Diffusion of Electric Busses for Public Transportation: A Case Study in Three Indian Municipalities
Acknowledgements

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Abstract

INTRODUCTION: In India, internal combustion (IC) engines are the main concern, due to the exhaustion of natural fossil fuelled buses. These are the three major factors which is considered as an urgency to find an alternate solution. First, the energy and emission trends from transports. Second, efficient urban infrastructures, such as mass transit system. Third, the policies to adopt the cleaner and efficient technologies such as electric vehicles and other available alternate fuels. This made the Indian government to think about adopting electric vehicles as a mode of public transportation.

PURPOSE: By initiating the use of electric buses this thesis will assist the three state transport corporations in India who are willing to initiate use of electric bus by overcoming their barriers. Furthermore, this research will be an implication for automotive industries in India towards their diffusion of electric buses.

FRAMEWORK: Electric buses usage has been a major part of this diffusion process where it helped the authors to analyse how important it is. Adding to this the different perceived attributes of innovation from Rogers model has been analysed in this research to find out the different factors affecting towards the diffusion of electric buses.

METHODOLOGY: This study uses the case study method to study the diffusion of electric buses in three municipalities. Primary data has been gathered through semi-structured interviews with representatives from the municipalities and suppliers. In Addition, secondary data, such as press releases from the municipalities and suppliers, has been collected.

CONCLUSION: It is been concluded that the adoption of electric buses is one of the major solution which will help the country carbon emission rate to go low with the technicalities involved in the electric buses. In addition to that if the private and municipality transports plan to expand their fleet of electric buses, complexity and nature of social system are the one of the major attributes which should be considered initially during the diffusion of electric buses.

LIMITATIONS: This research has a limit in the role of internal organisation (Government or Companies) of the municipalities, supplier’s business model, policy related issues between the municipality and the government has not been analysed. All these limitations in turn is a future research for the further researchers.

Keywords: Automotive, Sustainability, Electric buses, Public transportation, Diffusion theories
List of Abbreviations

ICRA- Information and credit rating agency
USD - United State Dollars
SEK – Swedish Kroner
INR – Indian National Rupees
CMTC – Chennai Metro Transport Corporation
BMTC – Bangalore Metro Transport Corporation
TSRTC – Telangana State Road Transport Corporation
CNG - Compressed Natural Gas
LNG – Liquified Natural Gas
CO2 – Carbon di Oxide
OECD -Organisation Of Economic Co-operation and Development
IC – Internal Combustion
EVs – Electric Vehicles
KWh – Kilo Watt per Hour
OEM – Original Equipment Manufacturers
PCI – Perceived characteristics of Innovation
BEB – Battery electric Buses
BEV – Battery electric vehicles
EL – Empty Load
HL – Half Load
FL - Full Load
AC – Air Conditioner
R&D – Research and Development
GOI – Government of India
US – United States
EU – European Union
FAME – Faster Adoption and Manufacturing of Electric Vehicles
NEMP – National Electric Mobility Plan
DHI – Department of Heavy Industry
BBMP – Bruhat Bengaluru Mahanagara Palike
GHMC – Greater Hyderabad Municipal Corporation
GCC – Greater Chennai Corporation
# Table of Contents

1.0 **Introduction** ........................................................................................................................................1
  1.1 Background and Significance ......................................................... 1
  1.2 Problem Definition ....................................................................... 3
  1.3 Purpose .......................................................................................... 5
  1.4 Research Question .......................................................................... 5
  1.5 Structure of paper ........................................................................ 5

2.0 **Tentative theoretical Framework** ..................................................................................................... 6
  2.1 Electric Buses ................................................................................ 6
  2.2 Theory of diffusion innovation ..................................................... 8
    2.2.1 Attributes of innovation and their rate of adoption ................. 9
      2.2.1.1 Perceived attributes of innovation .................................. 10
      2.2.1.2 Types of Decision innovation ....................................... 15
      2.2.1.3 Communication Channels ......................................... 16
      2.2.1.4 Nature of social system ........................................... 18
      2.2.1.5 Extent of change agents ........................................... 20

3.0 **Methodology** ................................................................................................................................. 25
  3.1 Philosophy .................................................................................... 25
  3.2 Research approach ......................................................................... 26
  3.3 Methodological choice .................................................................... 26
  3.4 Research strategy ........................................................................... 27
  3.5 Time Horizons ............................................................................... 27
  3.6 Data analysis .................................................................................. 28
    3.6.1 Secondary Data ...................................................................... 28
    3.6.2 Primary Data .......................................................................... 28
    3.6.3 Data collection ........................................................................ 28
    3.6.4 Case description ...................................................................... 30
  3.7 **RESEARCH ETHICS** .................................................................. 32
    3.7.1 Credibility .............................................................................. 32
    3.7.2 Dependability .......................................................................... 32
    3.7.3 Confirmability .......................................................................... 33
    3.7.3 Transferability ......................................................................... 33

4.0 **Empirical data** ............................................................................................................................... 33

5.0 **Analysis & Discussion** .................................................................................................................. 37

Aravind Venkatanarasimhan, Saivenkat Cherukuri
List of Figures

Figure 1: Carbon dioxide (CO2) emission by transport in India ............................................................... 4
Figure 2: Theoretical framework .................................................................................................................. 6
Figure 3: Rate of adoption ............................................................................................................................ 9
Figure 4: Australian road transport emission dimensioning a 40% cut on 2025 by 2030 .................. 12
Figure 5: Electric vehicles in megacities .................................................................................................. 13
Figure 6: EC of 3 BEBS under multiple AC and passenger load scenarios. EI: empty ................ 14
Figure 7: AERS of BEBS under multiple conditions .............................................................................. 14
Figure 8: Innovation-decision process as explained by Rogers ................................................................. 15
Figure 9: Mobile phone users in India in million (1995-2010) .............................................................. 17
Figure 10: Internet penetration in India (in millions) .............................................................................. 18
Figure 11: S-curve ....................................................................................................................................... 19
Figure 12: S-curve data gathering in time ................................................................................................. 19
Figure 13: Extent of change agent flow process ......................................................................................... 21
Figure 14: Research onion .......................................................................................................................... 25
Figure 15: Methodological choice ............................................................................................................ 26
Figure 16: BID Pricing in Different Cities – INR PER KM ................................................................. 35
Figure 17: Diffusion of electric buses ....................................................................................................... 43

List of Tables

Table 1: Commercially available electric buses and their power characteristics .................. 7
Table 2: Challenges, opportunities and policy initiatives for the market diffusion of ECVs ... 24
Table 3: List of Interviews Done .............................................................................................................. 30
Table 4: TSRTC tariffs for the state transport ......................................................................................... 36
1 INTRODUCTION:
This section talks about the background of the automotive industry with the use of fossil fuel and the current alternatives, with a clear problem definition towards the shift for sustainability, with a formalized research questions and the purpose of research.

1.1 BACKGROUND AND SIGNIFICANCE:

Need for Bus as Public Transport in India,

The bus industry in India is most popular convenient mode of transport in urban cities, there are around 1.6 million registered buses, out of which 17,000 are state owned public transport buses which consumes 70 million people every day. But it couldn’t been able to reach growing demand reported by national sample survey office (NSSO). However, it has turn over revenue of 120 billion dollars and industry with growth rate of 25% a year (Singh, 2016). Secondly, 2000 private bus operators are there in India, where they operate 20,000 buses for their everyday use to cover between states with different routes. Furthermore, this rapid bus transport system exist in some parts of India (Mahedevia et al., 2017), where it contributes about 90% of the public transportation in cities (Pucher et al., 2007), and serve as mode of transport. These inter city services are mostly run by state government owned transport corporations(Singh, 2005). Finally, bus as public transportation in India is seen as highly demanding as well as need for people of India.

As the requirement of the public transport is high what made the Indian government think to move towards sustainability? There are three major factors which is considered as an urgency to find an alternate solution. First, the energy and emission trends from transports. Second, efficient urban infrastructures, such as mass transit system. Third, the policies to adopt the cleaner and efficient technologies such as electric vehicles and other available alternate fuels. The adoption of cleaner technology may take a while to regain the profits as compared to existing diesel engine buses (Mittal et al., 2016). This lead the Indian government to move towards sustainability solution. As India being named as an agricultural country, however, other alternative fuels which can be produced without importing the fuels (Crude oil, Gas) from exporting countries.

The aim of sustainability in automotive industry is to build vehicles in a fuel-efficient way using alternative fuels of fossil fuels. One major possible solution is an electric vehicles which is growing rapidly all around the world and India had also started pushing aggressively towards it due to its the various advantages. Furthermore, by 2030 50% of vehicles are expected to be electrified (Whitehead et al., 2014). There are other alternative fuels that can be considered in case of sustainability.

When compared with fossil fuels, the use of alternative fuel is more benefited due to reduced carbon emissions, though there is some amount of CO2 emissions emitted in case biofuel, biogas, biodiesel, CNG, LNG. Biofuel is the next major alternate solution available due to its production cost. The bio fuel is mainly extracted from ethanol. Ethanol is majorly produced in Maharashtra and Uttar Pradesh, India. As per (Economic Times, 2017), currently Uttar Pradesh is the major producer of ethanol in India and the state had produced 56 crore litres of ethanol. Ethanol is mainly extracted from sugarcanes and these industries tries to break the record and help India for more sustainable future. The above mentioned two states together
accounted for 67% of ethanol production, and the rest of the states in India also helps for ethanol production.

Green Economy Initiatives by Government of India in Transport Sector

Indian economy is based on agricultural lands and products. Government of India is supporting the farmers to produce and Ethanol and blend it with petroleum and tries to reduce the CO₂ emission. Most of the private and government automotive industries are trying to shift the use of fossil fuelled vehicles to available alternative fuelled vehicles. This is done by the tax exemptions and subsidies given by the government of India. Moreover, India has the potential to generate bio-fuels and it has a vast advantage of creating job opportunities for many people. In this case, India is still in the emerging situation for producing of biofuels. In case of ethanol usage in India, the emission level varies from euro 5 to euro 6 which is cleaner than diesel engines.

In case of biogas, biogas can be generated from water waste or food waste which is therefore treated and used as an alternative fuel. The biogas extraction should be done under the strict rules by the government and each municipality should take control of collecting the waste and send it to the recycling plant, constituting towards this biogas production again creates job opportunities to many people. Karnataka, India has started recycling of water to produce biogas and they intend to increase 30% per year (Nitin, 2014).

Transport sector contributes 20% of commercial energy needs in India, of which it’s in form of liquid or gaseous fuel. As there is a lack of oil and petroleum India started importing all these mining’s from others countries. In turn leads to financial burden, earning financial, subsidy prices to make them affordable for every citizen in India which is cost expenditure for government (Majumdar et al., 2015).

Emergence of Sustainability

The concept of sustainability emerges in the years 1960s, later due to the environmental problems such as water and air pollution in crowded urban areas of developed countries as of now (Hughes, 2009). Moreover, rising public concern in those countries led to regulations for companies those who are violating environmental code of conduct (Cropper & Oates, 1992). However, in later years, companies also got adopted to regulatory framework and environmental code of conduct because of legal issues, high cost of fines and negative publicity (Watson, 2011). Moreover, this haven’t controlled pollution free environment because of ex post solutions like (illegal dumping, offsite treatments, and land filling). And moreover, economic viability over weighted the environmental sensitivity (Schaltegger & Wagner, 2010). Additionally, this led to monitoring and enforcement activities had additional disadvantage for both policy makers and industry. Which led to two more problems, on one hand slow development process and in turn led to slow process by enforcement officials. Rahman & Van Grol, (2005); Seliger, (2007) on other hand jurisdictional constraints on subject of matter, approach and scope cause of burden on bureaucrats.

Meaning of Sustainable Transport

Sustainability always should be defined by its problem and what might it do about it. In a way to create hopeful development and is setting a stamp on future generations in a way that holds great promise (Appleton, 2006).

OECD mainly started concentrating on the development of sustainable transport. Moreover, it defines for transportation system to be sustainable by following criteria is required
such as health standard for nitrogen oxides ozone, particulates, and noise pollution are the major emitter of CO\textsubscript{2} and measures to protect the ecosystem relating to the land protection in urban provinces (Azevedo & Barros, 2017).

In transportation sector, it consumes depletable resources like energy, human, ecological habitats, carbon in air and time consuming. However, transportation tend to be made in larger policy goals like economic growth, and job creation, intensity use of land, socioeconomic and geographic transfers of wealth. All these are powerful but often undermined agenda. for sustainable transport means is an exercise in resource optimization which completely new thing.

1.2 PROBLEM DEFINITION:

Stating the use of fossil fuels in India

Firstly, internal combustion (IC) engines are the main concern, due to the exhaustion of natural fossil fuels. These changes towards the electric vehicles are mainly concerned because of the market fluctuations and the CO\textsubscript{2} emission which is being emitted and damaging the environment. Moreover, CO\textsubscript{2} emissions are increased widely in the current years because of the multiplication of vehicles and increase in population in India (Srinivas et al., 2017). At present diesel powered engines had been widely used in India due to the large scale of public transport buses and by the farmers. However, India being an agricultural country and country with a population of 1.4 billion people the use of vehicles are increasing every day and the public transport services are also being increased to give an easier mode of transportation to the people where they need to travel to different places in their day to day life (Senthur Prabu et al., 2018). Due to the excess amount of emissions observed, Indian government had decided to adopt the use of new alternative fuels or technologies to restrict the emissions by introducing the electric vehicles as a mode of public transport, due to the zero tailpipe emissions and noise pollution.

Secondly, Road transport has turned out to be troubled by many issues identified with sustainability, specifically by the sort of energy that is utilized, the resulting emissions and perspectives of current society. In the late 1980's and 90's, there were environmental problems, climatic changes, reduction of the ozone layer, which then made all the countries to think for sustainable growth (Dalla & Pellicelli, 2016). According to Mayyas et al., (2012) the world's transportation system is mainly running because of the fossil fuels which has consumed around 96%, and the consumption is also around 70 million barrels per day. So, by using these fossil fuels it leads to pollution and which leads to a climate change and affects the ozone layer.

Whereas, India due to the major population and increasing number of public transports this lead to the heavy consumption of fossil fuels which is leading to financial burden. These fossil fuels are highly dependent on the oil, which increases the demand, all these demand leads to depletion of resources and supply concerns. Urban pollution release from the vehicles leads to health problems. This is one of the reasons that all the industries are concentrating to reduce the carbon emission and oil independent transportation (Mahmoudzadeh et al, 2017).
The above figure (1) shows the amount of carbon emission emitted by the transports in India. To restrict these emissions there are other alternative fuels or new technologies. Therefore, Indian automotive industries have begun to encounter the impacts of this worldwide interruption (Iyer & Mangaleswaran, 2017). Electric buses are one of the current alternative solutions towards this problem rather than the use of other alternative fuels. This idea is being spoken about all the government of each and every country and tries to implement some policies and strategies to implement the use of electric buses (Kontou & Miles, 2015).

Narrowing it down to research scope, this research will purely be concentrated on the field of electric vehicles for public transportation in India, so the focus will be on electric vehicles and sustainability. Electric vehicles have obtained a greater market share including various incentives and policies. All these incentives and policies had created a demand in the market and made the customers and the public believe that it can deliver broader benefits and controls the Carbon emissions, air pollution and increase penetration of renewables. Due to numerous positive effects many countries including has decided to move on with the electric vehicle solution which is more sustainable.

Battery electric vehicles can be an alternative solution by satisfying the conditions mainly, when the engines are replaced by motor and when connected to charging spot, when they are not in use, the benefits from these are low emissions emitted from the vehicle which is good for local air quality, and it is highly efficient, can be charged overnight with a low cost where the electricity can be produced from any station (Mahmoudzadeh et al, 2017).

Next alternative is electric vehicles which are creating demand in all major countries due to its benefits towards sustainability. Digitization, technological innovation towards automation and the growth of business models have reformed all the industries. As far as analysed 50% of Indian vehicles will be converted to EV’s or battery electric vehicles or plug-in hybrid. Speaking about electric vehicles Indian government had already set up a step forward toward this and exploring the different opportunities to reduce carbon emissions.

Due to the different diverse effects observed in India with the emission control plan, implementing new technologies, heavy usage of public transports within every individual states, we have decided to focus more on the developing such as India where the purpose and scope for this research will be a benefit for three municipalities, as they are in the initial stages of implementing electric vehicles. As India are more focused toward this alternative fuel rather
than fossil fuel, electric vehicles have been a trendsetter, because of zero tailpipe emission and zero noise pollution made the author focuses towards the electric buses for public transport in the India market.

1.3 PURPOSE:

The use of public transport especially buses are many in numbers and it leads to continuous exhaustion of carbon emission in India. To overcome this, as a pilot study the three municipalities have decided to initiate the use of electric buses which will resist the carbon emissions. To implement the use of electric buses it is clearly seen that it is not an easy way to bring new technologies into the market, while there are many hurdles or barriers which needs to be identified and by overcoming those it will lead to diffusion.

By initiating the use of electric buses this thesis will help, three state transport corporations in India who are willing to initiate use of electric bus by overcoming their barriers. Furthermore, this research will be an implication for automotive industries in India towards their diffusion of electric buses.

1.4 RESEARCH QUESTION:

What are the current barriers towards diffusion of electric buses in India and implications for automotive industry?

1.5 STRUCTURE OF THE PAPER:

The remaining aspects of the thesis have the following series and content:

In theoretical model the selected theoretical model from sustainability to electric buses and connecting to that the use of public transportation in India have been connected to find out the barriers.

Methodology section show the outline of this research approach and reason of methodological choices for all details of the research.

In empirical data section the studied state municipalities is introduced which is based on the analysed secondary data and complemented by means of semi structured interviews.

Analysis and Discussion section is mainly concentrated on revising the data collected and their analysis from different perspectives. At the end of discussion more reflections are drawn.

In Results section main objectives have been drawn out and state the different barriers on how to overcome it.

Conclusion section summarizes the obtained results from the previous sections and gives the connection with already existing research and some proposals for future research.
2. THEORETICAL FRAMEWORK:
This section will completely cover the theoretical frame of reference upon which the research is based upon. The author starts will start by conceptualizing theory of diffusion followed by diffusion of electric vehicles including the different impediments to support with the strong use of literatures.

Figure 2: THEORETICAL FRAMEWORK

2.1 Electric buses:
When compared to normal IC engine buses, electric buses has their own power source to run the vehicle designed with an individual propulsion system. Moreover, design of propulsion system is a minimum requirement for any type of buses and the power source used are different such as hybrid electric, Fuel cell electric and battery electric (Mahmoud et al., 2016). Mohamed et al., (2017) had explained, with 24% of greenhouse gas emissions electric powertrains are considered to be a suitable alternative for urban transport all over the world. All the governments had decided to mainly focus on the urban transports initially due to the scheduled timing and the distance covered by a bus from one point to another at an regular intervals. As there is a designated timing for the buses and has the enough time to charge the battery or swap the battery this can initially influenced on the public transport system.

Electric buses concept have equally attracting in all the countries and demand towards it is also increasing in a vivid way due to its different advantages. All these advantages mainly depends upon the battery, motor size, charge power capability etc., the range of the batteries will be varied according to the size of the battery which can be 60 to 548 KWh which can cover distance of about 200- 300 KWh range. All these are suitable for normal transit buses when compared to smaller ones (Mini buses) as they require only smaller sized batteries (Gao et al., 2017).
The heart of an electric bus is a battery and there are many options available for the transportation people to use. All these batteries consist of numerous battery sizes provided by different OEM’s and each OEM provides their different output. The list of electrical power characteristics has been listed below in table (1);

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>OEM</th>
<th>Max Motor Power (KW)</th>
<th>Battery Capacity (KWh)</th>
<th>Charge Power (KW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-60 ft transit bus</td>
<td>BYD</td>
<td>180-360</td>
<td>324-548</td>
<td>40/80/100/200</td>
</tr>
<tr>
<td>30-40 ft transit bus</td>
<td>CCW</td>
<td>-</td>
<td>311</td>
<td>40</td>
</tr>
<tr>
<td>34-40 ft transit bus</td>
<td>Design Line</td>
<td>335</td>
<td>261.8</td>
<td>-</td>
</tr>
<tr>
<td>35-40 ft transit bus</td>
<td>Proterra</td>
<td>220</td>
<td>53-321</td>
<td>500</td>
</tr>
<tr>
<td>40 ft transit bus</td>
<td>EBusco</td>
<td>-</td>
<td>242-311</td>
<td>125</td>
</tr>
<tr>
<td>40 ft transit bus</td>
<td>Hengtong</td>
<td>180</td>
<td>61-78</td>
<td>400</td>
</tr>
<tr>
<td>40 ft transit bus</td>
<td>PRIMOVE</td>
<td>200-400</td>
<td>60-90</td>
<td>200</td>
</tr>
<tr>
<td>40 ft transit bus</td>
<td>New flyer</td>
<td>160</td>
<td>200-300</td>
<td>500</td>
</tr>
<tr>
<td>Shuttle</td>
<td>Balqon</td>
<td>168</td>
<td>312</td>
<td>40/100</td>
</tr>
<tr>
<td>Shuttle</td>
<td>Motiv</td>
<td>150</td>
<td>80-120</td>
<td>60</td>
</tr>
<tr>
<td>Trolleybus</td>
<td>ABB</td>
<td>-</td>
<td>38</td>
<td>40/200/400</td>
</tr>
</tbody>
</table>

1ft = 0.305m.

Table 1: LIST OF COMMERCIALLY AVAILABLE ELECTRIC BUSES AND THEIR POWER CHARACTERISTICS (Gao et al., 2017)

There were many different battery options available and the cost of it were also high. Nowadays, new technology has been arose and many OEMs has discovered the use of lithium based batteries are one among the best to be used for buses as they cover huge distance. This
lithium based batteries are very good with their energy capacity and weight ratio and this specific battery can be recharged during the night and can be further used for a full day travel (Poizot et al., 2015). There are many alternatives with high powered and higher weight ratio which can charge the batteries at an quick interval but the size of the battery is small and doesn't require a huge amount of time, constituting to that it is more expensive when compared to lithium based batteries (Lajunen & Lipman, 2016).

During the adoption of electric vehicles in any country initial investment and power source requirements is the major demand for electric or hybrid buses. This can be adopted towards any urban transport system for their adoption due to their driving cycles and scheduled routes where by the transport corporation people doesn't need to worry about the charging infrastructure as they have their own at their respective bus depot (Lajunen, 2018). According to Ribau et al., (2014) hydrogen powered fuel cell electric bus can also be one of the option as the initial investment were very high during while setting up the infrastructure when compared to normal IC engines and once the buses are out on the roads there has been huge effect in the reduction of emissions and less money spent on refuelling the diesel engines, this is been implemented for the cities of Lisbon and Porto, Portugal.

2.2 Theory of Diffusion Innovation:

Some innovations will be originated by introducing and get expanded by spreading widely by using it on some point of time. This can be seen in various stages through how the variables determined by rate of adoption and how the rate of adoption has become an part of dependent variable (Rogers, 1995). The diffusion of innovation by various technologies is a best example for these problems. It might take a longer period for the end users to adopt to the new technologies which will most likely to benefited for their further use (Geroski, 2000). This technology comes into the market because of the various advantages for the ecosystem and for the betterment of end users. These are mostly understood by calculating the market diffusion curve to the current existing market technologies. In this research, we are heavily adopting the (Rogers, 1995) framework to implement the usage of electric buses in India. These technologies are need to be properly calculated and by risk taking the technologies has to be released into the market (Gnann et al., 2015).
2.2.1 Attributes of Innovation and their Rate of Adoption:

Five Attributes of Innovation which are dependent on rate of adoption of innovations;
1. Perceived attributes of innovations
2. Type of innovation-decision
3. Communication channels
4. Nature of social system
5. Extent of change agents promotion efforts
2.2.1.1 PERCEIVED ATTRIBUTES OF INNOVATION (Rogers, 1995)

- **Relative Advantage** is the degree to which innovations is always better than the idea it supersedes. Moreover, the nature of innovation determines relative advantage such as economic, social and Environmental.

- **Compatibility** is the degree to which an innovation is perceived as consistent with the existing values, previous experiences, and demand for adopters. An idea that is more compatible is less uncertain to the potential adopter. An innovation can be compatible or incompatible
  1. with sociocultural values and beliefs
  2. with previously introduced ideas
  3. with client needs for innovations.

- **Complexity** is the degree to which an innovation is perceived as relatively difficult to understand and use. However, some innovations are clear in their meaning to potential adopters while others are not. Moreover, the complexity of an innovation, is perceived by members of a social system, is negatively related to its rate of adoption.

- **Trialability** is the degree to which an innovation may be experimented with on a limited basis. Moreover, new ideas that can be tried on the instalment plan will generally be adopted more rapidly than innovations that are not divisible. But, innovation that is triable is less uncertain for the adopter. Furthermore, some innovations are more difficult to divide for trial than others. In spite of the lack of strong evidence, the trialability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption (Moore & Benbasat, 1991).

- **Observability** is perceived as positively related to rate of adoption. Moreover, results are visible to others. Moreover, when compared to this research the concept of electric vehicles is new technology and it is not feasible to communicate to the public and make them understand. Therefore, the concept of electric transportation has to be started and should be positively related to the rate of adoption (Rogers & Everett, 1983). Sustainable solution for a specific country is like an overall package which will include the parts for producing the bus, then the overall cost of the bus, resale value will be analysed according to the quality of the parts utilized during production and the battery performance is also considered for this, as the batteries are the one which makes it run for a long distance as expected by the end user (Sovacool, 2017).

However, the output of all the idea or technology are observed initially and communicated to others, whereas many new inventions are not easy to explain to people and make them understand. Moreover, observability is the people who are existing in the social system, which is an advantage towards the rate of adoption.

**Researchers Work on Perceived Attributes of Innovation:**

The innovation research was found and were discussed on this section to get an in depth view on rate of adoption towards the diffusion process. The literatures used towards for this rate of innovation adoption were tested out with the help of previous research, whereby it is also been evaluated according to the validity and reliability, which is seen explicitly by (Rogers, 1983) taxonomy was included Roger’s five attributes of innovation for the diffusion process (Ostlund, 1969). However only two parts of attributes were perceived, where it has no reliability on the document which had been reported. This case has been further taken forwarded by (Bolton, 1981), whereby he examined the different and diffused a new video technology context, whereby he eventually ended up using all the 5 perceived attributes of innovation while compared to Ostlund. Again, however, the psychometric properties of the instrument stayed
beneath the expected levels. Of 18 Cronbach's (ALPHA) coefficients from three extraordinary replications of the overview, just four were over 0.80. Of these, three were for the same perceived characters of innovations (PCI), Compatibility, from the three replications. due to low dependability coefficients, it was summarised that neither Ostlund's instrument, nor Bolton's expansion of it, could be utilized without adjustment.

Secondly, Holloway used Rogers’ attributes of innovation, and, after the review of the research, started to stay on the same attributes (Holloway, 1979). But still the author felt inadequate with the studies he did. The different factor of analysis had shown that many items which chose to have acquired the different attributes on the same area. This lead to validity problems, whereby it was concluded that cannot be continued with Holloway’s instrument.

Thirdly, to continue to develop the diffusion process more valuable and reliable many authors personally met Rogers’ (Katz & Rice, 2002). During the discussion the authors had various questions to Rogers how can diffusion happens without including the five perceived attributes of innovation by considering either of the one attribute. And then Rogers et al., (1977) explains that for any diffusion process the attributes are correlated with one another and that lead to diffusion of innovation. In spite of the fact that high reliability quality figures were gotten for Complexity and Compatibility, with ALPHA'S of 0.93 and 0.86 separately, factor examination of the outcomes did not support the general characterization. Fourthly, Trialability and Observability did not emerge as individual factors. Hurt and Hubbard presumed that either the things stated "did not obviously separate between the two theoretical outputs" or that "those two allegedly free attributes are dealt with as a solitary idea by potential adopters" (Moore & Benbasat, 1991). Our examination of the things did not help figure out which clarification was more probable, and relative advantage did not even diffuse as a common factor. It is been decide with two different purpose as perceived usefulness and perceived ease of use. The similarities will be the same with the Perceived attributes as Rogers explained where complexity is a correlated as a part of relative advantage. To use these data to be more reliable and valuable it has to be measured by means of observability and trialability.

As a result by the different researchers and Rogers, any diffusion process which has been or being done has be to analysed by using the five perceived attributes of innovation constituting towards the rate of adoption process (Rogers & Everett, 1983).

Case of Australian Carbon Reduction Plan and the output as Relative Advantage :
As mentioned above carbon emission plays a major role in all the countries whereby the Australian government had done some major changes in their in the heavy duty vehicle by introducing the low carbon vehicle plan which will meet up with the European emission standards and the Australian government had decided to increase the use of Low carbon vehicle to 40% (Stanley et al., 2018). The results of 40% reduction carbon emission in Australia had been shown below. The implementation of new electric vehicles in the country helped the Australian government to reduce the emissions on a major scale. The policy factor is one among that is influencing electric vehicle adaption around the globe (Barfod et al., 2016).
Due to the high amount of carbon reduction other countries had also started the implementation of electric vehicles. Norway, being the first country to sell many electric cars and the country government has decided to sell only electric cars from 2025 (Yong & Park, 2017). By looking at this success Japan and Germany had started to initiate the implementation of electric vehicles and Germany had also announced their “National Electromobility Development Plan” for their new development and building up their infrastructure.

Compatibility involved in electric vehicles and their technologies:
The technology factors are more likely related to the characteristics of Electric vehicles, for private and commercial use, due to its long driving distance, time for charging and the initial investment on the vehicle. If the distance travelled by a person is more likely less as well and in turn the time to charge the vehicle is more time than the running distance and from end consumer point of view the initial cost and charging time is more and it is been observed as an obstacles to Electric vehicle diffusion and adoption (Yong & Park, 2017). Saxton, (2011) explains that EVs require a minimum of 30 min charge with an fast charger to recharge the vehicle, whereas the Internal combustion can refuel the vehicle in less than 4 minutes.

Compatibility is seen as a combo of product where all the demands of the customers’ needs to be met when it comes to investment and performance of the bus. Biresselioglu et al., (2018) had explained barriers such as performance standards of Battery vehicles (BEV’s) when compared to traditional Internal combustion engine (ICE) while testing in European union during implementation of electric buses.
Complexity involved according to Consumer beliefs as EV vehicles in Shanghai:

![Complexity involved according to Consumer beliefs as EV vehicles in Shanghai](image)

Technological factor is one among that is influencing electric vehicle adaption around the globe (Barfod et al., 2016). Biresselioglu et al., (2018) had explained barriers like acquisition cost is high, upfront cost is high, lack of infrastructure and range of performance of the battery while testing in European union during implementation of electric buses.

**Trialability: Battery usage for electric buses in Macau, china**

Battery Electric Buses (BEB) plays a vital role in early investigation of the projects in China, at Shanghai Expo which held in 2010 (Woetzel et al., 2010). Moreover, sales of BEV’s exceeded 180 thousand units globally (Trigg et al., 2013).

Macao, is internationally known city for tourism. Moreover, road transport sector accounted for 25% of usage energy consumption in 2014 (Zhou et al., 2016). And moreover creating local air pollution problems (Sheng & Tang, 2011) and to avoid use of petroleum products Macau has conducted a 2 month pilot to assess real world performance of BEB’s by using a three different buses manufactured by BYD (BEB B), Ankaï (BEB A) and Dongfeng (BEB D) with variation in sizes. In which it shows that energy consumption in various conditions HL-half load, FL full load, EL empty load and AC- air conditioner in the following diagram.
The above figure (6) illustrates energy consumption of battery with variation of load by three bus manufacturers - Ankai, BYD, Dongfeng respectively. These pilot study helps the specific government to understand the advantages of implementing electric vehicles.

Case study of Observability:

![Figure 5: EC of 3 BEBs under multiple AC and passenger load scenarios. EL: empty (Zhou et al., 2016)](image)

![Figure 6: AERs of BEBs under multiple conditions (Zhou et al., 2016)](image)
The above diagram (7) illustrates range of electric bus by Dongfeng, BYD and Ankai from top to bottom.

In this research, they found that carbon emission compared to traditional diesel buses are relatively low and moreover, BEB’s have higher probability with significant load and congested traffic situation and charging efficiency would have enhance future benefits of BEB’s. This will resist the exhaustion of emission on heavy duty vehicles.

2.2.1.2 Types of Decision Innovation:
By the topic it means how can innovation decision relates to the rate of adoption. But in any case, of diffusion an individual opinion is required to let grow further the diffusion process due to the various parameters needs to be satisfied and later it will be adopted by any organization. To exemplify, in united states when decision to adopt fluoridation of municipal water initiation was taken by city mayor or city manager, the rate of adoption is quicker than collective referendum.

Researchers Work on type of decision:
The new technological change process containing of new technologies which diffuses from the previous studies, are wide spread to the adopters which is used in variable forms of the research (Braun et al., 1982). However, the growth and development are seen in 4 different ways towards the technological innovation. Therefore, the other option reinventing things with their existing technological solution to new technological solution which can lead the way to the rate of adoption. nevertheless, the researchers in the R&D and decision makers doesn’t involve on the decision making, whereby they act accordingly by the decisions taken by the superiors to follow up the diffusion through their new technologies where it can best fit.

Secondly, a very crucial part in an innovation diffusion is the decision making to begin the process for the end users. Once the decision is made by the authorities then the researchers, developers, commercialization systems begin to play their part on developing the technologies as they will have their idea towards their new solution with the existing option.

The Above figure (8) Illustrates innovation-decision process is depicted in Figure. The present conceptualization consists of five stages: (Rogers, 1995).

1. Knowledge comes when an individual (or other decision- making unit) is experiencing the new technology to find the operations and how does it function.
2. Persuasion occurs when an individual (or other decision-making unit) meets attractable or non-attractable attitude for the innovation.
3. Decision occurs when an individual (or other decision-making unit) involves in activities which will make them to think about reflecting those technology towards their idea.
4. Implementation occurs when an individual (or other decision making unit) has shown the success and makes it accessible for the end users.
5. Confirmation occurs when an individual (or other decision making unit) seeks reinforcement of an innovation-decision already made, but the individual has the right to turn the decisions if exposes towards the innovation.

In the following pages we describe in greater detail behaviours that occur at each of the five stages in the innovation-decision process.

Research on Optional versus collective decision in India:
India being an agricultural country many researchers had tried to come up with new innovations and they had come up with a new idea for packaging the crops, fertilizers and other agricultural chemicals. But the study says as the farmers can easy to adopt to this new of packaging innovation instead of practicing each and every farmer (Kivlin & Fliegel, 1967). The same is applicable in this research during the diffusion of electric buses, the technology doesn’t needed to be explained to each and every public transportation municipalities.

2.2.1.3 Communication Channels:
The communication channels used to diffuse an innovation also have an influence on rate of adoption. For instance, if interpersonal channels are used to create awareness-knowledge, as frequently occurs in late adopters (Rogers & Shoemaker, 1971).

Researchers Work on Communication Channels:
Here we study the different model’s on how communications flows, which is flown in a timely sequence in the beginning of the communication research scenario.

1. Hypodermic needle model:
This model had shown a major impact on the mass media which had a direct effect and by setting a huge demand. Later in years 1940’s and 1950’s mass media had created a huge impact on individual’s behaviour. media was just acting as a message transferring medium, where it does not create people expectation that much (Katz & Paul, 1970). The manipulative power is seen as evidence in the historical events such as public support, power of Goebbels machine during world war, influence of Madison avenue by advertising on different consumers and the end user behaviour.

2. Two Step Model:
The conclusive disposing of the hypodermic needle model came about fortunately from a great investigation of the 1940 presidential decision (Lazarsfeld et al., 1944). This request was composed in light of the hypodermic needle demonstrate and was gone for investigating the part of mass media in securing political choices. To the analysts’ surprise, the confirmation showed that no voting decisions were specifically impacted by the broad communications. (Paul & Menzel, 1963) conceded that: people were more into political decisions by observing it through face to face decisions by exploring contact through the known people, than by experiencing it through mass media. Later this is also seen as a medium of communication
where messages or information are transferred physically which had more value to it. Initially the sources are transferred to opinion leaders, which is seen as an information transfer.

Secondly the message is passed on from opinion leaders to their respective followers, where it can help them widespread their information. These two steps are together seen as a hypothesis to pass the information by word of mouth from leaders to followers, so this is seen as flown as mass communication tool.

This model made all the authors to think about the different dimensions of mass media and interpersonal influence. Then mass media was not being so powerful to follow the important discussion and to pass on the followers or the common people. If there is any diffusion process happening in a country where the measures are taken by the government and the government pass the information through communication channels to let the end users know more about it, or in other case if there are governmental political issues are communicated only through the opinion leaders and the people involved in this discussion. To conclude the impetus of the mass media will always lead to multistage communication process.

Communication channels used in mobile industry of penetration in India

![Figure 8:Mobile phone users in India in Million (1995-2010) (GOI, 2011)](image)

The usage of mobile phones and internet have witnessed phenomenal growth during past 5 years from above graph. However, mobile companies in India have segmented market and positioned various price points, and had communication which is consistent, tailor made to various profiles (innovators, early adopters etc). When it comes to pricing, pricing strategy increase drastically according to the demand. Here, the communication strategy is based on the mass media whereby all the details about the mobile will be displayed through mass media and it make the end users to decide. If the price of the product will help the consumers to satisfy it the industries working toward this will have a great margin as the demand meets the end user, as end users are the one who sets their demand to the industries.
2.2.1.4 Nature of social system:
The flow of social system and degree where the communication network shows a high quality of interconnectedness. As (Rogers, 1975) explained an individual has the right to accept or reject the innovations, which is being diffused in the social system. Moreover, social system is always in both the rate of knowledge and rate of adoption. and level of given learning whenever is a sign of aggregate sum of data about information accessible to social system.

Researchers Work on Nature of Social System:
Firstly, the most important shortcomings of diffusion of research is the pro innovation bias. This was one of the things which had been noticed (Rogers & Shoemaker, 1971) but a few, as of now, has a solution towards this problem with some remedies.

Secondly, there should be some ground work done by any research for the innovations to be adopted and used by all the members. Nelkin, (1973) says it should be a technological fix for the researchers to be more clear on their innovations to solve any social problems.

For instance, Hybrid corn was one of the best innovation then in the past which had been explained by (Ryan & Gross, 1943), and the author mentioned not all the people should expect the same too good to achieve more profits. People should adopt only the new technologies which will suit for their development. If the pro Innovation was not biased in the 1940s and 1950s, it could have been avoided. These are the result of S- curve development which will replicate towards the diffusion of any technological solution.

How the pro-Innovation bias be overcome
Elective research ways to deal with post hoc information gathering about how a development has diffused ought to be investigated. We believe that diffusion inquire about does not really simply must be led after a development has diffused totally to the individuals from a framework (Figure 11). Such a rearward introduction to most diffusion studies encourages lead them to a fixation on effective development.
This figure (11) illustrates usual diffusion study gathers data from adopters after the innovation has diffused widely asking respondents to look backward retrospectively in time. Because of successful diffusion are usually selected for study, a pro innovation bias is introduced in much diffusion research (Rogers & Shoemaker, 1971).

The above figure (12) illustrates alternative research design for a diffusion to gather data from adopters at several points in time during diffusion process (Rogers & Shoemaker, 1971).
The research conducted in-process type of diffusion study faces some challenges (Emrick, 1977; Rogers, 1975). For instance, the results of this data gathering (when the innovation was only adopted by a relatively few individuals) were implemented by change agents into various new diffusion strategies that affected diffusion process. However, in feedback effect which led to further research according to right strategy for their decision for further implementation.

**Nature of Social system, in Habit of eating and Agriculture system of India**

In modern India eating with left hand believed to be unclean and it has begun in Indian villages past centuries ago because of function associated with defecation. During those times there were inadequate washing and sanitary facilities. But today easy for middle class and urban people to wash their hands before meals. However, change in promoting innovations run counter to strongly held values (Rogers & Everett, 1983).

In case of agriculture, package of innovations have been introduced like crop varieties, fertilizers and other agriculture chemicals. But experiences indicates all the villagers would have easily and rapidly adopt to this kind of package of innovations compared to implementing it individually to each farmer (Fliegel, 1967). When considering the performance of the vehicles there is always the person who expects the driving convenience as they are connected emotionally towards their respective vehicle. The drivers in public transportation always drives their vehicle on an everyday basis with different vehicles and they get more attached to the performance of the vehicle as the driving pleasure is mixed towards the mix of engine power to take control over the vehicle. All the drivers had felt their driving pleasure in the IC engine vehicle, so while this change might disturb their emotions. This needs to be equalized by the new technologies to become more aware of it (Sovacool, 2017). Similarly, the use of diesel engines was most successful and by observing the adoption of electric buses in other countries, Indian had also decided to adopt the use new technology as the value towards is more evident. Biresselioglu et al., (2018) had explained barriers such as consumer acceptance and lack of awareness while testing in European union during implementation of electric buses.

### 2.2.1.5 Extent of change agents:

The relationship between rate of adoption and extent of change agents is neither direct or linear relationship. However, there is greater effect on pay off from a given amount of change agent activity at certain stages in innovation diffusion. As (Stone, 1952) show that greatest response occur when opinion leaders are adopting, which is usually between 3 and 16 percent of adoption in most systems.

As (Emrick et al., 1977) explained there are seven points which can help any author to diffuse the new technologies by the rate of adoption.
1. **Develops need for change**: A change agent is often initially required to help his or her clients become aware of the need to alter their behaviour to initiate the change process, the change focuses on their existing solutions to invest new technologies by convincing the clients, giving the importance of these problems, and may convince clients that they are capable of confronting problems. The change agent assess needs of client at this stage, and also may help to create these needs in advising manner.

2. **Establishes an information-exchange relationship**: Once a need for change is created, a change agent must develop interrelationship with his or her clients. Moreover, the change agent can enhance his or her relationship with clients by creating credibility in his or her competence, trustworthiness, and empathy with the clients' needs and problems. However, clients are ready to accept the new technology due to the increasing demand by all the country that an individual will always promotes, because the innovations are often judged in part on the basis of how the change agent is perceived.

3. **Diagnoses their problems**: The supplier main goal to analyse the problems faced by the clients and explain the use of new technology why the technology is much needed. In arriving to sudden conclusions, the change agent must review the scenario emphatically from the customer's perspective, not his or her own. Moreover, The change agent must psychologically zip him or herself into the clients' skins, and see their situation through their eyes.

4. **Creates intent to change in the client**: After a change agent explores various avenues of action that his or her clients might take to achieve their goals, the change agent seeks to motivate an interest in the innovation. But the change must be always on customers perspective, rather than innovation-oriented, concentrating on the client’s hurdles.
5. Translates intent into action: A change agent seeks to influence his or her client’s behaviour in accordance with recommendations based on the client's needs. However, interpersonal network influences from close companions are most imperative at the influence and choice stage in the innovation choice process. So the change agent can operate only indirectly here, by working with opinion leaders to activate peer networks.

6. Stabilizes adoption and prevents discontinuances: Change agents may effectively stabilize new behaviour by directing reinforcing messages to those clients who have adopted, by "seizing" the new behaviour. This assistance is frequently given when the client is at the implementation or confirmation stage in the innovation-decision process.

7. Achieves a terminal relationship: The end goal for a change agent is to develop self-renewing behaviour on the part of the client system. Furthermore, change agent should seek to put him or herself out of business by developing the client's ability to be their own change.

Researchers Work on Change Agent:
One of large-scale investigation dealing with change agent success by Niehoff and using yet another research approach arrived at similar conclusions: change agent effort leads to success in introducing innovations to clients. Niehoff & Anderson, (1968) concluded from his analysis of several hundred case studies, each dealing with a change agent's attempt to transfer an innovation cross-culturally, that one of the most fundamental factors in success is the extent of change contact with clients. Moreover, the communication interface submerges on the heart of the Roger's diffusion process.

Finally, the sheer amount of client contact is by no means the sole explanation of change agent success. However, to exemplify, the timing of the client contact, relative to the stage of diffusion of an innovation, is a factor in success. Stone, (1952) analysed the amount of effort expended by agricultural extension agents in promoting a new idea to Michigan farmers. In the first years of the diffusion campaign the rate of adoption of the innovation roughly paralleled the amount of change agents' efforts, as measured by the number of agent days a year devoted to the innovation. After about 30 percent adoption was reached, however, the extension agents' efforts decreased, whereas the farmers continued to adopt the new idea at an almost constant rate. Once the opinion leaders adopt, the adoption curve shoots upward in a self-generating fashion, and a change agent can begin to retire from the scene. The adoption curve will then continue to climb, independent of change agents' efforts, under further impulsion from the opinion leaders.

Incentives Supporting for Electric Vehicles in EU and US:
Adoption of electric vehicles in many countries is still at early stage of procurement when compared to the existing fossil fuelled vehicles. Therefore, the government's new policy effort is a major factor for the market creation and diffusion of EVs. Hence, all the country government has decided to implement policies to support the usage of electric vehicles such as purchase subsidies, public expenditure, tax reduction, tax exemption, parking permission etc. In US government had already started producing tax exemptions and tax subsidies for the end consumers on the purchase of electric vehicles (Yong & Park, 2017). Whitehead et al., (2014) identified that tax policy congestion can drastically improvise the percentage of energy efficient vehicles in Stockholm. The promotional efforts by the government help the municipalities or the automotive industries who are willing to start the use of electric buses in India with the support of different tax incentives and new technologies due it to good cause effects (Yong & Park, 2017). Tax incentives, is one among the factor which is influencing electric vehicle adaption around the globe (Barfod et al., 2016).
The Acceptance of alternative fuel saving transport vehicle is till marginal and sale of EV’s is low. For instance in case of Sweden, is about 3.8% and Belgium about 2.8 % sales of new cars in first quarter of 2017, which accounts 2% of new car sales in both countries (Wu & Zhang, 2017). On other hand Netherlands account about 3.8% EV share in 2014 dipped to 1.5% in 2017 because of withdrawal in tax incentives (Dhar et al., 2017; Trigg et al., 2013). However, Norway maintains tax incentives have EV diffusion growth rate to 28.9% . this shows low figures in EU needs governments and institutions to take action in order to increase market diffusion as in Norway.

As discussed above for the diffusion of electric vehicles below are the barriers in the table which are faced initially in all the countries during the diffusion of electric vehicles.

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Challenge Type</th>
<th>Challenge Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Financial</td>
<td>High purchase cost</td>
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| 2     | Physical       | Missing publicly available charging stations  
                         Lack of network service  
                         Lack of service network in rural areas  
                         Roads in rural areas need to be proper to implement the ECVs |
| 3     | Operational    | ECV doesn’t provide long range for everyday long travellers  
                         Recharging difficulties because of the stopping patterns of ECVs |
| 4     | Technological  | Unpredictability in winter conditions  
                         Trade-off between comfort (heat) and range during winter |
<p>| 5     | Psychological  | Fear of accident involvement due to low noise level of ECVs |
| 6     | Opportunity type | Opportunity description |
| 7     | Technological  | Individual expectation or demand should be equal to existing technology when the EVs are out in market |</p>
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<th></th>
<th>Operational</th>
<th>Environmental</th>
<th>Financial</th>
<th>Branding</th>
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<td>8</td>
<td>Suitability of ECVs to firms needs on vehicle performance</td>
<td>Long term benefits to the environment from driving ECVs</td>
<td>Advantages in terms of energy cost</td>
<td>ECVs as a tool for generating good public image</td>
<td>Policy initiative description</td>
<td>Free parking for electric vehicles</td>
<td>Emission-based taxes on vehicles</td>
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<td></td>
<td>Ease of adoption ECVs for the needs of firms</td>
<td></td>
<td>Potential opportunity</td>
<td>Opportunity for the firm to be a pioneer and innovator</td>
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<td>State subsidies for the purchase or use of electric vehicles</td>
<td>High petrol and diesel prices</td>
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<td>Low registration fee for electric vehicles</td>
<td>Cap on firms’ carbon emissions</td>
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<td>Limitation on the purchase of conventional fuel vehicles but not on ECVs</td>
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*Table 2: Challenges, opportunities and Policy Initiatives for the Market Diffusion of ECVs (Barfod et al., 2016)*
3 METHODOLOGY:
The current section will talk about the different methodological framework used for this specific research by (Saunders et al., 2015). The different choices made for this research is from ‘research onion’ which is shown below in the figure, sum the stream of research, which brings together all the methodological decisions. At last, reflections on the strategies are conferred.

![Research Onion](image)

3.1 PHILOSOPHY:
Research philosophy is the initial step of the research onion, whereby it is believed that the data’s used for this specific research is been gathered, analysed and implemented. There are five different philosophies which can be supported to any research. They are Positivism, critical realism, interpretivism, postmodernism and pragmatism. There are two major philosophies which has been spoken about the western tradition of science, is positivist and interpretivist (Chen & Hirschheim, 2004). All these different philosophies are being purely working under the different aspects of Ontology (realities), Epistemology (Knowledge measures) and Axiology (different roles).

For answering to our research question we have chosen pragmatic approach, because as it is more appropriate for researchers in this study to think philosophy adopted as continuum rather than opposite position. This means our emphasis on current barriers for implementation electric buses will lead to rate of adoption in three municipalities.
3.2 RESEARCH APPROACH:

In this section, the research is about how the researchers are clear about the theories where the theories raise the question on how to develop a design towards the researchers work. Saunders et al., (2015) has differentiated the research approach design based on the Logic, generalisability, data usage and the approach to theories. These factors are connected to the different research design process namely Inductive, Deductive and Abductive, whereas, deductive approach is used in testing theories, while an inductive approach is in line with building theory (Saunders et al., 2008). As Bryman & Bell, (2011) explains inductive approach is more of qualitative study when compared to deductive where it is quantitative.

In this these we wanted to find out the barriers during the diffusion of electric buses at this particular time with the new technologies so called electric buses. As authors, we would like to find out the barriers and impose a suitable solution for the municipalities and therefore a inductive approach has been used. The whole research process are made flexible with a formulated research question and to get an overview of our research topic all the methodological choices have been made accordingly by meeting and interviewing the municipalities and some experts in India. Through these the author had got strong points focusing on barriers to identify which helped us to build up our findings and connect to our analysis. This made the authors to opt for an inductive approach.

3.3 METHODOLOGICAL CHOICE:

The method of choice in a research is to initially identify the right method such as quantitative and qualitative method. Quantitative method always deals with the statistics and graphs, whilst qualitative data are more of primary and secondary data with a focused interviews and data processing. But nowadays it is in a bit of confusion because most of the research are always a mix of quantitative and qualitative method (Saunders et al., 2015).

Qualitative data, is one of the option available for all the authors to collect data by means of interviews or data analysing procedure, without the use of non-numerical data.. Therefore , it can refer to data other than words, such as pictures and video clips (Saunders et al., 2015). Therefore in this research we had decided to pursue with qualitative research as it deals with the government public transport sector whereby decisions are taken by head of department to interview rather than taking a survey. As this research, is on finding out the barriers towards
implementation of electric vehicles, collection of data is done with the help of semi structured interviews. For this research as mentioned above Indian government is one key factor for the transport municipalities were the norms are provided with different regulations which is highly confidential. These confidential data’s cannot be collected by the researchers as we don’t have the permission to collect data. Therefore, author had decided to pursue with qualitative data and had a chance of meeting the municipalities and gathering the information through them.

3.4 RESEARCH STRATEGY:
This section is a one important criterion whereby all the researchers has to critically analyse which strategy to follow to attain the expected result. Research strategies is a supporting layer for the research to prove their research with the list of strategies explained by (Saunders et al., 2015), they are Experiment, Survey, Archival and Documentary Research, Case study, Ethnography, Action Research, Grounded Theory, Narrative Inquiry.

Case study is one of a strategy for doing research which involves an live investigation of a particular contemporary phenomenon within its real life context using multiple source of evidence (Robson, 2002) this gives clear understanding of where the number of variables are limited and data can collected. The source are mainly primary and secondary to prove any research. As the current research focuses on India context towards the diffusion of electric buses and the barriers, the researchers had observed that the public bus transportation in southern municipalities are going to start initiating the use of electric buses. The authors had observed this information through the news whereby, it made the authors to go deeper into this case by finding the research gap and intend to provide a possible solution for the municipalities. Case study approach is done with the help of semi structured interviews with the municipalities, suppliers, bus driver, and in one more professional who has an idea about the electric vehicle. As mentioned the case study is process is chosen on articulating to the point where the municipality people can help the authors to identify the barriers as they are working on the diffusion of electric buses. As these three municipalities are in their verge of diffusion process the authors had decide to interview these state municipalities to find out the barriers. These three municipalities had been particularly chosen by the authors mainly because in the southern region as these three states are working on the diffusion of electric vehicles.

3.5 TIME HORIZONS:
The time horizon basically depends upon the research gap identified by the researchers and they intend to choose whether the research work needs to be in a particular point of time or over a period of time. This is where the author (Saunders et al., 2015) mention in two different ways, they are cross-sectional which clearly indicate the particular period and longitudinal which shows the different horizons.

Due to the time constraint for the authors, we decided to pursue qualitative approach way as this research is about analysing the barriers in Indian market towards the diffusion of electric buses as the Indian municipalities are keenly looking to start the use of electric buses. For this research, we had chosen a process focus on the implementation of electric buses for a shorter period. As these municipalities (BBMP, GHMC, GCC) are the early stage we focused on analysing the barriers during the diffusion electric buses which tells clearly the cross sectional method will be a best suitable time horizon.
3.6 DATA ANALYSIS:

3.6.1 SECONDARY DATA:
The secondary data are one of the existing data which is been reviewed and used for the other purposes and it has been used for the this specific case study and it has been helped in this research to collect and analyse the primary data. These secondary data were taken out from the different web sources, company’s website and press releases from by the transport corporation and by the supplier, which is used as a raw data sources (Saunders et al., 2015). Secondary data is also used as alternative data to support this research and it has been analysed and reviewed in the discussion. Moreover, secondary data is being used to find impediments faced in different parts of the world and because of agreements between companies and municipalities are highly confidential in India.

3.6.2 PRIMARY DATA:
For any research primary data is an advantage which helps to support the author's research by adding more value with present details by means of interview and observing the live situations on the different field on which the research is focused on. Primary data was accumulated by means of focus interview’s that is face to face interviews and analysed (Saunders et al., 2015). These data are collected and it is been taken as notes to use it later in the analysis and discussion. Researchers’ objective was performed in the state transport municipalities for the implementation of electric buses. A short informal discussions had been performed with the bus drivers who is been currently driving the diesel engine buses and been observed and to provide it as a state of proof. These data has been collected and observed only with the people who is currently working on the implementation of electric buses.

3.6.3 DATA COLLECTION:
For this particular research the interviews are perform with the transport sector which is owned by the state government on the southern part of India and the exact same implications have been and being performed in Northern part of India. As mentioned above the only participant involved in this implementation of Electric vehicle buses for the public transportation is the transport government. Interviews has been performed in 3 states BBMP (Bengaluru), GHMC (Telangana State) and GCC (Chennai). All these transport department have made an agreement with the BYD company who manufactures electric buses. There were also interviews performed with an Indian supplier company MG groups who develops the body works for electric buses and one more interview with an automobile company called TVS who is the largest producer of motorbikes in India and are looking for the adoption of electric vehicles. This BYD company has taken this contract through the auction. The ideology behind this data collection analysis is to find out the in-depth information and the steps taken by the transport government for initiating the electric buses on the roads and what steps they have implemented towards it.

In the beginning short introduction have been given to the interviewee about the research to clearly specify what the author is looking into it. Secondly, the author had a set-up of open ended questions to get out the complete information. These interview were performed face to face and some telephonic calls as well. It is not allowed to record the interview as this research deals with the governmental issues and the author had written down the important points required for this research study and observed.
At first the interview was done with Mr Anandakrishnan who works in Human Resources department for TVS motor India Pvt Limited. Tvs motor company was founded by Mr T.V. Sundaram Iyengar and sons in the year 1911. It is one of major motorbike production in India and a well-established company in India. The interview was done with Mr Ananda Krishnan regarding the sustainability measures and their next proposals towards their implementation of electric vehicles. This telephonic interview had lasted for about 45 - 50 minutes and the main focus was on the diffusion of electric vehicles.

Secondly, the interview was performed with Bangalore metro Transport corporation (BMTC) with Mr Mallikarjun who works as an Junior assistant in mechanical department. BMTC transport is a state government owned public transport corporation which is controlled by the Karnataka state road transport corporation whereby BMTC covers the whole city Bangalore with a fleet of 6726 buses which runs every day. This was an face to face interview with Mr Mallikarjun where we met in BMTC head office Bangalore at his cabin and the interview had lasted for about 35 - 40 Minutes.

Third, the interview was performed with Telangana state road transport corporation (TSRTC) with Mr Ravinder who works as Executive director in mechanical department at TSRTC. TSRTC transport is a state government owned public transport corporation in the southern state of India. TSRTC has approximately 10,679 buses in TSRTC. The interview with Mr Ravinder was face to face interview where we met at TSRTC head office Hyderabad in his cabin and the interview had lasted for about an hour and the main focus was on the implementation of electric buses.

Fourth, the interview was performed with Chennai Metro Transport Corporation (CMTC) with Mr Natarajan who works as an Deputy Manager Technical Department at CMTC. CMTC is a state government owned Public transportation in south India controlled by Tamil Nadu state road transport corporation whereby CMTC covers the whole city of Chennai which is a part of Tamil Nadu. The interview was held at CMTC head office Chennai in His cabin and the interview had lasted for about 30 minutes and the main focus was on the diffusion of electric buses.

Fifth, the interview was performed with Mr Rudranshu Nautiyal who works as an Head of strategy and corporate communication at MG groups which is a parental company of Goldstone Infotech Limited. MG groups is a private owned organization where they build the outer body of all buses and starting to develop body for electric buses as well in India. The interview took place in ITC grand chola a 7 Star hotel in Chennai, where we had an opportunity to meet him in person at the cafe and the interview had lasted for about an hour. The main focus on this interview was to know about the evolution of electric buses and the barriers faced by them as they are one of the supplier.

Sixth, the interviews was done with Mr Selvam who is a bus driver working for SRS Travels. It is a private company where they operate buses between different states of India. This interview was an informal interview on the bus while i was travelling in the bus. The interview lasted for about 15 minutes and the main focus was to know about the existing experience with their diesel engine buses.
<table>
<thead>
<tr>
<th>Sl. No</th>
<th>NAME</th>
<th>LOCATION</th>
<th>TIME FOR INTERVIEW</th>
<th>MAIN FOCUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mr Anandakrishnan, HR</td>
<td>Telephonic call</td>
<td>45-50 mins</td>
<td>Diffusion of electric vehicles</td>
</tr>
<tr>
<td>2</td>
<td>Mr Mallikarjun, Jr asst. Mechanical dept.</td>
<td>BMTC head office</td>
<td>35-40 mins</td>
<td>Evolution of electric buses</td>
</tr>
<tr>
<td>3</td>
<td>Mr Ravinder, Executive director mechanical department</td>
<td>TSRTC Head Office</td>
<td>60 mins</td>
<td>Implementation of electric buses</td>
</tr>
<tr>
<td>4</td>
<td>Mr Natarajan, Deputy technical Manager mechanical department</td>
<td>CMTC head office</td>
<td>30 mins</td>
<td>Diffusion of electric buses</td>
</tr>
<tr>
<td>5</td>
<td>Mr Rudranshu Nautiyal, Head of strategy and corporate communication</td>
<td>ITC grand Chola Hotel</td>
<td>60 mins</td>
<td>Evolvement of electric buses</td>
</tr>
<tr>
<td>6</td>
<td>Mr Selvam, bus driver</td>
<td>In Bus (SRS Travels Pvt Ltd)</td>
<td>15 mins</td>
<td>Driving comfortness</td>
</tr>
</tbody>
</table>

Table 3: List of Interviews done

### 3.6.4 Case Description:
For our research question semi structured interviews was conducted in 3 municipalities namely Bruhat Bengaluru Mahanagara Palike (BBMP) (Bengaluru), Greater Hyderabad municipal corporation (GHMC) (Hyderabad) and Greater Chennai Corporation(GCC) (Chennai). Furthermore, local bus transportation corporation in these three municipalities are operated by Bangalore Metropolitan Transport Corporation (BMTC), Telangana State Road Transport Corporation (TSRTC),and Chennai metropolitan transport corporation(CMTC). Which are in turn owned by state governments of their respective states Karnataka, Telangana and Tamil Nadu respectively.

The first interview was with TVS groups, who is the major motorbike producer in India. TVS groups was founded in 1911 by Mr T.V. Sundaram Iyengar and sons in Hosur in the state of Tamil Nadu in India. TVS has made their company successful by acquiring the major share of supplying mopeds with a low CC engine and created a major market share throughout India. This company also sells motorbikes with various engine size and they have a good market with a good profit and been an one of the best company in India. The interview was performed with
Mr Anandakrishnan who works as an senior employee as an Human Resource head for many years. The company vision was always to supply the bikes at an nominal price to the required market.

BMTC (Bangalore Metro Transport Corporation) is city in Karnataka located in the southern part of India. BMTC is a state government owned public transport corporation which is controlled by the state of Karnataka. BMTC has a bus fleet of 6726 buses at present which covers the whole city of Bengaluru to make the common people to connect to their destination at their footstep by making it accessible. The interview was performed with Mr Mallikarjun who works as an Junior assistant in Mechanical department and at present he takes care of the diesel buses for their everyday maintenance. He is also an active member in the diffusion of electric buses and he will be taken control of the mechanical issues.

TSRTC (Telangana State Road Transport Corporation) is an another state in south India where they have many cities covered in this state including Hyderabad, Nizamabad (Hyderabad, Sangareddy, Mahabubnagar, Nalgonda, Miryalaguda, Warangal, Karimnagar, Nizamabad, Bodhan, Adilabad, Nirmal, Khammam, Bhadrachalam etc). TSRTC is also stated owned public transport for their city use including the urban and rural areas. TSRTC has a bus fleet size of approximately 10,500 buses which covers the whole state on the above mentioned cities. The interview was performed with Mr Ravinder who works as an Executive director for mechanical department whereby he controls the overall bus fleet on the approval of any new technologies by testing it out. The person is currently in charge of everything and the daily bus schedules will be approved by him and he has the full control over the buses for all maintenance and to push in new technologies for their development.

CMTC is another state owned transport corporation located in the southern part of India. CMTC covers the whole Chennai city where the city is located under the state of Tamil Nadu and CMTC has a bus fleet of about approximately 4000 buses with 33 depots and covers the entire city with all the suburban areas as well. This interview was performed with Mr Natarajan who is an deputy manager technical department and he controls the everyday process of CMTC of all the outflow and inflow of the buses. He controls the service and maintenance department of the current diesel powered buses and report to the superior with an everyday performance of the buses.

MG Groups is a private company and it is has been merged with Goldstone Infratech Limited who has been one of the best supplier of buses to all the commercial vehicle producers in India. This company had also been partnered with BYD a Chinese company who develops the batteries for the buses and builds chassis and send it to MG groups, where they have a major role in building up the outer body of the buses and supplies to the customers. The interview was performed with Mr Rudranshu Nautiyal who works as head of strategy and corporate communication whereby his role is to meet the customer demand at the given specified time.

SRS travels is a privately owned bus organisation where they have around 5000 buses for their everyday travel between the states of India. There are many other private travels which functions like SRS and uses this mode of transportation for the public to travel on their everyday basis. SRS travels has many buses including VOLVO, Scania, Mercedes Benz buses, etc. Mr Selvam works as an permanent driver for SRS travels where he travels different states according to his Schedules or time table and drives different buses.
3.7 RESEARCH ETHICS:

To ensure high quality of qualitative research it is important to build trustworthiness (Alan Bryman & Bell, 2011). Moreover, to certify this trustworthiness of this study we have following four criteria into consideration: credibility, dependability, confirmability and transferability. All these are explained as four subsections.

3.7.1 CREDIBILITY:
Credibility is about “reducing the possibility of getting the answer wrong (Saunders et al., 2008). Usually, respondent validation is commonly used among qualitative researchers, however, “they frequently want to ensure there is good correspondence between their findings and the perspectives and experiences of their research participants” (Bryman et al., 2011) and “whether the findings are really about what they appear to be” (Saunders et al., 2008). Due to our time spent at the case in two municipalities of the study were accustomed to us when we started our research. Moreover, informants feel safe with the researcher but heads of municipalities are not allowed to share information regarding some confidential matters because of sensitivity in issue of allegations in corruption and fear of data leaks to among public.

Aiming for high credibility we have sent out the finalized thesis to two municipalities and its participants prior to publication to ensure that our understandings and impressions were in line with the beliefs and perspectives (Becker et al., 2012). “but the most predictable mistake made in a study is credibility where the research objectives respond towards their thinking which will be accordingly towards the social response” (Krefting, 1991). Moreover, for this research semi-structured interviews have been performed to gather and analyse the data. Whereby the employees were interviewed according to the designations and to the role who works on the diffusion of electric buses. These primary data’s were collected and in turns secondary data (BMTC, TSRTC, BYD press releases) were also gathered from the different municipalities and from the suppliers. Having a continuous dialogue with, and access to the municipalities kept the door closed for follow-up questions if we found any information missing (Krefting, 1991). There has been a lot of time spent preparing a good manuscript for the proper information with the continuous reformulation of questions to make the data strong.

Furthermore, by using more than one source of data we can explain the richness and complexity of the phenomenon since we studied from different perspectives. According to (Cohen et al., 2011) multiple data sources helps to increase the confidence of the researcher. Given this we have been able to view the municipalities in different ways and perspectives, which has enriched our study by being able to explain certain events from more than one standpoint (Bryman & Bell, 2011).

To ensure this, discussion had been performed with the proper information regarding to our research to make sure the interviewees are in track with us and to make sure the report has been sent to the mentor and rechecked and confirmed.

3.7.2 DEPENDABILITY:
In order to achieve dependability we have adopted an auditing approach, which means that the entire research process should have complete records consisting of problem formulation,
selection of participants, transcripts, methodological choices, fieldwork notes and so on (Becker et al., 2012). Moreover, we have made our entire data collection and analysis procedures to be as transparent as possible. We were not allowed for interview recording and however, we are able to use personal notes while interviewing heads of electric bus divisions in two municipalities named as TSRTC and BMTC designated as executive director and mechanical engineer respectively. Furthermore, collected data is available for supervisors, examiners, to our class mates and scholars throughout the research process.

3.7.3 CONFIRMABILITY:

Confirmability is about neutrality (Krefting, 1991). The researcher should be apparent and not allow the research to be biased by letting theoretical inclinations or personal values to sway the conduct of the research and its outcomes and findings (Becker et al., 2012). The written notes form the interview had ensured a high degree of confirmability where there was more about the diffusion of electric without deviating into any unrelated topics. The written notes has been transcribed into our data collection part as soon as the interview is done within 24 hours of time to strengthen the degree of confirmability.

To make this happen there was a professional who is been acknowledged already and was our supporting mentor for this research in India whereby after each interviews the transcribed data are sent and cross checked and after explaining in the data collection part, report has been sent to the mentor to cross check and there was a continuous confirmation was done weekly once during the data collection and throughout the research.

3.7.4 TRANSFERABILITY:

Transferability is about applicability (Krefting, 1991). Transferability addresses the issue of whether the research findings are transferable into another context, or in the same context at another time (Becker et al., 2012). However, qualitative researchers should create a so-called ‘thick description’ to ensure high transferability, which is supposed to create a possibility for other scholars to make judgments about the transferability of the study (Bryman, 2011). Moreover, Krefting, (1991) argues that, “as long the authors provides enough data for comparison unless the individuals address the problem of applicability”. By gathering a rich amount of data from different perspectives we aim at generating a thick description of the current case. Krefting, (1991) further highlights that in qualitative studies “each situation is defined as unique and thus is less amenable to generalization”. The purpose with our study is to explore impediments in diffusion of electric buses in three municipalities (BBMP, GHMC and GCC).

4 EMPIRICAL FINDINGS:

This section will explain about the different views of the interviewee’s about the diffusion of electric buses in India and then to support the data collected by the author, secondary data are also attached to have a strong argument in the analysis and discussion part.

The interviews were performed with different professional to understand an holistic view on the implementation of the electric buses in India. The interview was done with Mr Anandakrishnan who works in TVS as Human Resource head. This company is also looking for sustainable opportunity by introducing their first fleet of electric vehicles to test the market and their demand. The interviewee impression towards electric vehicle if India is moving towards electric vehicles there has to be certain criteria which has to be considered and
implemented as a basic amenity for the end user, as they are going to be our end users of it. From his perspective there are several factors which can be considered from the customer point of view as there should be charging infrastructures set up across the city at the required distance for the people to charge their vehicle, due to the number distance travelled by a common people across the city. For example, if the people are in a hurry to their work with their own electric vehicle and if there is not enough charging infrastructure, the owner who needs to charge a vehicle has to go to one of the charging point which is no way related to his route and he/ she needs to leave an hour early to the office and go the charging point and charge their vehicle and this takes a lot of time. By considering this each individual will not prefer to buy an electric vehicle until or unless they have their charging point nearby to the place where their final destination is, this is for a normal car or a two wheeler. When considering heavy duty vehicles the size of the vehicle is too big and the battery charging time also takes a lot of time and this might make the other normal people to wait to charge their cars while during the peak hours. So from an customer perspective there can be many barriers which could stop them buying electric vehicle.

For an end user initially the mindset is considered as one of a barrier, cost of the vehicle, lithium battery is expensive and if there is a point where they need to replace a battery how much will it cost, resale value, how reliable is the motor when compared to engines, whether the battery or motor decides the car, because of the two electrical component present in it. The interviewer point of view was to go on an hybrid vehicle if this research is for heavy duty vehicles as there are many criterions needed to fulfilled. When considering other alternative fuels, alternative can one of the best solution as India is an agricultural country and there can be a question on will it be issue on food security. The country to move on to electric vehicles, interviewee’s suggestion was to release electric two wheelers whereby they don’t travel many distance so that it can be used for short distance and recharging the batteries are also done quickly. Another suggestion by the interviewee was to have a dedicated bus line so that some alternative solutions can be built to charge the vehicle where the vehicle can able to charge on the go.

BMTC is currently working with only diesel engines and they had observed usage of diesel engines is a good profitable business in the past. But now during the later stages BMTC has started facing a huge loss due to the people moving into private vehicles. BMTC has decided to implement the usage of electric buses in their city due to the different technological benefits and governmental push. BMTC has already decided to purchase 80 buses in their initial stages to see the success of it. This is done under the FAME & NEMP scheme with provided subsidies by the government. The subsidy provided from the government of India allocates 60% of the total cost to the state transport municipalities for the bus if there 30 % Indian manufacturing parts. The interviewee is very happy to see the first bus supplied by BYD who is major electric battery provider and they have decided to supply the buses BMTC government under the given norms. There is also a press release from BMTC and BYD stating that BMTC has ordered around 100 buses for their everyday usage by maintaining the current fleet size with the use of electric buses and tries to reduce the CO₂ emissions (BYD, 2014; Gururaj, 2017). This was decided by the board of members of BMTC department with the support of Government of India (GOI). These state transport people has started setting up their charging infrastructure in their respective bus depot in 28, 32 and 19.

The next observation was done at TSRTC whereby they have many buses, whereby they operate for different areas according to the schedules. As the interviewee was not satisfied with the current operation due to the huge loss faced by the state transport corporations and they have to stabilize their public transport by introducing with new vehicles and with new
technologies. So they already started the initiative with the alternative fuels by acquiring 150 CNG buses and 30 Bio diesel buses which can reduce the state emissions. GOI when they revealed the FAME and NEMP scheme, the state government were very much interested by the technology of electric buses and planned to implement it for their state. The subsidy provided from the government of India allocates 60% of the total cost to the state transport municipalities for the bus if there 30% Indian manufacturing parts. The electric buses has been tested by the technicians and they had decided to purchase 40 buses as a pilot project to support the environment growth and to stabilize the state government. The subsidy from the state electricity is also tending to support the public transport municipality with their refreshed rates according the availability and the usage. The electricity tariff rate has been mentioned below in the table 4 at the end of empirical part. The interviewee is very much interested on the implementation of electric buses due to its different advantages though the cost is high. TSRTC press release also states that electric bus will start function very soon with 40 seats with Wi-Fi and tracking app facilities for the end user to have a convenient travel at the required time. This was spoken by MR Ravinder who works as executive director for TSRTC (Baski, 2018). These state transport people has started setting up their charging infrastructure in their respective bus depot.

The state municipalities BMTC & TSRTC chooses the supplier of electric buses according to the auction criteria and whoever wins the bidding and quote a low price which is most suited with the budget allocated by the government of India, the state transport municipality can sign a contract with them on their implementation of electric buses.

As mentioned above in the figure goldstone Infotech has merged with BYD to supply the electric buses in India with provided by the government. If all these criteria’s satisfy with the perceived attributes of innovation, then it leads to diffusion of electric buses. As (Rogers, 1975) there is always different variable which leads to the rate of adoption and in any diffusion process either of the one variable will be mainly concentrated and helps to leads towards diffusion.

The next interviewee was Mr Natarajan who works in CMTC and his perception towards electric bus was also quite better when compared to normal IC engines. But CMTC government has no idea on when are they going to initiate the use of electric vehicles. As they are facing
65 crore loss with their existing bus fleet and it is needed to be stabilized to acquire the new technological innovation.

BYD parental company MG Groups who builds body for the electric buses has seen a huge demand for the electric buses as many state municipalities had started initiating the electric buses. The interviewee had seen a good growth in demand for the electric buses and they are now waiting for many private entrepreneurs to start the use of electric vehicles and they can be supplier for all the automotive. From the interview point of view the private entrepreneurs are waiting due to lack of upfront cost and it can be funded only by the stakeholders. The interviewee had said diffusion of electric buses are going to change the environmental conditions and public behaviour due to it qualities. BYD also said in a press release that they are working on the implementation of India’s first pure electric vehicle to reduce CO₂ emissions with BMTC and TSRTC with the support of Indian government (BYD, 2014).

The Electricity Tariff Price:

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>FIXED/ DEMAND CHARGE (Rs./ Month)</th>
<th>ENERGY CHARGE Rs./ kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>UNIT kVA</td>
<td>Rate 390</td>
</tr>
<tr>
<td>Airports, bus stations, railway stations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11kV</td>
<td>kVA</td>
<td>390</td>
</tr>
<tr>
<td>33kV</td>
<td>kVA</td>
<td>390</td>
</tr>
<tr>
<td>132kV and above</td>
<td>kVA</td>
<td>390</td>
</tr>
</tbody>
</table>

**TIME of DAY TARIFFS (6AM to 10AM)**

| 11kV                            | 8.50 |
| 33kV                            | 7.85 |
| 132kV and above                 | 7.45 |

**TIME of DAY TARIFFS (6PM TO 10PM)**

| 11kV                            | 8.50 |
| 33kV                            | 7.85 |
The table shows the electricity tariff rates of Telangana state according to the different regions and then the electricity rates have been mentioned for the different commercial purpose whereby the cost for each unit has been mentioned for the different time zones.

As spoken by Mr Mallikarjun (BMTC), Mr Anadakrishnan, Mr Rudranshu Nautiyal (MG Groups) there are barriers which are been mainly analysed by the transport corporations or as an end user due to the different involvement the technologies and governmental policies. The barriers are listed below in the table which are considered during the diffusion of electric vehicles which is considered as one of the important criterion. Barriers are the same as identified above in the literature, lack of awareness in all perspective of decision making. There has not been an real time proof between the links and relationships towards the diffusion of electric vehicles.

5 Analysis and Discussion

In this chapter, the results are analysed. By using independent variables determining the rate of adoption to dependent variable i.e. rate of adoption of innovations (Rogers, 1995).

5.1 Perceived attributes of Innovation:

On the diffusion of electric buses there are variables which take part to guide it towards the rate of adoption explained by Rogers model. The author believes the different perceived attributes of innovation leads to the rate of adoption which constitutes towards the diffusion of electric buses. The various perceived attributes are seen below.

5.1.1 Relative Advantage for electric buses in three municipalities:

As India being a developing country there are many sustainable measures initiated by the Government of India to reduce oil import bill which is about 25% of total expenditure from taxpayers revenue and environmental benefits by adopting sustainable goals amended in UN.

Secondly, new technological changes always diffuses with their existing technologies and these existing technologies are leading to a numerous disadvantages, hasn’t the release of exhaust from the diesel buses leads to a huge environmental pollution which cannot be controlled due to the mixtures used in the IC engines and adding, by reducing economic burden on import of fossil fuels on electric vehicles in turn impacts diffusion of electric buses.
Heavy duty vehicles and light duty vehicles are the major emitters of CO$_2$ pollution and noise pollution. Heavy duty vehicles has only 13% of vehicles in Europe out of all the vehicles whereas they account for one third of the CO$_2$ emission (Biresselioglu et al., 2018). All the country follows the European emission standards now, presently India is in EURO IV level, this is the one of the reason India is planning to adopt the new technologies and shift towards EURO VI emission standards (Iyer & Mangaleswaran, 2017). As seen in the case of Australian government the implementation of low emission vehicle will reduce the carbon emission (Stanley et al., 2018).

*Relative Advantage for electric buses in various parts of world:*

Economic benefits for electric buses showed 25% lower total cost of ownership for electric buses compared to diesel buses for urban public transport and gives a positive impression to stakeholders towards electric buses. Furthermore, electric buses tested in USA have more than 6 dBA lower noise level compared to CNG and diesel buses during acceleration. This is an indication for reduction in noise level in urban bus transportation system. As seen from the Australian case of reduction of carbon emission and the authors finding from the interviews states, implementation of new low carbon emission vehicle will lead to an valuable effect and create a major impact in India such as noise level reduction, CO$_2$ emission, reduce oil bill imports etc.

### 5.1.2 Compatibility of electric buses in two municipalities (BBMP & GHMC):

From the data collected author states that, the state transport corporation had a success by using the fuelled vehicles and they were achieving the success with the existing technology, possible solution by adopting the usage of electric technologies. Battery electric vehicles or buses are seen as a winning alternative for the relative advantage like environmental and up to extent for governmental import bills in fuels. moreover, For the diffusion of electric buses there should be compatible measures taken by the municipality such as charging infrastructures(still in process), space for charging, maintenance area, special engineers for maintaining the buses and the power supply from the state electricity board also should be constant by speaking before hand with the prices and the demand expected by the municipality. These criteria should be satisfied by the municipality before they start the use of electric buses (Mahmoud et al., 2016). Likewise, BYD company, the electric manufacturer company had release a report stating they had made contract with the BMTC to provide the first pure electric buses to reduce the CO2 emissions with the above mentioned criteria (BYD, 2014). As observed from the interviewee’s the main barrier which the transport municipality expect is the range and performance of the battery. If these demands meet up such as battery performance and range it can lead to the diffusion of electric buses. According, to agreement for two state transport corporations BMTC (Bengaluru) and TSRTC (Hyderabad) looking for Battery performance range about 200 kms to 225 kms per single charge respectively. And cost for electricity is compensated by TSRTC and BMTC for Goldstone Infratech (BYD) for next 12 and 10 years. and price compatibility for buses is 0.43 USD/km for 9 meters non- air condition bus, 0.55 USD/km for 12 meters air conditioned bus (UITP, 2017).
5.1.3 Complexity Involved in Diffusion of Electric Buses in BBMC and GHMC:

Complexity deals with the technical side towards the diffusion of electric buses in the battery by considering the performance, size, range, life, charging capacity and the time required to charge the battery. These are also considered as one of the barrier towards the implementation of electric buses which can be further connected towards the price of the electricity. The interviewee had mentioned that, there will be always a constant supply of electricity from the electricity board for each and every state whereby the payments will be made on KW basis or the amount of power used by the transport to charge the buses. The charges are fixed according to the industrial rates for every individual states. In India each and every state has different price for the residential and commercial purpose which will be released by the state electric board of their respective states, and every year the rates will be revised according to the demands. The rate revised by the electricity board for the year 2017-2018 is increased to 8.45 Rupees per unit with an existing rate of 8.35 for consumption beyond 25,526 Million SEK units (KERC, 2017). Whereby the other state, Telangana has also increased their cost by the revised plan for the year 2017-2018.

The tariffs rates is to be as compatible towards the implication of electric buses as the charging time required by a bus takes longer and, as observed by the author’s from the interviewee mentioned the buses are going to be charging during the night hours and buses will be run during the day time. The battery size of the bus and with the expected range of the bus also a complex process due to it scheduled routes and the city distance. As seen from one of the interview from CMTC municipality are ready to adopt the diffusion of electric in their respective state, as their complexity in the state is high such as the electricity rates, current loss faced by the diesel buses, governmental supports is not fully acquired when compared to other states. If all these coincide with CMTC state municipality it will help them to adopt the use of electric buses. Charging infrastructure should be set in a proper place for safety issues and there should be always a continuous supply of electricity to charge the bus. The electricity will help the buses to charge even though there is different battery sizes (Mahmoud et al., 2016). The most important factor considered for the success on implementation of electric buses is to have a frequent electric supply to the charging stations to recharge the battery, which can be the most essential need for any electric vehicle.

5.1.4 TRIALABILITY OF ELECTRIC BUSES IN TWO MUNICIPALITIES (BBMP & GHMC):

Trialability concept is often related to the pilot study such as testing the new technologies, for any sustainability measures. In this research, towards the diffusion of electric buses, transport corporations has done a trial run with the electric buses to look at the different advantages such battery range, comfortless, features provided by the supplier to make the end customer have a safe and convenient travel. The same way shanghai and Macau had done the pilot study for the tourist buses to see the cause and effect of introducing the electric vehicles. In most of the case the pilot study will help the government to analyse the advantages of introducing new technologies (Zhou et al., 2016). As per the author’s observation from the state municipalities, one of our interviewee said that state public transport after the trial, they had decide to adopt the new battery technology on the implementation of electric vehicle. The result of acquiring the new battery electric buses is to get rid of the CO2 emission which needs to be restricted in a country like India due to a huge population and the number of public and private transports, this mission is also called as first zero emission electric buses in India (BYD, 2014).
5.1.5 OBSERVABILITY OF ELECTRIC BUSES IN BOTH MUNICIPALITIES (BBMP, GHMC & GCC):
Here the implementation or rate of adoption is always connected towards the relative advantage by capturing and delivering opportunities by connecting it towards the adoption of new technologies in the specific country. Since the environmental factors are considered to be the first barrier for any automotive industry, the business scenarios are being changed towards this new evolvement, which is more user friendly, cost beneficiary and competitive. So that many government and private automotive industries can start absorbing the different practices performed by other countries and can adopt the same technologies in India for the green solution towards sustainability (Govindan et al., 2014). However, consumers in India consider many barriers for the vehicles in the day to day life such as charging time, performance of the battery, technology of battery, battery cost where the price of the battery had been decreased from 1000 Kw/h to 300 Kw/h. Therefore, due to the different technological options in the battery, current solution is lithium Ion batteries are the current alternative when compared to fossil fuel and this lithium ion battery has an expected range of 200 - 250 km range with full charge (Dhar et al., 2017). To showcase this, as explained by Zhou et al., (2016) states that trial run or implementing battery electric buses with a minimal amount will help the municipalities to conclude the results and can observe the different pros and cons of the electric bus usage. The authors observation from the interview explains there are only a limited buses has been ordered initially to test out with the consumers and analyse the challenges. lastly, after the trial run the municipalities have their chance to focus on overcoming the barriers and further introduce a fleet of electric buses on their day to day basis by omitting fossil fuelled buses.

5.1.6 Overall view on perceiving the attributes towards Indian Context:
As the observation from the different interviewees the major factor where the state municipalities are concentration on are the incentives and subsidies given by the government. Therefore after the announcement of several norms by the government to undergo, diffusion of electric vehicles with various battery manufacturing companies which took part in the auction and later the bidding happened within all these companies in state municipalities (UITP, 2017). Moreover, the bidding list are presented in empirical data figure 16 indicates the different regulations, set by the government of India at various parts of the country.

As observed from the interview goldstone Infotech has merged with BYD to supply the electric buses in India with provided by the government. If all these criteria’s satisfy with the perceived attributes of innovation, then it leads to diffusion of electric buses. As (Rogers, 1995) there is always different variables which leads to the rate of adoption and in any diffusion process either of the one variable will be mainly concentrated and helps to leads towards diffusion.

5.2 Types of Innovation Decision: By Government of India

The decision for electric bus is purely Authoritative because our interviewees said government of India has taken an initiative to implement policy for electric vehicles under FAME policy to control emissions in Cosmo and metropolitan cities of India for public transportation. The two municipalities BBMP (Bangalore) and GHMC (Hyderabad) just followed FAME policy to initiated use of electric buses in public transportation through state transport corporations and sanctioned about 40 buses out 150 buses (UITP, 2017).
Policy by government of India towards electric mobility:
Government of India introduced the national electric mobility plan (NEMP), (GoI, 2013) to streamline the electric and hybrid components in the automotive field. Moreover it focuses on manufacturing and implementation of electric vehicles in India. However, department of heavy industries(DHI) has introduced FAME (Faster Adoption and manufacturing of hybrid and electric vehicles) in April 2015.

As mentioned above in the theoretical framework the flow of the process by any organization should be a systematic for any diffusion process to achieve a sustainable future by following the five criteria’s: Knowledge, Persuasion, Decision, Implementation, Confirmation. These five criteria will help the innovation decision process to keep on track towards the diffusion process.

5.3 Communication Channels used for rate of adoption by government of India:
Government of India has introduced this policy through media at parliament house, website for stakeholders (FAME) and further agreements are made between and government which is confidential, heard from one of interviewee. Mostly, between interpersonal as well as mass communication. When the author had done interview with BMTC, TSRTC and CMTC corporations the interviewees said the diffusion of electric buses goes through mass media and interpersonally about the new technological innovation. The mass media will help the end users to get know about the diffusion of electric buses which is going to be introduced in the city and then the end users will have some idea about the benefits of using electric buses. Therefore, for any industry the pricing is one main factor where the end consumers will look for, but in the case of diffusion of electric buses as observed from the interviewee the price of the tickers will be the same when compared to diesel buses and the communication is been made through mass communication as explained by (Rogers & Shoemaker, 1971).

5.4 Nature of Social System in India:
In the early stages technological and economic factors affect EVs adoption indirectly, towards the adoption of electric vehicles, which includes Price of fuel, consumer characteristics, income, and education also affect the purchase of EVs (Yong & Park, 2017). The nature of social system is most probably concentrated on the initial challenges faced by the diffusion of electric buses during diffusion process, whereby each individuals behaviour and response are considered on the diffusion of electric buses, as the end users are the main target.

Barfod et al., (2016) explained the people behaviour are no predictable for any technological diffusion due to their emotions connected towards it. As one of our interviewee explained, for a customer who buys an electric bus, the individual take a look into the different technological benefits and how it can be utilized. The customer while buying a bus will have some criteria’s in the mind like the comfortless, cost efficient, resale value of the vehicle or the performance of the vehicles as they are the one who is going to drive it, so they will be more emotionally and personally connected. The customer will always compare the existing fossil fuelled engines with new battery vehicle to make sure so that they can have a fair amount of connection on the both the vehicles (Sovacool, 2017). In addition, government of India had decided to implement tax incentives to Faster Adoption and Manufacturing of (hybrid) and Electric Vehicles (FAME). The factors analysed in this section are elements that are connected to pricing strategy with respect to social system in India.
5.5 Extent of Change Agents “promotion efforts”: Initiatives taken by local bodies and government of India.

According to UN goals for sustainability government of India takes an initiatives towards emission reduction in transport sector. Moreover, Diffusion of Electric bus technology has to establish relationship between OEM, electric batteries and infrastructure required to create awareness like credibility, reliability and trustworthiness in change agent (state municipalities). Manufacturer of OEM, batteries and infrastructure has created viable solution for diffusion of electric bus this, it means the state and central government will have to be well equipped physically and mentally by knowing about the electric bus and various parts (batteries, motors, charging time, charging requirement, technical maintenance, outer body conditions, etc.), all these information’s are supposed be known by the state municipalities to implement the usage of electric buses, and above that government has given incentives for these manufactures at various stages. However, these incentives have created competitive advantage for electric vehicles to translate technology into action by both government of India and manufactures. To stabilize the diffusion, government of India and bus manufacturers are closely monitoring the feedback from electric bus.

Adding to this, Yong & Park, (2017) explained the support of government by providing tax incentives, supporting infrastructure all over place same like fuel pumps will help the customer to invest on the electric buses as these are one of the main concerns. This will lead to major impact on adopting the electric buses. Authors have found out in this research, the seven variables as mentioned in rogers framework are worked together with OEMs, and Suppliers with the support of municipalities, state transport corporations and government of India which is leading to diffusion of Electric buses.
To summarize this, for any rate of adoption on adopting new technologies the following variables are one of the key factors which can be considered for the diffusion process. If all these factors in each of the attributes has been considered, it will gradually lead towards the rate of adoption of new technology. As observed above the adoption of electric bus is complex process whereby any automotive sector planning to initiate the use of electric bus must consider the following factors such as charging infrastructure, space for charging and parking, government bills supporting electric vehicles and tax incentives, battery capacity and performance of the battery. These are actually seen as barriers and these are also the factors which leads to diffusion of electric buses.
6 Conclusions:

In this chapter, main conclusions of current study are presented. Some of them are connected to findings of other researchers. Furthermore, practical implications of theoretical conclusions as well as limitations of current research.

Firstly, the purpose of this study is to find out the barriers and overcome it, that are affecting three state transport corporations in three municipalities (BBMP, GHMC, CGC) and implications to automotive industry in India who are willing to adopt the use of electric bus. Moreover, the application of Rogers model in this research had helped the authors to find out the barriers, which can help three state transportation sectors to initiate the use of new technologies (Diffusion of Electric Buses) and leads to an incremental change. Furthermore, the complexity involved in this process are identified mainly such as battery charging infrastructure, performance of the battery, bus rapid transit system and pricing of the tickets. These are the major barriers which are identified by the authors while conducting semi structured interviews with the interviewees. However, the road transport corporations of BMTC in Bangalore, and TSRTC in Hyderabad has initiated setting up their charging infrastructure and price of the tickets has been finalized which are more likely to be the same when compared to existing diesel engines.

Secondly, setting up of more number of bus rapid transit system, charging infrastructure at different locations and performance of battery at various conditions (climate changes, landscape) in three municipalities (BBMP,GHMC,CGC) will lead to incremental innovation, whereas, incremental innovation happens gradually for any rate of adoption, it is the factors need to be considered and looked deep inside by which the factors will help lead towards diffusion process depending upon three municipalities. In addition, as we discussed above in the analysis, the barriers are analysed with each of the perceived attributes as an independent variable. After analysing, the authors had observed Complexity and nature of social system are the initial factors which needs to be considered due to the technicalities involved and acquisition cost of vehicles which are highly important and understanding needs of a customer (state municipalities) during the adoption of electric buses which effects indirectly end user (community).

Thirdly, electric buses will shape the future with the use of new technology. By creating, significant shift in the automotive industry especially in bus public transportation in India with the help of FAME policy by government of India. Furthermore, electric bus technology will lead to India’s reduction in carbon emission by collaborating with various stakeholders like government of India and suppliers of electric buses BYD and MG groups and gradually laying a stepping stone towards UN sustainability goals.

To conclude, overcoming the barriers by setting up more bus rapid transit systems in different routes, charging infrastructure at different locations of Three municipalities (BMTC, TSRTC, and CMT) and improving the performance of battery as per customer needs (municipalities) will lead to new future of electrified solution for bus as public transportation in three municipalities of India.
6.1 Implications for automotive industry:
For sustainability of automotive industry in public transport, government of India has introduced tax incentives for manufacturing of electric buses. However, each company has to understand technical requirements like battery performance, infrastructure requirements depending on municipalities in India. In our opinion, Pilot project would be better option for automotive industry to standardized technical requirements as well as ticket pricing strategy(same as IC engines ticket pricing) depending upon municipalities demands which can benefit both customer(municipalities) and in turn creating social awareness in the society(end user).

6.2 Limitations and Future Research:
This research is performed at a micro level, analysing the current situation. The municipalities are studied in the cases and the barriers are analysed for diffusion of electric busses. However, a study at the organisational level, i.e. how the internal organisation (both state municipalities and automotive companies) would react to the employees behaviour towards the diffusion of electric busses is worth an analysis. In addition to this, it was realised during the thesis study that government plays a major role, especially in India when it comes to public transportation system. Policy related issues (with changing lawmakers every 5 years) could lead to issues related to funding towards the FAME policy. Therefore a socio-economic study on the influence of the government would also make an interesting read. Whenever, there is a change in the technology, there is always a change either big or small in the business model. This research has its limits to looking into the diffusion of the electric busses alone. A business model analysis could be pursued to communicate the value as well as to understand the value delivered and captured. Diffusion of a new technology always comes with a risk, both within an organisation and the customers. This paper focuses more on the municipality level or the state level which is an intermediate level between the organisation and the customer level. Any of the other level can be analysed for a deeper understanding of diffusion of electric busses.
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Collier Macmillan.


## Appendix:

<table>
<thead>
<tr>
<th>BMTC</th>
<th>TSRTC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>(Mr. Mallikaarjun Jr Assistant Engineer Mech. Dept Production)</strong></td>
<td><strong>(Mr Ravinder Executive director Engineering)</strong></td>
</tr>
<tr>
<td>Buses not purchased</td>
<td>Buses not purchased</td>
</tr>
<tr>
<td>Expecting 200-250 Km range per day</td>
<td>Expecting 300 Km range per day</td>
</tr>
<tr>
<td>Operations will be the same unlike other diesel buses</td>
<td>Operations will be the same</td>
</tr>
<tr>
<td>BMTC started setting up charging infrastructures in bus dipot (28, 32, 19) out of 45 dipot</td>
<td>TSRTC is going to set up charging infrastructures</td>
</tr>
<tr>
<td>BYD company Supplies electric buses to the BMTC</td>
<td>BYD supplies electric buses to TSRTC</td>
</tr>
<tr>
<td>BMTC will provide Bus conductors to collect revenues per day</td>
<td>TSRTC will also provide Bus conductors to collect the revenues</td>
</tr>
<tr>
<td>BYD will provide the buses, drivers and take care of maintenance as well</td>
<td>Same applies</td>
</tr>
<tr>
<td>Cost per km: 37.35 per Km for A/C 24.03 per Km for NON A/C</td>
<td>Cost per km will be the same like diesel buses FOR A/C: Min of 10 to 60 Rupees FOR NON A/C: 5 to 30 Rupees</td>
</tr>
<tr>
<td>30-40 Seats in Electric Buses (A/C and NON A/C)</td>
<td>30 – 40 Seats (A/C and NON A/C)</td>
</tr>
<tr>
<td>60 A/C buses order has been placed to BYD 20 NON A/C buses order has been placed</td>
<td>Only 40 A/C buses order has been placed Adding to that 150 CNG buses on Road and 30 Bio diesel buses are available</td>
</tr>
<tr>
<td>BYD quotes 2.5 Crore (25 Million) for A/C buses</td>
<td>25 Million</td>
</tr>
<tr>
<td>Indian government gives 60 % subsidy if there is 30% of Indian parts in the electric buses.</td>
<td>Same applies</td>
</tr>
<tr>
<td>Transport department Initially planned to hire buses and share the revenues obtained from the cost per km fixed by the transport</td>
<td>Different rate has been fixed and the revenues will be shared</td>
</tr>
<tr>
<td>This BYD contract with the transport is for 10 years</td>
<td>The same applies here.</td>
</tr>
</tbody>
</table>
The list of questions the author had was,

1 what are the differences (advantages) do you see when compared to diesel engines and electric vehicles?
2 what are the barriers for diffusion of electric vehicles?
3 what is the cost per km do you expect towards this change?
4 what are the market changes made towards this electric vehicles?
5 what is the expected operational efficiency for the suppliers to improve the profits?
6 Are you ready for the change towards this electric vehicles from diesel engines?
7 what is your expectation towards this change in case of tax exemption by the government?
8 how do you expect the battery performance in case of charging and battery life?
9 how do you expect your suppliers and stakeholders to support this change of diesel engines to electric vehicles?
10 how do you expect the profit from electric vehicles, either through service or by selling?
11 what will be the ticket price for the customers when EV’s come into market? will it be the same like diesel engines or more costlier?
12 is it accessible for the buses to charge in case of emergency unlike other buses to fill diesel?

Interview Observations at Three state Transports:

As observed from these two transport corporation this sudden change towards sustainability has been admired by the Indian government and decide to make the change of diesel engines to electric vehicles. This is done because of the technological innovation and the reduction in pollution. Therefore, to implement this sustainability concept Indian government decide to set up new scheme to start practising this Sustainability concept called FAME scheme. This fame scheme has many tax exemptions and subsides to provide to the different state transport government to implement the use of electric vehicles. However, there was different companies who took part in this auction to produce electric vehicles, whereas BYD a Chinese company who won the auction and given a statement that BYD will deliver the Electric buses in 6 Months of time. BYD quoted 2.5 Crore for A/c Buses and 1.5 Crore for NON A/C. The transport government doesn’t need to invest in any cost for the purchasing of buses, but need to take care in setting up the charging infrastructure and provide space for the buses. The electricity should be taken care by the transport government.

CMTC are still in the emergence of implementing electric vehicles and they have started testing out the different types of electric buses and searching for the right model to implement if suppose the government fund for it. Now currently CMCT is facing a huge loss in the transport approximately 65 crores per month. Initially their plan is to test the vehicles and then CMTC are planning to initiate the use of electric vehicles for the public. This Interview was performed at CMTC with Mr. Natarajan Deputy Manager Technical department.
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