018

As per the interview in Genesis Motor They said that the major Barrier are Range & Price and then safety, losses. government is less aggressive. major enablers are Pollution free & low maintenance and low running cost. charging infrastructure & Battery cost not acceptable. Subsidy should increase.
No Financial & non financial incentive. ICE car is a better option at same price.

→ Pollution free
→ low running cost
→ Low Maintenance.

→ Charging Infra → Awareness
→ Range → Battery
→ Price

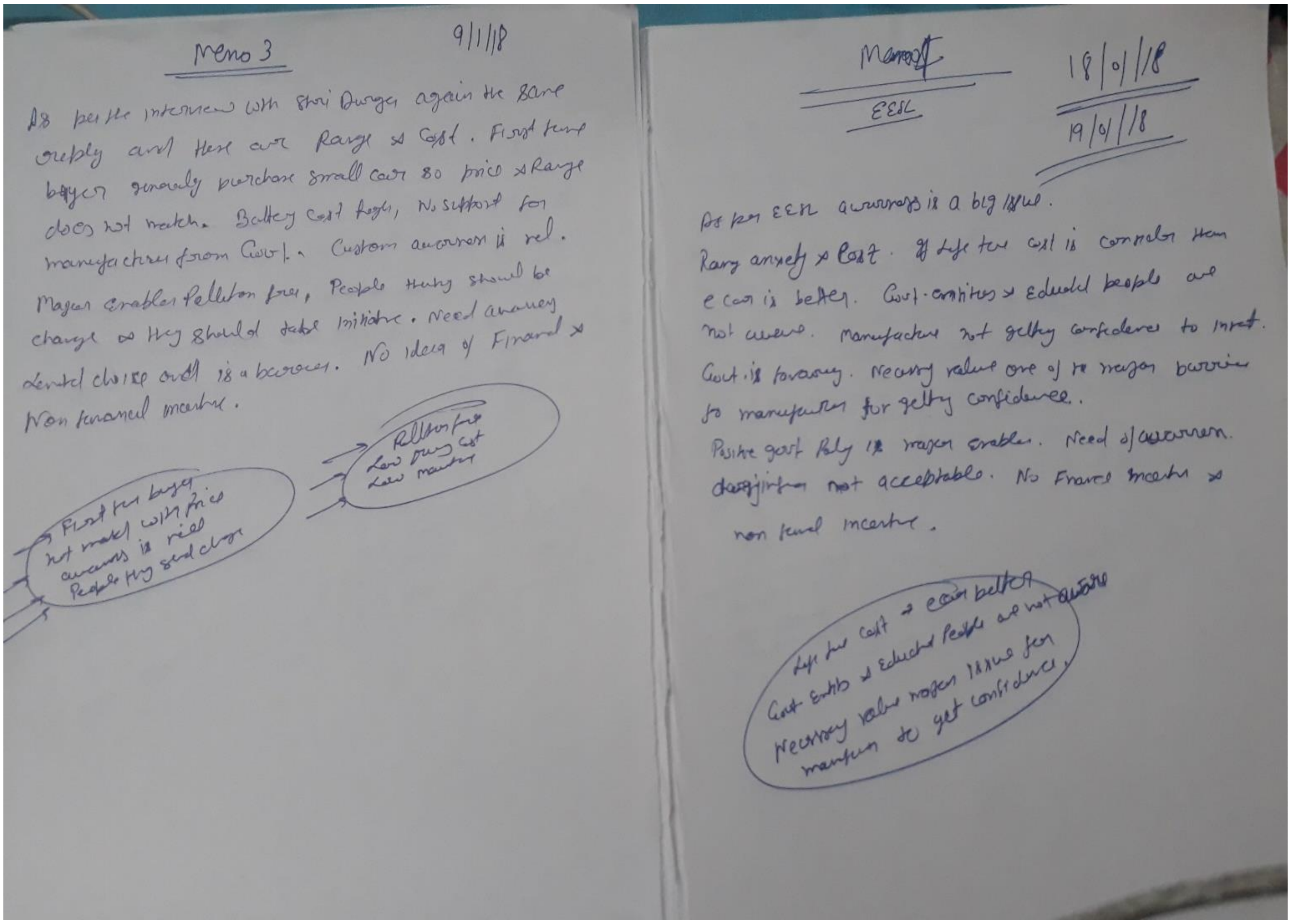
Memo 2 8/1/18

As per the interview with Koncept automobile charging Points is one of the major barriers & charging duration should be decrease. Price of car is great. Adequate awareness is one of the major barrier. *Low advertising & Promotional activity
Same as Genesis, he said that Pollution & Low maintenance & Low running cost is major enablers. Need awareness. Price & charging infra not acceptable. Limited choice & Competition is a major barrier. Registration charges is high (60 – 70 K). No Financial & Non financial Incentive.

Pollution free
Low Maint
Low running Cost

→ Charg. Points → Price
→ Awareness → Range.
→ Battery cost

Figure memo 1: Memo 1



Memo 3 9/1/18

As per the interview with Shri Durga again the same reply and these are Range & Cost. First time buyer generally purchase small car so price & Range does not match. Battery cost high, No support for manufacturer from Govt. Custom awareness is nil. Major enablers pollution free, People thing should be change so they should take initiative. Need awareness Limited choice and is a barrier. No idea of Financial & Non financial incentive.

First time buyer not match with price awareness is nil People thing should change

Pollution free Low running cost Low maintenance

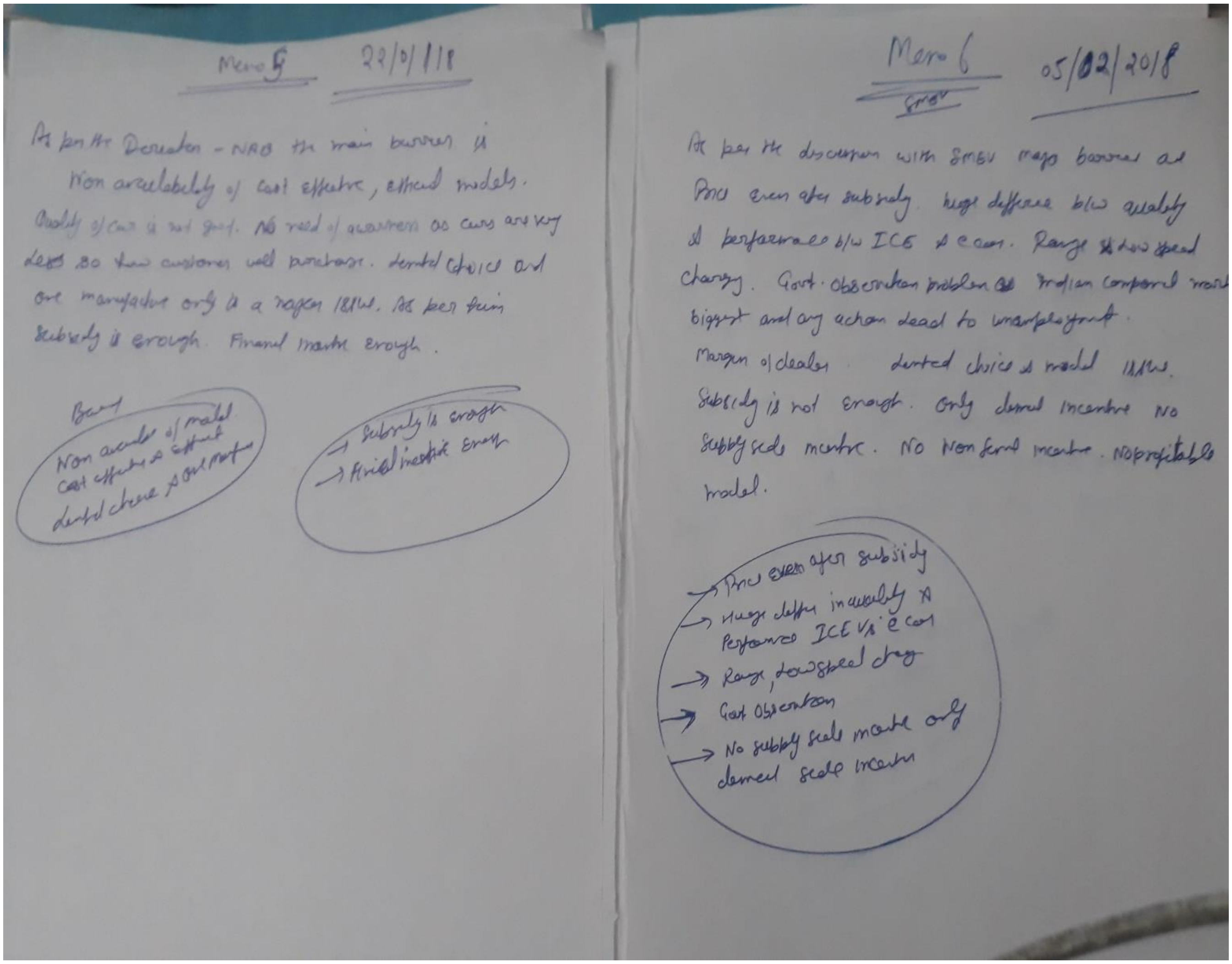
Memo 4 EESL 18/01/18 19/01/18

As per EESL awareness is a big issue. Range anxiety & Cost. If life time cost is consider then e car is better. Govt. entities & Educated people are not aware. Manufacturer not getting confidence to invest. Govt. is favoring. Recovery value one of the major barrier to manufacturer for getting confidence.

Positive govt policy is major enabler. Need of awareness. charging infra not acceptable. No Financial incentive & non financial incentive.

Life time cost → e car better Govt Entities & Educated people are not aware Recovery value major issue for manufacturer to get confidence.

Figure memo 2: Memo 2



Memo 5 22/01/18

As per the Director - NAB the main barrier is Non availability of cost effective, efficient models. Quality of car is not good. No need of awareness as cars are very less so how customer will purchase. Limited choice and one manufacture only is a major issue. As per him subsidy is enough. Financial market enough.

Barrier

Non availability of model

Cost effective & efficient

Limited choice & one manufacturer

→ Subsidy is enough

→ Financial market enough

Memo 6 05/02/2018

SMEV

As per the discussion with SMEV major barriers are Price even after subsidy. huge difference b/w quality & performance b/w ICE & e cars. Range & low speed charging. Govt. observation problem as Indian component market biggest and any action lead to unemployment. Margin of dealer. Limited choice & model issue. Subsidy is not enough. Only demand incentive No supply side incentive. No non fiscal incentive. No profitable model.

→ Price even after subsidy

→ Huge differ in quality & Performance ICE V/s e car

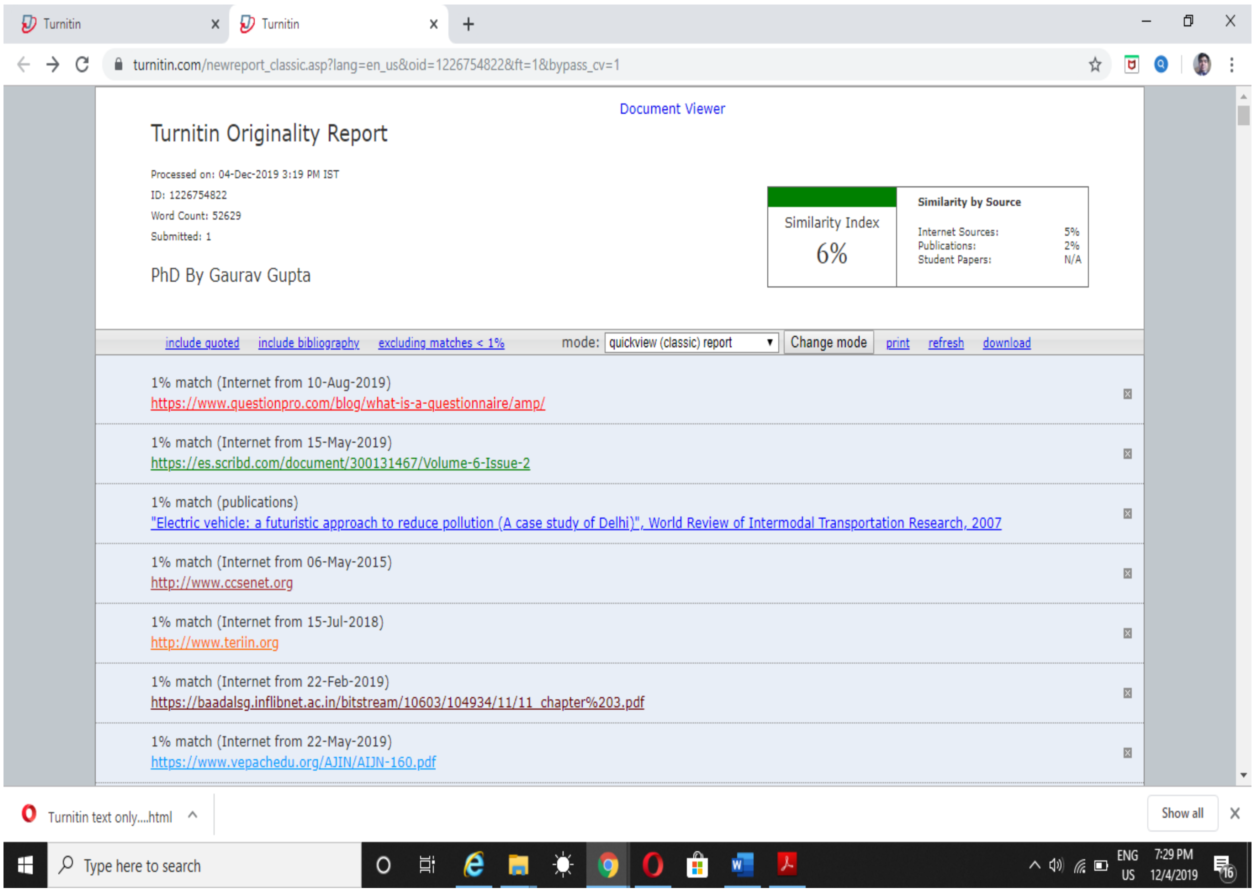
→ Range, low speed charg

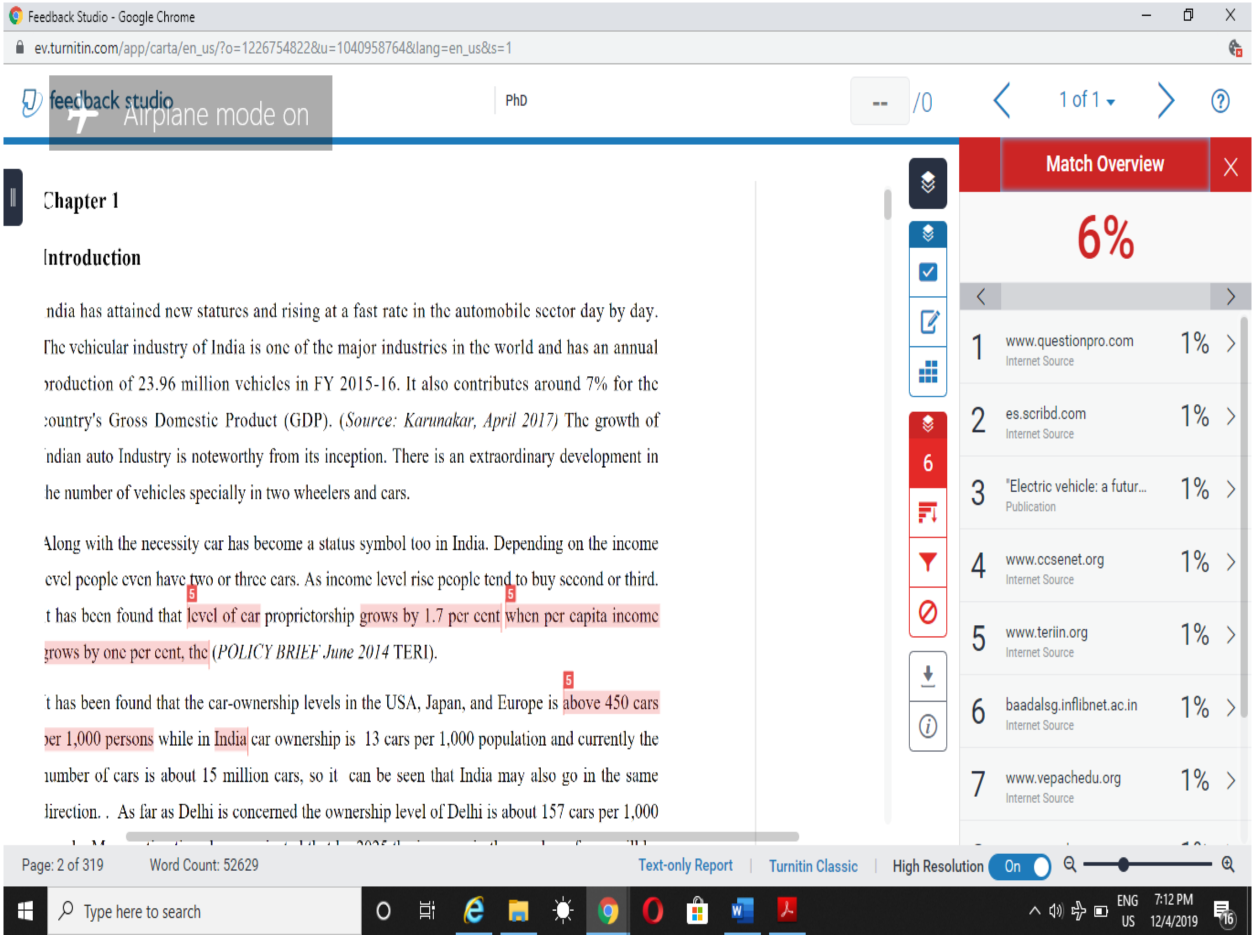
→ Govt observation

→ No supply side incentive only demand side incentive

Figure memo 3: Memo 3

Plagiarism report

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Chapter 1
Introduction
ndia has attained new statures and rising at a fast rate in the automobile sector day by day. The vehicular industry of India is one of the major industries in the world and has an annual production of 23.96 million vehicles in FY 2015-16. It also contributes around 7% for the country's Gross Domestic Product (GDP). (Source: Karunakar, April 2017) The growth of Indian auto Industry is noteworthy from its inception. There is an extraordinary development in the number of vehicles specially in two wheelers and cars.
Along with the necessity car has become a status symbol too in India. Depending on the income level people even have two or three cars. As income level rise people tend to buy second or third. It has been found that level of car proprietorship grows by 1.7 per cent when per capita income grows by one per cent, the (POLICY BRIEF June 2014 TERI).
It has been found that the car-ownership levels in the USA, Japan, and Europe is above 450 cars per 1,000 persons while in India car ownership is 13 cars per 1,000 population and currently the number of cars is about 15 million cars, so it can be seen that India may also go in the same direction. . As far as Delhi is concerned the ownership level of Delhi is about 157 cars per 1,000
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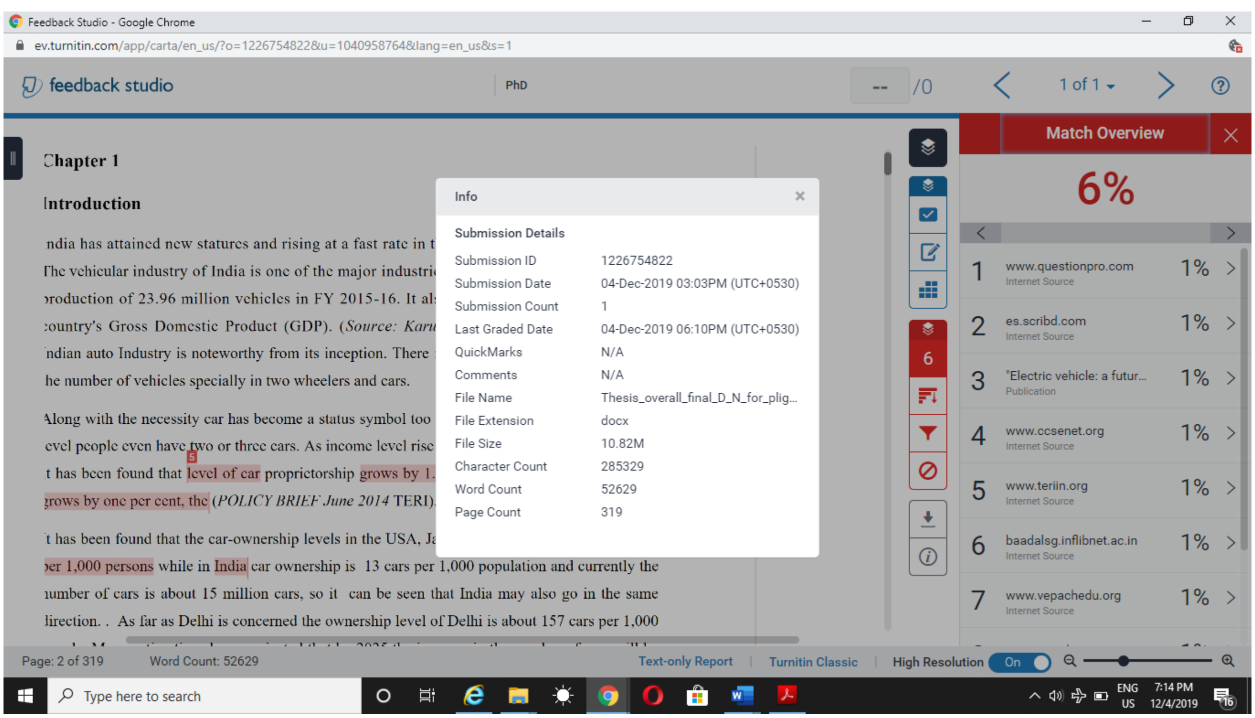
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