Scaling up electric vehicles in India

A focus on Maharashtra state, Mumbai

Market formation and demand side policies

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Thesis for the fulfilment of the

Master of Science in Environmental Management and Policy

Lund, Sweden, March 2021

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ISSN 1401-9191

Acknowledgements

There are several key people that I would like to express my gratitude for being part of this journey and fulfilment of this master thesis.

First, I would like to include a special thank you note to my supervisor Philip Peck, that provided valuable support for the realization of this thesis work and from whom I have learned a lot in this process. Thank you for the time given even during/after very busy periods at the institute and for your patience and attention to details. Also, thanks to Naoko Tojo, the new director of studies at the IIIEE and Philip for handling further the thesis submission.

I would also like to express my gratitude to the IIIEE former director of studies Beatrice Kogg for providing the required support in various instances and to the student coordinator Birgitta Olofsson for her kind and wise input.

Also, thanks to my friends and family for being around always with the needed moral support in different times and for my enterprises.

Abstract

Governments around the world have begun to adopt measures in support of electric vehicles. The supply push policies have been traditionally studied leaving the demand side innovation policy without much investigation. Therefore, policy makers lack institutional knowledge and policy experience. The demand side innovation policies have always been part of the public policy decisions but not part of the innovation policy strategy. They point on increasing the uptake of the innovation and the growth in manufacture production. The aim of this study is to find good policy pull strategies to support E-cars in India with a mix of policies to build the needed capacity for E-cars in Maharashtra state, Mumbai. Maharashtra has the highest number of vehicles in India with Mumbai being one of the most polluted cities in India. India wants to increase the domestic economic activity and reduce GHGs. E-cars are known to reduce CO_2 emissions, pollutants, and noise. The research question is: *How can Mumbai city implement policy pull-strategies that drive the scale up of E-cars?* Firstly, barriers for E-cars development in India, Maharashtra state, Mumbai are identified. Subsequently, good policy actions are pointed out in the UK, Sunderland and China, Shenzhen city and suggested as possible actions for India. Data was found through a literature review of academic and non-academic sources, been compiled using a literature synthesis. A case based oriented research is used. The TIS framework is used to arrange the data and make the analysis. Key barriers identified are missing environmental reasons in policy designs, low car ownership preference of consumers, lack of proper infrastructure and standards, high upfront costs of E-cars and lack of waivers. Some UK learnings: include environmental issues in policies; inform consumers about E-cars total cost of ownership; develop E-cars charging infrastructure; encourage E-cars producers to adopt business models. Few recommendations from China: develop the charging infrastructure for E-buses; adopt business models for E-buses; adopt uniform charger standards. These recommendations for policy makers in India may support further academic research such as to study the environmental policy issues using the environmental evaluation framework due to the missing environmental instruments in policy actions, also to make a study with all including missing functions when data is available for a more complete understanding of the TIS in India.

Keywords:

India

Electric cars

Demand innovation policies

Market diffusion

Technology innovation systems

Executive Summary

The transport sector is one of the main causes of climate change with a high dependence on oil and an accelerated growth, especially in many of the developing countries. India has an economy that is rapidly growing largely depending on oil resources for sufficing its transport needs. India is also importing around 80% of the crude oil used and 18% of the natural gas requirements.

Electric vehicles are considered a technology that can help reduce the environmental impact of road traffic, reducing CO_2 emissions, and other harmful pollutants. The automotive industry in India is important for economic growth and development, and the manufacturing growth of vehicles play a significant part in the national GDP. However, the right set of policies are required to set way for such new technology development. India needs good strategies to foster the demand of all electric vehicles, but especially for electric cars that have a lower proportion in the market. The demand side innovation policies are required to work adequately for changing to new technologies. Such policies work on the segments where the innovation takes place, supporting the increase of the new technology demand and manufacturing development. Thus these, policies work on barriers that affect the demand and diffusion of the new technology.

Demand policies have the potential to support the transition to new technologies, however they were left aside and been reconsidered in research studies only in recent times. This affected policy makers that required better knowledge and policy instruments to properly act in such circumstances and to include the demand as a driver for the innovation to take place. The demand side innovation policies target to improve the context where the innovation take place, for instance including measures to increase the demand along with the new technology manufacturing development. Elements of the demand innovation such as the ability and willingness of the consumer to demand, adopt and use innovation have been part of the public policy but not included in the innovation cluster. The demand side innovation looks not only at the financial incentives when supporting E-car technologies but also at the non-financial sides. Waivers are found to bring better results than rebates or tax credits. Some studies proved that public procurement creates better innovation than R&D subsidies, but its use has been ignored for a long time. Standards have also not been much included in policies aimed at spurring innovation.

In India electric cars have a costly price compared with conventional vehicles. There is a low preference for E-cars even if in the NEMMP 2020, it is mentioned the existence of a latent demand in consumer choices for E-cars. The number of local cars in India is low and this might be an important factor to consider when designing new policies for electric vehicle promotion. Maharashtra state has the largest number of vehicles in India with Mumbai being among the most highly polluted cities in India. The local government express those interventions at urban level are required to tackle such issues and reduce impacts. In Maharashtra state EVs (E-2wheelers, E-3wheelers, E-cars, E-buses) are received positively as useful technologies and the EV Policy 2018 was created supporting manufacturers, infrastructure, and consumer's side. This was adopted subsequently in Mumbai city.

Assessing system performance can serve policy makers to craft better actions. Moreover, comparability with other systems could bring an additional dimension from where best practices can be learned and adopted especially where the comparability can be established.

The aim of the study is to find suitable measures for improving existent demand policy actions in India, focusing on Maharashtra state, Mumbai city. Firstly, barriers are identified in India to explain restraints that could lead finding suitable supporting mechanisms of the system and build stronger policy initiatives. The present study focuses to identify mainly such weaknesses in India. The identified barriers in India affecting E-cars development are from a demand

perspective, looking at financial incentive measures, public E-bus procurement, charging infrastructure and regulatory standards for charging stations. Then it looks at other cases from where India could learn such as the UK, Sunderland, with Nissan and China, Shenzhen city with manufacturer BYD. By looking at such cases the study also contributes to add data for subsequent improvement of analytical tools such as technological innovation system, with evidence providing new insights for its functionalities that bring greater support for policy makers.

For answering all these a main research question was formulated to guide the study:

How can Mumbai city implement policy pull-strategies that drive the scale up of E-cars?

In support of the research question, three tasks have been created. Firstly, the study looks for barriers in India, Maharashtra state, Mumbai city that affect E-cars development measures from a demand side, E-bus procurement, charging infrastructure and regulatory standards for charging stations. The second task is to find policy actions in the UK, Sunderland city that India, Maharashtra state, Mumbai could learn from with a focus on E-cars purchase and manufacturing support and charging infrastructure. The last task is to find good policy actions from the case of China, Shenzhen city especially for the E-taxi and E-bus fleet and its related infrastructure development.

To realize all of this, the study follows a qualitative research method with a case-oriented research also called comparative case research. The study has a main case at the centre using two other cases from where different views are collected and analysed for a proper complementation of the case in focus. For doing this the joint method of agreement and difference is being used.

The findings of a literature review combined in a synthesis is the fundamental source of data collected and analysis, from where conclusions are formulated. Data sources include academics such as journal articles and grey literature.

A descriptive explanatory design method is used to analyse the data. The analysis and discussion of the findings are guided by the Technological Innovation System (TIS) framework, with few countries reviewed and revealing the explanatory process path. The findings are also formulated following the logic of the TIS framework. The essentials from findings are subtracted and arranged in each of the TIS functions selected for this study. From each faction then specific recommendations are derived followed by a general recommendation including all functions cumulative causations.

The centre case study being investigated is E-cars in India, with a focus on Maharashtra state, Mumbai city. The complementary cases are the UK, Sunderland city and China, Shenzhen city.

In the analysis barriers to E-cars scale up in India were identified, being mapped according to the selected TIS functions. Some of the barriers are lack of expertise, knowledge, and coordination to achieve the targets set, unstable targets, initiatives in Maharashtra are not yet fully aligned with national level actions, high upfront costs of E-cars, not enough charging stations, low investments in manufacturing and not enough awareness. Moreover, environmental reasons such as GHG emissions, particulate matter, noise, and other harmful pollutants resulted from the use of combustion engines vehicles are not considered fully, being only stated as a reason to decrease dependence of oil imports. In addition, waivers are not sufficiently used, coordination failure is identified between central government and local governments when trying to procure E-car fleets for local governments and FAME II policy in India excludes measures for private E-cars. There is a low ownership of cars per capita, coupled with the dilemma of the chicken and egg when it comes to building the infrastructure for E-cars and lack of well-defined standards.

In the conclusions, policy actions that India and Maharashtra state, Mumbai city could learn from the case of UK, with a focus on Sunderland and China, Shenzhen city are highlighted. These are structured according to the TIS functions. From the case of UK, some recommendations especially to support E-cars purchase and manufacturing and creating a proper charging infrastructure are set as follows:

- Strengthen and work in partnerships with industry, local government, and consumers
- Consider environmental issues in policy actions and build actions tailored specifically at reducing environmental impact
- Include initiatives to support E-cars through the Competition Act
- Allocate funds targeted directly to finding strategies for reducing harmful emissions
- consider not only financial but also non-financial measures directed to reducing range anxiety
- Increase variety of car models etc.
- Build an appropriate extensive charging infrastructure
- Develop standards and technology use data
- Encourage the introduction of business models that may reduce technology price

From the case of China policy actions found are mostly for building an E-taxi, E-bus fleet and E-car infrastructure. Some of these are:

- Initiate strong network collaborations at local and national level that are important for a successful establishment of infrastructure for E-cars and increase consumer confidence in E-cars.
- Adopt procurement targets of national to local government fleets to be comprised of electric vehicles, with subsequent increase of targets.
- Adopt sound government incentives and subsidies for building an E-taxi and E-bus fleet and increase sales of E-buses and E-cars.
- Allocate funds for building the charging infrastructure for E-cars especially in cities that have reached enough E-cars sales that are requiring additional charging stations.
- Allocate funds and adopt proper measures for building the required charging infrastructure for E-buses
- Adopt business models for E-buses
- Make the use of standards uniform with other cities and states to support innovation for E-bus chargers and for E-cars.

Results in China show that developing a public E-bus segment significantly increases the E-car industry increasing awareness of E-cars and help creating a critical E-car market. In Shenzhen not only the E-bus fleet is 100% electric but also the charging infrastructure for E-buses is impeccably built.

Recommendations for further research point at the environmental evaluation framework, that was used briefly in the study to highlight the main environmental policy issues present in India. An in-depth study would more accurately bring optimal support for including environmental tools in policy making.

The future research could also look into the functions of the TIS that were mentioned but not analysed in the present paper such as entrepreneurial experimentation and legitimation/counteract resistance to change. Moreover, each function could be analysed in more depth, to identify patterns and provide more precise measures.

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Abbreviations

UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organisation
EV	Electric vehicles
E-car	Electric car
E-taxi	Electric taxi
E-bus	Electric bus
E-4 wheeler	Electric vehicle with four wheels
E-3 wheeler	Electric vehicle with three wheels
E-2 wheeler	Electric vehicle with two wheels
ICE	Internal combustion engine
GDP	Gross domestic product
TIS	Technology innovation system
R&D	Research and development
NEMMP	National Electric Mobility Mission Plan
FAME	Faster Adoption and Manufacturing of Electric Engine Vehicles
GOI	Government of India
EESL	Energy Efficiency Services Limited
RQ	Research question
GHG	Greenhouse gas emission
CO_2	Carbon dioxide
TCO	Total cost of ownership
CCS	European Combined Charging System
UK	United Kingdom
COR	Case based oriented research
IV	Independent variable
OEM	original equipment manufacturing
USD	United states dollar
BYD	Build your dreams
HEV	Hybrid electric car
PHEV	Plug-in hybrid electric car
AC	Alternative current
DC	Direct current
MIC2025	Made in China 2025
VAT	Value added tax
INDC	Intended Nationally Determined Contribution
NDC	Nationally Determined Contributions
EESL	Energy Efficiency Services Limited
MoU	Memoranda of Understanding
STU	state/city transport corporation
TCSM	Transport Commission of Shenzhen Municipality
UPLRC	Urban Planning, Land and Resources Commission of Shenzhen Municipality
EVI	Electric vehicle initiative
INR	Indian rupee
BNEF	Bloomberg new energy finance

DISCOM	Distribution Companies
kW	kilowatt
LEAF	Leading, Environmentally Friendly Affordable Family Car
STU	State/city transport corporation
GST	Goods and services
e.g.	Exempli gratia

1 Introduction

Global warming and factors contributing to this such as greenhouse gas emissions (GHG) are fundamental aspects to be tackled in the 21st century (WHO, 2011; IPCC, 2014; Gnann & Patrick, 2015; UNFCCC, 2015). As the IPCC is stating, GHG emissions need to be reduced by 50% by 2050 from the 1990 levels. Combustion engine cars demand has been increasing with the continuous countries' development. The transport sector is currently one of the main contributors of climate change with a 20% share in GHG emissions (Gnann & Patrick, 2015), with the road transport holding a share of 16% of man-made CO_2 emissions (Altenburg et al.,2012). The transport sector poses a global concern regarding its dependence on oil and grows particularly rapidly in many developing countries. Petrol and diesel cars are planned to be banned between 2030 and 2040 in several leading cities around the world determining a crucial need of power trains options (Express, 2019). India is one of the fastest growing economies in the world and has a high dependence on oil resources to fuel its transport needs (GWI, 2017). According to the Ministry of Petroleum & Natural Gas 2014 press release, Petrol consumption is almost entirely accounted by the transport sector with a 99.6% (GOI, 2014). India imports around 80% of its crude oil and 18% of its natural gas requirements (Aggarwal & Bhaskar, 2017). BP Energy Outlook predicts that India's oil imports are expected to rise by 165%, for gas with 173% and 105% in coal imports by 2035. India imported 202 million tons of oil in 2015-2016 (Aggarwal & Bhaskar, 2017). The energy used in transport increases by 5.8% per year with oil remaining the main fuel source with a 93% market share in 2035 (BP Energy Outlook, 2017). Moreover, urban areas are extending rapidly accompanied by the motorized transport that created increasing polluting cities in India (Dhar & Shukla, 2015). The increased per capita income in India shows a high correlation with the increased mobility (Dhar et al., 2017). According to UN projections, India will be the second largest in the world after China by 2050, with an expected urbanization level of 52% reaching a population of 0.87 billion. According to the GOI's (Government of India) Automotive Mission Plan 2016-2026, with the registered growing population and income levels the number of vehicles in India are expected to increase four times from 3.2 units in the present to 13.4 million units by 2026. Thus, India faces a worsening of its serious problems with congestion, pollution and reliance on exogenous fossil fuels (oil). Electric vehicles are considered a promising technology that holds the potential of drastically reducing the environmental impact of road traffic (Delft, 2011). They were advocated as an important factor for reducing CO_2 emissions mostly for the use of passenger cars and light commercial vehicles and reduce emission of pollutants and noise (Delft, 2011).

Internationally, automobile manufacturers are working proactively to develop better technology for electric vehicles and battery innovations to stay competitive in the emerging markets (Shukla et al., 2014). Electric vehicles have undergone significant improvements and because of this, manufactures around the world have announced to turn their production towards electric vehicles. These changes are pushed by several expected innovations that include vehicles with state-of-the-art technology with high performance batteries and with an increased efficiency (Dhar et al., 2017). Despite recent developments and government support in leading electric mobility countries and that all big car manufacturers around the world turn to electrifying their vehicles (Keneally, 2019), plus having petrol and diesel increased prices (Carrington, 2019), buying an E-car is still a big leap (Keneally, 2019). However, such progress brings optimism among manufactures of automobiles around the world that are expecting to reduce production costs and increase sales. Nissan Leaf has released a new model made at the Sunderland factory, that has 85% less running costs compared to an average petrol or diesel family car (Ward, 2018). BYD in China are expecting increased revenues from E-buses. This is expected due to infrastructure build up and falling of battery costs (Cox, 2018).

The automotive industry in India is important for economic growth and development due to its high contribution to the national GDP and a major driver for the manufacturing gross domestic product (GDP), exports and employment generation (Miglani, 2019). However, the direction of the automotive industry need be shaped if it is to promote sustainable growth (Gulati, 2012). The government of India conducted studies that identified the existence of high demand for environmentally friendly vehicle technologies but also needing strong upfront continued government support to realize this demand. In other words, in India E-cars have been slowly driven for the consumer's market. The reduced income level coupled with the high cost of E-cars technology and reduced ICE-cars intake are identified as major concerns for maximizing new technology demand as shown previously by Heidrich (2017). Nevertheless, the current established auto manufacturing industry in India accompanied by the accelerated growth in transport demand and the recent interest in electric vehicles offers a good perspective for India to create a domestic E-car industry and even emerge as a global leader in E-car manufacturing market (Shukla et al., 2014). To accelerate this transition India needs conducive actions towards supporting car manufacturing and E-car production with an appropriate design of its policies. In exchange, this will contribute to reduce emissions of transport related greenhouse gases, enhance national energy security, and improve air quality. India needs both financial and non-financial policies for promoting E-car market uptake, R&D and charging point development. Government support is essential to provide appropriate push and pull mechanisms to increase production and sales of E-cars.

According to its National Action Plan on Climate Change, India desires increased domestic economic activity and reduced GHG emissions (CSIS, 2017) while adding to their Intended Nationally Determined Contribution (INDC) which enlists electric vehicles as a focus area under transport mitigation actions (Ray, 2015). Recently, in India was launched the National Electric Mobility Mission Plan (NEMMP) that follows to incentives electric vehicles production and sales having a total proposed investment of around USD 4 Billion (Rs 224 billion) by 2020. Some key strategies proposed in the NEMMP are on demand creation, local product manufacturing, charging infrastructure companies, fleet operators, and service providers. The Minister of Power initiated the program and will be implemented in the country by the Energy Efficiency Service Limited (EESL). Under the NEMMP 2020 in 2015-2016 the Indian government launched a scheme called Faster Adoption and Manufacturing of (Hybrid&) Electric Vehicles (FAME), that offers financial incentives to buyers of electric/hybrid vehicles with a total of around USD 2000 (INR (Indian Rupees) 1.38 lakh) for cars (GWI, 2017) that was extended two times with the last date being up to March 31, 2019 (GKT, 2017, National Automotive Board, 2019). Moreover, India has already set a target reduction in carbon emissions of 33-35% of GDP by 2030 (GWI, 2017). However, Shukla et al. (2014) is mentioning that ambitions must be higher if EVs are to deliver their full potential from such incipient market where charging networks to support EVs are lacking, and confidence is low. India is supporting and expressed its desires to create a domestic EV industry and also to target the export market as stated in the NEMMP (Gulati, 2012). Nonetheless, according to Dhar, Pathak and Shukla (2016), India lacks good strategies on how to stimulate demand. Electric vehicles, especially electric cars (EVs), have a low presence in the market and in consumers' choices and manufacturing of electric 2 wheelers, 3 wheelers and electric cars in India has just recently started. It is known that only few car manufacturers began producing electric automobiles in India (Dhar et al., 2017),

The shift affects an industry that is the most important support of manufacturing in many countries (Altenburg, 2012). China is the largest electric car market in the world, with approximately 1.1 million electric cars sold in 2018, and with 2.3 million units it constituted half of the global car market (IEA Global Outlook, 2019). In Sweden, Volvo plans to phase out vehicles that run solely on gasoline or diesel fuel and have 20% of its sales plug-in vehicles by 2020 (Mitchel, 2019). In 2019 India's production of electric cars decreased to half between April and September to 340, with only 1500 electric cars for personal use being sold during the financial year (Narasimhan, 2019). However, India has the potential to become one of the largest markets of electric vehicles (The Economic Times, 2019) being the sixth largest producer of automobiles in the world, with a total vehicle average of 29 million produced in 2017-2018 from which around 4 million were exported (Miglani, 2019). India is the sixth largest car manufacturer in the world (Miglani, 2019). To achieve a substantial reduction in emissions from the road transport in India it is imperative to replace a substantial part of internal combustion vehicles (ICE) and EVs offer a suitable alternative with the same mobility solution but with low emissions (Altenburg, 2012). Maharashtra state has the highest number of vehicles in India with more than 12% of over 31 million vehicles in India, as for March 2015 (Purva Chitnis, 2018) and its capital, Mumbai is one of the most highly polluted cities in India (Mashukar Varshney, 2018). The local government recognizes that interventions at urban level are important measures to be considered for addressing such issues and that transitioning to electric roads will reduce these impacts.

As recognized in response to these issues a shift to more environmentally friendly technologies is needed. However, these technologies are prone to go through a lengthy process, filled with uncertainty of markets, technology, and policy, with obstacles and failures of development and diffusion (Bergek et al., 2008 a). The process of diffusion of a certain emerging technology is reflected in the formation and evolution of technological innovation systems (TIS). The TIS is built from two directions that is a bottom-up approach when firms initiatives develop new technology and directly bring it to the market, and a policy role to enable several different TIS towards a phase of self-reinforcing growth (Jacobsson & Bergek, 2004; Bergek et al., 2008 a). In such early-stage formation of the TIS firms have also strong reasons to pay attention to "sector building" in an early-stage formation (Suchman, 1995). As literature shows the firms are revealing challenges that are associated with technological discontinuities (e.g., Utterback, 1994; Christensen, 1997). Thus, policy makers need to consider firms needs and find system building activities using a balanced mix of interventions (Bergek et al., 2018 a; Van de Ven, 1993). These activities are constructed to increase the strength of inducement mechanisms and reduce the power of blocking mechanisms (Johnson & Jacobsson, 2001).

In support of this shift to occur requires certain changing instruments of innovation policy. Demand side policies is such a tool that can lead markets and user/consumer innovation initiatives (OECD, 2012). It is known that the focus shifted recently on demand side policies from the traditional supply side policies that were not able to bring the desired productivity and performance (OECD, 2011). Demand-pull innovations are required to be used properly to work on specific problems to help technology changes (Rosenberg, 1969). The policy rationale of the demand has three main areas: 1) to react to market and system failures on the demand side (e.g. information asymmetries, adoption externalities, high entry cost, path dependency etc.) 2) respond to needs of the society 3) support the economy on the supply side (Izsak & Edler, 2011). Hence, demand side innovation policies are important instruments targeting to improve the setting where the innovation occurs such as increasing the uptake of innovation or spurring positively the dynamics of the demand (Izsak & Edler, 2011) and facilitate the desired growth in productivity (Guerzoni & Raiteri, 2015) and manufacture expansion. Some of the demand-based measures are public procurement schemes, demand subsidies, tax incentives and standards use (Edler, 2013).

The demand side innovation policies are reacting on situations where barriers affect demand creation and market introduction and diffusion of innovations. These barriers are seen to form mainly also by the high price of changing to new technologies because of lock-in effects (Edler, 2007) and total cost of ownership compared with conventional vehicles. Demand policies by addressing the potential of buyers (Edler, 2013) are outlining a need and supporting the ability and willingness to purchase new innovation. This in turn can further spur the demand of EVs that will support manufacturing various intentions to accelerate industry action (Sahay, 2019) and support continued improvements in governments' "backing and direction" (The Economics Times, 2019).

1.1 Problem definition

A large-scale e-car market diffusion can highly contribute to realize the benefits associated with such technological change. Such pathway can be realized when well-coordinated and effective policy decisions are made that help create an adequate system for such emerging technologies. Different policies are complementary with their factors contributing but also interacting at the same time (Nemet, 2009).

While demand side policies have a large potential to support the transition to innovative technologies such as E-cars (OECD, 2012) the role of the demand in innovation policy perspective has not been considered (Boon & Edler, 2018). Because demand instruments have been traditionally ignored, have left policy makers without sufficient institutional framework and policy experiences (Mundaca et al., 2019). The key role of the demand as a driver for innovation needs to be made. This was not realized yet despite the demand representing an important source for innovation (Edler & Georghiou, 2007). Public policy has always included the demand of innovation such as the ability and willingness of potential buyers to demand, adopt and use innovations but many of these have not been systematically constructed as part of the innovation policy portfolio (Edler, 2013). These were formulated for specific objectives and not considered part of the dynamics of the innovation, concomitant with the demand side being excluded from policy practice and discourse for many years (Edler, 2013). A return to of the demand discourse and instruments in innovation policy from national to European was only made in 2003-2005 (Edler, 2013; Aho et al., 2006).

Nevertheless, with institutional frameworks and policy experiences that are not strong these measures could create new market issues or effects like crowding-out (Roolaht, 2010). They might not have the capability to sustain growth in innovation or productivity levels and even worst could result in creating short term interests in certain innovation activities that loosens strengths as soon as the policy measure is phased out (Roolaht, 2010). A weak developed policy will not create the right means towards a self-sustaining goal of private market for innovation technologies (Roolaht, 2010).

As part of the demand side innovation the monetary incentives, for accelerating diffusion of EV tech, in many facets have less importance than for instance the rise of petrol price, the average income of buyers, or average miles travelled (Edler, 2013). Relying only on the monetary incentives is found to have a weak effect when given as rebates or tax credits rather than waivers. It has been proved that incentives showing a benefit faster attract more consumes than those showing a benefit after some time (e.g., rebates, tax credits) (Edler, 2013; Diamond, 2009). Moreover, public procurement as a demand innovation policy has been omitted and considered not so important, being an essential support for new technologies. Empirical studies in the years 1970s demonstrated that state procurement created stronger innovation output on longer period of times compared with R&D subsidies (see for example Mowery & Rosenberg, 1979; Rothwell and Zegveld, 1981; Rothwell, 1984; Rothwell & Zegveld, 1981). Additionally, public policy is improved when public demand is geared towards innovation creation and products (Edler & Georghiou, 2007). Tougher competition regulations as have been enacted in the European Union resulted in a decreasing use of this instrument (Edquist et al., 2000; Edler & Georghiou, 2007). Furthermore, standards have not been used that much in policy programs dedicated to increase innovation (Blind, 2013). This also resulted in a low number of empirical studies that have looked at standards and standardization in innovation (Blind, 2013). Generally, the technology agnostic and not overly prescriptive standards have to be adopted for supporting the innovation (Catapult Electric, 2019).

The research in management, entrepreneurship and innovation policy research was not much focused on finding flows and strengths of the system considered at the present complicated to realize (Bergek et al., 2008 a). In India E-cars are seen as not affordable having still a significant higher purchase price than their gasoline counterparts (Bloomberg, 2019). E-cars are very efficient in terms of running cost, maintenance cost and their total cost of ownership (TCO), giving them the advantage over the conventional vehicles (Shalender & Yadav, 2018). Moreover, consumer preferences for E-cars exist as stated in the NEMMP 2020, there is a present latent demand that waits to be materialized. However, in India overall E-cars ownership per capita is still low. Also, because the number of local cars is low in India, it might be necessary to encourage the implementation of policies that are not specifically focused on E-cars promotion but including measures supporting car ownership in general (Heidrich, 2017). These could represent one of the most important factors staying at the base for increasing E-cars uptake in India (Heidrich, 2017). Furthermore, in Maharashtra state the government cabinet has recently undertaken positive actions towards adopting electric vehicles and created the Electric Vehicle Policy 2018 (Saumy Prateek, 2018). The policy supports all three sectors of E-cars – manufacturing, infrastructure development and consumers. Mumbai is one of the first cities where the policy will be implemented (Bhavika Jain, 2018). Manufacturing companies are waiting for such initiatives to accelerate and develop better E-cars production and increase demand (Kumar, 2017; Digital Catapult, 2019).

However, acceleration of production will not be possible without the development of an effective demand side incentives scheme and conversely this will not emerge as long as the manufacturing parameters will not evolve correspondingly in order to be eligible for demand incentives. Long term alliance between large corporations can help overcome such disharmonies (Altenburg et al., 2012). As well, governments need to measure well the effect of their policies on the competitiveness of the national market. For instance, when setting new industry standards for batteries or plugs, these can affect important industry players that developed different technology standards to lose multi-million investments (Altenburg et al., 2012). The largest auto manufacturers in India have been lobbying to impose their own standards made for the E-cars they manufacture (Shanti, 2019). While India has no such infrastructure in place to charge the daily millions of E-cars, the various opinions on which charging infrastructure is appropriate is one of the barriers to large commercialization of E-cars in India (Shanti, 2019). Some rumours say that India might adopt all three charging standards used by the automakers in India that is CHAdeMO, European Combined Charging System (CCS) and the Indian Bharat Standard (Shanti, 2019).

After an assessment of the system performance and factors influencing performance more practical guidance is/would be available to policy makers (Bergek et al., 2008 b). Subsequently comparability between systems would better serve to analyse specific innovation systems such as Maharashtra state, Mumbai city in India, to identify key policy issues and gaps and set policy goals (Bergek et al., 2008 b). A closer look at policy strengths in other E-cars contexts where the parameters for comparability can be established could serve as inspirational means as good practices for the city of Mumbai. As for example, cities such as Sunderland in UK and Shenzhen in China that have long experience in the industry and largely invested in their ambitious E-cars targets. For supporting this an identification and analysis of key interventions would serve to stimulate manufacturing of E-cars in India, Mumbai. Due to the high purchase price and TCO the study will focus on policy measures that cut such differences and support the needed infrastructure development.

Undertaking this study will contribute to supporting the development of E-cars industry in India, with specific focus on Mumbai city, Maharashtra state by engaging and stimulating the dynamics of the demand in innovation policy. It is meant to support policy makers to undergo better decisions in their attempt to promote and strategies E-cars diffusion and support the development of manufacturing industry. On another side, the study is inclined to supplement the research studies towards the enrichment of analytical tools such as the technological innovation system and improve its application effectiveness in the policy field.

1.2 Aim and Research Question

The purpose of this study is to identify supporting elements for improving policy measures, pull strategies that India with a focus on Maharashtra state, Mumbai city can learn from in order to scale up E-cars. More specifically, the study looks at improving undertaken actions for encouraging the manufacturing sector to accelerate production of E-cars concomitantly with infrastructure development and using better concerted demand side incentives. This will be done by looking at and benchmarking with other cases from China and UK. More specifically data from Shenzhen city, China, BYD manufacturing and Sunderland, UK with Nissan manufacturing is collected and analysed. The 'scenario(s)' are selected according to the contextual similarities with the city of Mumbai in India. This will be analysed from the perspective of government policies and the associated good and bad practices.

The analysis responds to the following overarching research question (RQ):

Research question	**How can Mumbai city implement policy pull-strategies that drive the scale up of E-cars?**
Task 1	Look for barriers (blocking mechanisms) in India, Maharashtra state, Mumbai city affecting E-car scale up with a focus on E-cars demand measures, public E-bus procurement, charging infrastructure and regulatory standards for charging stations.
Task 2	Find possible policy actions that India and Maharashtra state, Mumbai city could learn from the case of UK, Sunderland especially, to support E-car purchase and manufacturing and building charging infrastructure.
Task 3	Find possible policy actions that Maharashtra state, Mumbai city could learn from the case of China, Shenzhen city especially for building an E-car fleet and infrastructure.

1.3 Scope and delimitations

Demand incentives for increasing purchase of E-cars and infrastructure development in Mumbai city represent the coverage area of the TIS from a governmental policy flow perspective of actions coupled with E-cars manufacturers view. E-cars are considered to include plug-in hybrid E-cars, hybrid E-cars, battery E-cars, and fuel-cell E-cars. EVs are including all types of electric vehicles such as E-2wheeler (include E-scooters, E-motorcycles and E-mopeds), E-3wheeler (E-autorickshaw) and E-4wheeler (E-car, E-truck, E-bus). In addition, if added in further research, the evaluation of the environmental impact of the policy (see Appendix B) could expose the level of its effectiveness towards reducing CO_2 emissions. Then the main unfunctional areas and barriers identified for the TIS can serve for providing handholds for policy makers to formulate appropriate measures and improvements. Exponential leading practice cases are used to serve as complementary examples from where to identify and adapt ideas for improvement of policy strategy actions for the city of Mumbai. The case study of Shenzhen city in China serves as a model for the creation of an E-car and E-bus fleet and increase consumer uptake and the Sunderland city in UK for subsidies schemes and infrastructure. It is also important to note that the preparedness of the national or regional distribution grids for electricity in Mumbai, Maharashtra, India it is not included in the present analysis.

Due to the fact that the study approaches case comparability between cities from a demand side perspective, it excludes the idea of looking at the whole system of policy mix. Not even that the scope ignores other demand instruments but as well the whole analysis of the supply side measures. This automatically is restricting the clear overview of the system and thus sets the impossibility to suggest clear policy measures for the Mumbai setting, allowing the contribution to merely suggest by explorative means and exemplification of other more or less similar structures.

The study adopts a case-oriented research, with a main case study at centre and drawing specific inferential views from two other cases. For doing this it is realized an in-depth literature review and synthesis. The data collected is of secondary nature. The data collected through this process it is analyses and then conclusions are derived. The study excludes primary data collection (such as interviews, surveys, questionnaire, observations etc.).

The cases selected to support the scale up of electric vehicles in India, Mumbai, were chosen firstly due to their level of development. UK and China are much more mature electric vehicle markets, that have already increasingly experimented finding specific measures to work well, and in tandem with other measures. From such combinations India can subtract measures that can be adopted and adapted to its national and local strategies and help them increase the demand of E-cars. The cases are distinct, mainly due to their political context, resources, economic goals, and consumers motivations. Hence, the principal elements selected from the different cases are believed to deliver best practices for India, and due to their performance and leadership. For instance, Shenzhen is the first city in the world to deliver 100% electric buses on its roads, UK on the other hand is showing a good incentives system for example. Next to these other areas are included to be considered for the Indian context that support one another. Presently the EV sector, including E-cars, E-buses, is moving fast, thus the data available is increasing and changing at the same time.

1.4 Ethical considerations

Researcher honesty and personal integrity

The research has not been funded by any external organization. There was no one in the position to influence my analysis and subsequently my conclusions other than my supervisor.

The usually used academic standards are respected and the external used texts are accompanied by cites, properly attributing ownership to the ideas of the respective owners and external texts. The text was built accurately and honestly without selectivity or actively ignoring contrary evidence.

The research does not include primary data collection thus there is no ethical considerations for such subjects to be discussed.

The "research design has been reviewed against the criteria for research requiring an ethics board review at Lund University and has been found to not require a statement from the ethics committee" (IIIEE thesis guide 2020, p. 7).

1.5 Audience

The research study in this paper is aimed at contributing to the ongoing work made by researchers on the demand side innovation policy and technological innovation systems. The paper stands to derive policy recommendations for supporting the Indian government and Mumbai, Maharashtra state to get inspired and better strategies E-cars to diffuse on their market. As such, the study also serves as direction and provides information to E-cars and E-buses manufacturers and related industries and businesses in India but also world-wide to increase their production and better canalize investments. Even more, the data present in this paper could serve further work of researchers especially for refining the technological innovation system framework. The study can also benefit practitioners in the field such as policy makers at large and many other actors involved in the transitioning towards electric vehicles.

1.6 Disposition

Chapter 1 presents the nature of the problem addressed in this research and the specific problem(s) addressed. The content then identifies research scope and delimitations, describes the intended audience, and provides a thesis outline.

In Chapter 2 (Literature review), a more thorough analysis of the immediate field of study is presented and the main gaps in the research field are outlined. Based on these gaps, specific research questions are developed, and an analytical framework/theory used for data analysis is developed/presented.

Chapter 3 (Research design, materials, and methods) presents the methods used.

Chapter 4 (Findings/Results & Analysis) presents the main findings and the analysis of this data.

Chapter 5 (Discussion) presents the significance of the results considering what was already known regarding the research problem under investigation.

Chapter 6 (Conclusions) presents the main conclusions of the work and then provides recommendations directed to the principal audience(s). This final section then outlines areas of future research.

2 Literature review: EV market and the demand side

2.1 Current knowledge related to EVs in India

2.1.1 Overarching Challenges

Studies have established the dominant presence of internal combustion engine car technology in the automotive industry for over a century now as lock in through path dependency (Dijk, 2010). Reconfigurations for technological transitions are not emerging easily, as long as the various elements in the sociotechnical construct translate in existent configurations that are strongly linked and aligned to each other (Geels, 2002). The prevailing technologies are not easily replaced by radical new technologies when changes in other elements are also required (Geels, 2002).

The major obstacles for any developing technologies are cost and innovation (GWI, 2017). Under these issues the market share of E-cars will only increase significantly if the total cost of ownership (TCO) is lower than the cost of the internal combustion engine cars (ICE-cars) (Delft, 2011). This premise is generally valid and found to be also an encouraging objective thrived to build supportive policies for E-cars market diffusion in India.

Moreover, the uptake of E-cars technologies needs to be supported from various interdependent directions (Nemet, 2009). An adequate strategy including the supply side technology-push and demand-pull is required where both work simultaneously (Mowery & Rosenberg, 1979; Nemet, 2009) and foster innovation. Additionally, it is found that economic growth is a stronger driver of new technologies diffusion than the technology-push and demand-pull mechanisms however showing relative lower effectiveness in stimulating innovation (Sam, 2016). As a consequence, governments interventions should be directed not only at shielding E-cars from competition with ICE-cars but also to stimulate aggregated demand and economic growth and thus carefully balance policies.

2.1.2 EV Policy demand side in India according to NEMMP 2020

India has the potential to become one of the main EV technology drivers in research since it has the large market potential of experimenting and it does not have a high oil endowment (Dhar et al., 2017). This means that India's context allows a better performance in terms of innovation and alternative technologies and energy efficient technologies (Kim, 2014).

The EV industry in India highlighted two most important barriers that need to be improved in the earlier and existing EV demand incentive schemes: lack of continuity of the incentive policy/scheme for all EVs needed to build confidence to the industry for committing large investments for developing supportive domestic manufacturing facilities; simple and effective incentive delivery mechanism to allow the intended beneficiaries to reach the facilities easier, faster and efficiently. These important commitments are to be taken upfront for encouraging domestic investments and for the creation of a domestic EV manufacturing eco-system, including E-cars (Gulati, 2012).

When examining the prospects for the sector earlier this decade a study by Gulati indicated that the government industry study in India comprising an extensive ground level consumer survey showed that original equipment manufacturer (OEMs), research institutes and component suppliers expressed that the low demand for EVs in India is due to high price, low performance, lack of infrastructure and low awareness (Gulati, 2012). Also, the study has revealed that there is a high latent demand for E-cars in consumer preferences with a 25-30% of surveyed consumers preferring E-cars to traditional ICE-cars if the price performance deliverables are met. Preferences for battery E-cars are lowest amongst 4-wheeler EVs (5%), the higher preference being for hybrid E-cars (approx. 14-15%) and plug-in hybrid E-cars (approx. 9-10%) (Gulati, 2012). Amongst the different vehicle segments, the easiest uptake of EVs will be for E-buses, E-2wheelers followed by E-cars and E-3wheelers. The main barriers upholding battery E-cars uptake are stated to be poor pick up, low top speed and issues related to battery replacement. The study revealed that demand side incentives would be critical to enable local production and demand creation in addition to technology and infrastructure development to realize the latent demand for E-cars. Sensitivity analysis across the four key parameters of price, running cost, recharge time and range was conducted part of a conjoint analysis on consumer feedback in various cities. In case of E-cars it was demonstrated that consumers are highly sensitive to price and range of E-cars where lowering the acquisition cost can be effective in stimulating demand (Gulati, 2012).

In India the projections based on TCO analysis for E-cars indicate that with suitable provided incentives the EVs (includes HEV, PHEV, Extended-Range EV and BEV) will have significant latent demand by 2020 with a 1.6-1.7 million units by 2020. The projection assumes that the scale effect will be produced in 2020 and will determine a 10% reduction in the acquisition price (Gulati, 2012). Within this E-cars can have a latent demand varying from 2.5% to 5% based on cost. EV 4wheeler most preferred incentive by consumer was indicated to be cash/tax subsidies (58% respondents) to increase demand for adoption of EVs (Gulati, 2012). The cash or tax incentive can be offered through an OEM or to the consumer either directly or routed through the OEM. Subsidy of batteries emerged as the second most favoured way (56% respondents). Due to the recent utilization of Li-ion batteries in E-cars adds 7-10 years to the replacement of batteries after purchase thus battery subsidies may not be a requirement. Free parking is situated third in the preference rank (Gulati, 2012). However, the number of EVs sales for E-cars reached 1,200 for 2018 and 3,600 for 2019 (Marketsandmarkets, 2019).

The comprehensive demand incentive scheme according to NEMMP 2020 strategy, should comprise a quantum of incentive, the parameters for deciding their distribution amongst the various vehicle segments and technologies, the minimum qualifying criterion/boundary parameters that need to be insisted upon, and the supplementing demand assurance measures for some of the vehicle segments (Gulati, 2012). This was the main propulsion of the NEMMP 2020 strategy for a faster adoption and support for manufacturing in the country. In this respect the EV 4wheelers may require a demand assurance to take place through mandate of government fleet procurement (Gulati, 2012).

After the industry study conducted by the government, recommendations for a possible demand incentive strategy stem that from EV 4wheelers, battery E-cars (and PHEVs) should receive the highest amount of incentive due to higher battery size as compared to HEVs. Within the battery E-cars it is mentioned that higher incentives should be given to high performance battery E-cars. High performance has been defined in terms of the main consumers issues mentioned that are pick up and top speed of the vehicle. It is stated a need for further definition of the optimum and most effective performance parameters (Gulati, 2012).

In India the Alternate Fuels for Surface Transportation Program (AFSTP) is the most recent demand generation incentive program for EVs initiated by the Ministry of New and Renewable Energy (MNRE) (Gulati, 2012). The program gave incentives between 2010-2012 to all OEMs with a total of approx. 13.5 mil USD (Rs 95 crore). This gave at least 1-year warranty and setting up 15 service stations across India (Gulati, 2012).

Incentives have been provided also by some state governments. For instance, Maharashtra state has unveiled an EV industry policy that aims to attract an investment of 3.5 billion USD (Rs 25,000 crore) and create 100,000 jobs (‘one lakh jobs’) in the next five years (Swapnil Rawal, 2018).

The NEMMP 2020 promised high achievements in scaling up EVs including E-car sales through key points to help EVs diffuse. It promised support for innovation development, alternative technologies, and energy efficiency and to reduce the oil dependency, reduce the local energy use of resources and the harmful impact on the environment. Even if some progress was made the desired achievement targets after the implementation of the NEMMP 2020 were not reached.

2.1.3 The case of Mumbai, Maharashtra state

Maharashtra state has the highest number of vehicles in India with over 12% of more than 2 million (21 crore) vehicles, as for March 2015 (Purva Chitnis, 2018) and its capital, Mumbai is one of the most highly polluted cities in India. Mumbai is considered the financial capital of India, holding a population of 21.3 million with a high density close to 21,000 person/square km. A proper transportation system is required having the middle-income earning population heavily relying on it with the bus and public rails services being the main transportation modes used. Even more, Mumbai needs to improve its traffic congestion issues (action comprised in the national government agenda for urban cities), being the most car congested city in India (Business Today, 2019) and reduce GHG emissions (Madhukar Varshney, 2018).

Under the NEMMP the government of India was aiming to achieve 6 million electric and hybrid vehicles on national roads by 2020. FAME I and FAME II has been launched to support this purpose by promoting the use of EVs to save 120 million barrels of oil, 4 million tons of CO_2 and reduce vehicle emissions by 1.3% by 2020 (Government of Maharashtra, 2018). For instance, FAME I scheme works on four areas that are technology development, demand creation, pilot projects and charging infrastructure. Propelled by the recent economic developments and the governments support of India, Maharashtra government desires to develop Maharashtra as "a model state in EV" objective (Government of Maharashtra, 2018). As a result, the Electric Vehicle Policy is adopted in February 2018 with 500.000 EVs to be manufactured (Prateek, 2018). Under this policy the Maharashtra state envisions to become a leader in EV manufacturing and use of EV, create new employment opportunities, and promote a sustainable transport system (Government of Maharashtra, 2018).

The Electric Vehicle Policy is targeting a boost in electric vehicles and aim to attract an investment of 3 billion 625 million USD (Rs. 25,000 crore), aiming to achieve the creation of 100 000 (one lakh) jobs in the coming five years (Swapnil Rawal, 2018). The EV industry policy gives incentives and aid to manufacturing and benefits to consumers. To lower the price of retailers, electric vehicles will be exempt from road tax and registration fees (Swapnil Rawal, 2018). Due to the higher cost of electric vehicles compared with conventional cars a 15% exemption incentive on the registered electric vehicle's original cost was introduced by the government. The principal secretary in the industries department Sunil Porwal announced that "With the policy, we are trying to help the whole cycle of manufacturing—vehicle manufacturing, components, batteries, and charging equipment. Then creating charging infrastructure and ultimately, helping the consumer by subsidizing cost of the vehicles so that the demand is created. In the next 10 years, we will spend 406 million USD (Rs 2,800 crore) on this" (Swapnil Rawal, 2018). The policy supports the charging station with a 25% capital subsidy for the first 250 charging stations, having a maximum limit of around 15,549 USD (Rs 10 lakh) per charging station (Swapnil Rawal, 2018; Prateek, 2018).

Automobile companies such as Mahindra and Mahindra, Tata and even JSW Steel are planning to manufacture electric vehicles and the policy will leverage such initiatives. As for August 2017 JSW planned to roll out its first electric car by 2020, becoming the first non-automotive business in India to produce electric cars, batteries and build support for the charging infrastructure (Mukherjee, 2017). The JSW Group however abandoned its plans after more than 18 months due to perceiving high risks associated with the EV market (Chaliawala & Gaur, 2019). In the May of the same year, Mahindra and Mahindra promised to invest in long range electric vehicles by mid 2019. In 2010 the company debuted in the electric vehicle industry by acquiring Bengaluru-based Reva Electric Car Co (Mukherjee, 2017). Mahindra and Mahindra and Tata Motors joined forces to sell 500 E-cars to the Indian government that later could turn in larger numbers (Balachandran, 2017). Tata believes in EVs sales and prepares to launch its second E-car for individual customers, the Nexon EV planed for 2021 January 28 (Banerji, 2020).

2.2 Theories, tentative explanations, and conceptual frameworks of relevance to electric vehicles' demand

2.2.1 Push-pull mechanisms link in innovation policy

Innovation policy looks at public support, market introduction and wider use of innovation. Supply side policies were a traditional focus for innovation polices, present in discourse and innovation policy practice in the last 15 years (Edler, 2013). They are important in supporting the increase of innovative potential of organizations involved in an innovation system (Roolaht, 2010). Supply side measures are dedicated to certain areas of the technology in focus and usually the output of the innovation is being left for the end segments to deal with this (Edler, 2013). Therefore, if supply side policies are more targeted the system leads to market failures thus under-investment in research and innovation activities (Edler, 2013). Demand side policies on the other hand look at buyer potential. They reveal a need or support the present potential and willingness of buyers to demand/request an innovation or co-produce it with suppliers (Edler, 2013). This requires policy makers to develop an additional set of skills, where they are able to understand and define needs, and be more specific (Edler, 2013). Policy makers need to target their work in supporting both directions and understand the market and system failures that occur.

According to Nemet (2009) to support change and technological innovation governments could adopt measures that reduce costs of the innovation production and adopt measures sustaining private pay-off to successful innovation. Theories for technical change have supported a dual set of general interventions, technology push and demand-pull theories (Dosi, 1982). Examples of public policies that support companies to reduce costs of the new technology from the supply side technology push are government sponsored R&D, tax credits for companies to invest in R&D, enhancing the capacity for (Nemet, 2009). On the femand side policy pull some examples are intellectual property protection, tax credits and rebates for consumers of new technologies, government procurement actions, technology mandates, regulatory standards and taxes on competing technologies (Roolaht, 2010; Nemet, 2009) (see Table 1).

Table 1 Public policy support for technology innovation

		Citations
Supply side technology push	Sponsored R&D	Nemet (2009); Roolaht (2010); Johnson (2001); Hughes (1993)
	Tax credits for companies to invest in R&D	Roolaht (2010); Johnson (2001)
	Enhancing the capacity for knowledge exchange	Galli & Teubal (1997); Edquist (2010)
	Funding demonstration projects	Roolaht (2010);
	Support for education and training	Galli & Teubal (1997); Roolaht (2010); Hughes (1987)
Demand side technology pull	Intellectual property protection	Blind et al., 2006; Nemet (2009)
	Tax exemption, credits and rebates for consumers of new technologies	Cantono & Silverberg (2009); Roolaht (2010); Hekert (2007);
	Purchase subsidies	Cantono & Silverberg (2009)
	Reduced vehicle license tax	Caulfield et al. (2010); Jieyi (2018)
	Government procurement actions, technology mandates	Dalpe (1994); Izsak & Edler (2011); Roolaht (2010)
	Infrastructure subsidies	Wang et al., 2014
	Regulatory standards	Blind et al. (2017); Izsak & Edler, 2011; Van de Ven (1993)
	Taxes on competing technologies	Tietge, 2016

Source: Author's own depiction

Importantly to mention is that the development of one technology can stimulate the interest investments in another related technology, characterised by mutually supporting each other (Mowery & Rosenberg, 1991; Nemet, 2009). The transition from combustion engines to electric transport must be supported by a proper policy strategy, holding a good coordination to avoid future failures (Altenburg et al., 2012). For instance, entrepreneurs are hesitant to invest when faced with an activity that lacks investment and an activity without such entrepreneurial support will not develop (Altenburg et al., 2012).

2.2.2 Demand in innovation policy

The demand side innovation policies are having a major influence on diffusion of innovation along with the desired growth in productivity (Roolaht, 2010). Regulations, public procurement, subsidies for private demand etc. are measures part of the demand side policies classification (Roolaht, 2010). The demand side policies are not to be viewed as a potential substitute of pull policies but a complementary measure to the traditional supply side measures. The power of consumers to request, adopt and use innovations namely the demand side of innovation, it has always been included in public policy (Edler, 2013). Nonetheless, these government initiatives were mostly used for certain policy achievements and have not been tailored part of the innovation policy portfolio systematically. This absence in innovation dynamics changed only some years ago, after a long break of not including the demand side innovation practice and discourse (Edler, 2013). Policy makers need to look at the demand innovation policy considered the most important dimension to learn from (Edler, 2013; Izsak, 2011; Boon & Edler, 2013). Basically, demand conditions are increasingly stated as primordial conditions for innovation systems (Allman et al., 2011; Miles et al., 2009).

"Demand side innovation policy can be defined as all public action to 'induce' innovation and/or speed up the 'diffusion' of innovation by:

- Increasing the demand for innovation (e.g., willingness and ability to buy and use an innovation)
- Defining new functional requirements for products and services and/or
- Improving user involvement in innovation production (user-driven)" (Edler, 2013, p 6)

In more clear terms, the demand consists of the willingness to pay a certain amount of money for a good or services having the purpose to satisfying a certain need or want (Mowery & Rosenberg, 1979).

Most of the policy instruments of the demand side positively affecting innovation and diffusion are usually formulated and implemented in policy areas such as health, environment, transport, energy, and similar others (Edler, 2013). In the transport sector policy instruments that are targeting demand are designed and implemented producing and determine innovation to occur. An important part in innovation creation is played by regulations, standards, and public procurement (Izsak & Edler, 2011). The obvious innovations effects generated from such policies are "diffusion policies in disguise" (Stoneman & Diederen, 1994 p. 927) when they were conceived without being under innovation policies. Many times, their effect of innovation and innovative capabilities is not even recognized or evaluated (Edler, 2013). Despite that, it is obvious that those instruments affect the demand and influence innovation, therefore, have to be considered when analysing the potential of demand-based instruments for creating innovative dynamics (Edler, 2013).

Demand side policies are looking at the customer potential, it reveals a need or helps the potential buyer to acquire an innovation or co-produce it with suppliers (Edler, 2013). This induce more specific direction to the upstream innovation activities and inquires additional, different kind of skill set for policy maker, to be able to understand and define needs and make more specific choices (Edler, 2013). Demand side instruments, such as consumer subsidies are considered specifically important during the early commercialization period of new technologies such as E-cars (Sierzchula et al., 2014). It is important that radical technologies attract a significant number of early adopters to develop a viable market niche (Geels, 2002). This makes important that manufacturers continue to develop and materialize enough demand along with governments mixed incentives to help attract early adopters of E-cars (Sierzchula et al., 2014).

Demand drives firms to work in certain directions and solve certain issues. Shifts in factor prices (the various costs and incentives of producing a product), geographic variation in demand, the identification of "latent demand" and potential new markets, all influence the successful pay-off of the investment in innovation (Nemet, 2009). It is mentioned that incremental innovation has a higher probability of response to demand-pull than technology-push and non-incremental innovation to technology push (Dosi, 1988; Nemet, 2009). Surveys conducted revealed that firms consider demand pull interventions as primordial factors for innovation creation and success as compared to supply factors (Allman et al., 2011). Fast growing demand is considered to be the most important incentive for investment in innovation and a main propulsion of technology diffusion due to the direct profit from the innovation produced in the ascending market (Horbach et al., 2012; Newell, 2010). The diffusion level in in link with the innovation activity (Edler, 2013).

Schmookler (1966) argued that new technologies are created by the nature of demand, playing a primordial role for determining the direction and "magnitude of the inventive activity". It was determined that the demand led technical invention (from a patent measure view) (Edler, 2013). Another way of stating the argument could be that uncertainty for innovation is viewed by firms as a draw back for innovation process. Thus, firms that were asked about the essential policies that support innovation, they ranked policies that increase demand creation on a first place (European Commission, 2009).

2.2.2.1 General overview of innovation policy instruments

Policy instruments are meant to induce change (or to avoid change) using a certain way that is stimulating innovation with the purpose to achieve some specific goals. The instruments of innovation policy are focused on fostering innovation however innovation is more a way to achieve broader political goals such as economic growth, increased employment, environmental protection, public health etc. Thus, innovation instruments are meant to influence innovation processes that lead to the fulfilment of the ultimate political goals (Borras & Edquist, 2013). This is done by achieving the innovation objectives formulated in the innovation plan.

Every policy instrument used by governments, or a public agency have a unique characteristic. They are designed and chosen for a specific problem, at a certain point in time respecting the specific policy context and political ideology (Borras & Edquist, 2013).

The primordial categories utilized in public policy are regulatory instruments, economic and financial instruments, and soft instruments. There are other classifications of policy instruments however these are the widely most accepted in the literature on instruments (Borras & Edquist, 2013).

1. Legal tools are used by regulatory instruments to drive social and market interaction regulation (Borras & Edquist, 2013). The regulatory instruments are powered by laws and binding regulations are essential in the innovation policy domain as for instance in competition – antitrust policy measures regulations concerning R&D and innovative activities by firms in the market and some specific industrial sector regulations that influence innovative activities (Borras & Edquist, 2013).

2. The economic and financial instruments give specific supportive incentives or disincentives and support certain social and economic activities. Mainly speaking they involve economic ways in cash or kind and can be supported by positive incentives (encouraging certain activities) or disincentives (discouraging activities). It is important to use the innovation policy instrument

that fits the specifics of the problems in the innovation system and administrative structures features (Borras & Edquist, 2013).

Table 2 Economic and financial instruments

Economic modalities in cash:		**Economic modalities in kind:**
Positive incentives (encouraging): • Cash transfers • Cash grants • Subsidies • Reduced interest loans • Loan guarantees	Disincentives (discouraging): • Taxes • Charges • Fees • Customs duties • Tariffs	Positive incentives: • Government provision of goods and services • Private provision of goods and services under government contracts • Vouchers

Source: Bemelmans (2011)

3. Soft instruments are those measures done voluntary and non-coercive.

Mandatory measures, sanctions or direct incentives or disincentives set by the government, or its affiliated public agencies are disregarded in soft instruments (Borras & Edquist, 2013). These instruments offer recommendations and or offer voluntary or contractual agreements. Examples are recommendations, campaigns, voluntary agreements and contractual relations and public private partnerships (Borras & Edquist, 2013). These are based on less hierarchical situation, where mutual exchange is exercised in forms of cooperation between public and private actors (Borras & Edquist, 2013). Regarded as the main force of transformation in the public administration of most nations, soft instruments are increasing in use. The instrument has been named governance, meaning that the government's role has switched from a provider and regulator to a coordinator and facilitator (Borras & Edquist, 2013).

2.2.2.2 Subsidies and taxes to stimulate demand

For purchasing an innovation there are different kind of instruments that give financial incentive. Tax incentives and subsidies are two broad general categories of priced based instruments (Edler, 2013). Demand subsidies and tax incentives on the demand side decrease the price of the innovation this way confronting different market failures (adoption externalities, risk-reward consideration etc.) making the innovation more attractive especially in the early stage of its development. Moreover, from a theoretic point of view, the required economic incentive can be offered before, during or after acquisition being designed for one time or a recurring payment, technology specific or neutral (Albrecht, 2012).

Table 3 Price based instruments

Instrument type	**Subcategories**
Direct subsidy	Up front price reduction: cash grants, cash back, cash equivalent credits, points and vouchers, fixed price. Less financing burden over time (plus risk reduction): loan guarantees, preferential loans.
Tax incentive	Reduced purchasing price: different tax waivers. Reduced tax burden over time: Tax relief/rebate, tax credits, tax deduction, tax deferrals, accelerated depreciation allowance.

Source: (Edler, 2013; Machiba, 2011), modified

It is found that there is no clear answer as of which instrument works best to support diffusion of innovation and innovation activity (Kemp & Pontoglio, 2011). No rank has been succeeded in terms of innovation effect and welfare (Requate, 2005). In the literature contradictory opinions are found regarding the support of innovation diffusion when comparing command and control regulations and market-based instruments (Edler, 2013). Some studies suggest that market instruments are more effective in inducing innovation (Vollebergh, 2007; Jaffe et al., 2004) whereas others point on stronger support from command-and-control regulations, especially on more radical innovations (Ashford et al., 1985; Kemp & Pontoglio, 2011; Taylor et al., 2005). Moreover, investment subsidies for innovation have been demonstrated to have limited impact on decision, and factors related to the functionality of the technology itself were more important than the price lowering (Kemp, 2000). A limited effect on adoption decision is seen to come with a limited effect on innovation (Kemp, 2000) and differences can be understood in their specific regulatory and market context (Edler, 2013).

In terms of financial incentives, it has been demonstrated that consumers had a higher response to incentives giving an immediate effect (waivers) than for those realizing a gain over a longer time (rebates, tax credits) (Edler, 2013). This stands as one reason as why generally the monetary incentives had a weaker effect, been largely offered as rebates and tax credits instead of waivers. Diamond (2009) holds that the monetary incentives must give a benefit when the purchase is made and not over the lifetime. He further assumes that the windfall profits of the intermediaries such as dealers are determining the low effect of tax subsidies. Edler (2013) says that there might be a redistribution effect since these subsidies drag people with higher income to buy HEVs and benefit (Edler, 2013).

Cantono and Silverberg (2009) looked at designing a minimal way of intervention for demand subsidies effect to kick start the diffusion of innovation. Their findings revealed that the optimal level of the subsidy depends on the nature of the economy on focus. With this saying they reveal that if costs for learning economies are high the subsidy need to be adopted on a permanent nature whereas in a learning economy with low costs, the subsidy will produce a windfall profit. Low learning costs imply that the technology will diffuse without any subsidy support. Even more, the time length of the subsidy has an important influence and same for its level (Edler, 2013).

2.2.3 Theoretical Framework

Austrian economist Joseph Schumpeter (1883-1950) expressed that, imitations and innovations are elements through which industries tend to develop. The innovation is viewed as a combination of newly defined elements of productive resources that aim at increased profit (Arif, 2012). Schumpeter studied the emergence of new technology and innovation and elaborated a scheme of technological change comprising invention - the first demonstration of an idea; to innovation - the first commercial application of an invention to the market; to diffusion - the spread of the innovation into the market (Dijk, 2010). This scheme was subsequently used by economists and improved the evolutionary theory of innovation since 1980s onwards. However, these models are found to be less applied in consumers products when a changing social context takes place. Consumers tend to put a symbolic meaning on products. However, only few theories in economic field include this interaction of such social and technological aspects (Dijk, 2010) and are poorly understood (Saviotti, 2005).

2.2.3.1 Rationalizing the choice of framework

It is known that for a large transition scale of EVs there is a needed dual change: a radical dimension and systemic changes (Smith, 2009). The radical change implies going beyond incremental actions to improving the present design and transitioning to new core technologies. The systemic dimension targets the change of foundation in the technology regime, requiring new combinations of the industrial sub-systems, and different created relations between institutions and power relations between industry actors. These interrelated technical and organizational innovations that supports transitions from fossil fuels to e-mobility may be regarded as a techno-economic paradigm shift. This paradigm degrades and establishes new sub-systems and gives rise of new collective beliefs, leaving behind the old ideas while embracing the new common sense (Altenburg et al., 2012). Due to the environmental degradation pressure this paradigm shift needs to be accelerated, thus large and coordinated government efforts are required to accelerate e-mobility. Hence, the creation of the direction towards technological change is fundamentally dependent on policy makers choices and decisions on the future shape and political settlements between stakeholders-parties and especially their conflicting interests (Altenburg et al., 2012). (Paragraph retrieved from Arseni (2018))

Such a techno-economic paradigm, in this case represented by E-cars, requires interventions that will change the technological subsystems, the interactions between institutions and the common sense of what people know as being good practice (Altenburg et al., 2012). A system is seen as a group of components (devices, objects, or agents) working for a common purpose such as common objective or overall function. However, to recognize the important policy problems from a certain innovation system the structural side should be complemented with the process dimension (Bergek et al., 2008 b). The technology innovation system (TIS) brings this dimension and is an approach largely used to study the emergence of new technology and their development and identify barriers and strengths to new technology (Bergek et al., 2008 b).

While other relevant frameworks are mentioned and used for context (Altenburg et al. 2012, Geels, 2002 the multi-level perspective framework; Dyjk, 2010 the co-evolutionary analysis) the technological innovation system framework is chosen for this study. The choice of the framework is motivated by the focus of this study to support the diffusion of E-cars technologies in a specific area, the Indian context, which is the fundamental concern of the TIS framework. TIS framework looks at the successful diffusion of technologies and focuses on prospects and dynamics of a particular innovation while other frameworks are focusing on other aspects as for instance, the multi-level perspective is concerned with the transformative societal processes focusing on a broader transition process of innovation (Twomey & Gaziulusoy, 2014) and the co-evolutionary theory is preoccupied by the relation between micro looking at the internal organization setting and macro being the external environment (Madhok & Liu, 2006).

2.2.3.2 Technological Innovation Systems' framework

There are six highlighted guiding steps in the literature for applying the TIS analysis (data subtracted from Bergek et al., 2008 b) which are:

1. Setting the starting point for the analysis – defining the TIS of the study
2. Identify the structural components of the TIS (actors, networks, and institutions)
3. Move from structure to functions – use functions to describe what is happening in the TIS reading through the key processes lenses resulting in a snapshot of the achieved functional pattern – description of how each function is filled in the system
4. Normative – assess how well the functions are fulfilled then set goals in terms of a "desired" functional pattern
5. Identify mechanisms that induce (drive) or block a development towards the desirable functional pattern.
6. Specify key policy issues with respect to these mechanisms of inducement and blocking mechanisms

Usually, the analysis is not following such a step by step setting but includes many iterations between the stages in the process of the analysis (Bergek et al., 2008 b).

TIS structural components

The system is regarded as a group of elements (devices, objects, or agents) that have the same aim that is achieving the same objective or overall function (Bergek et al., 2008 b). Actors, networks, and institutions are elements of the innovation system that work towards the overarching function of developing, diffusing, and utilizing new products and processes (Bergek et al., 2008 b; Galli & Teubal, 1997). These could be part of certain technological innovation systems though are not always technology specific (Bergek et al., 2008 b; Carlsson & Stankiewicz, 1991). An innovation system is an analytical construct to better illustrate and comprehend system dynamics and performance (Bergek et al., 2008 b). This transcends the meaning of a system that does not have to necessarily exist fully fledged but just starting to take form thus showing at this stage weak interactions between its elements (Bergek et al., 2008 b).

The TIS is comprised by the elements forming the studied technology plus the components influencing the innovation process where this specific technology is involved (Bergek et al., 2008 b). A TIS can be a sub system of a sectoral system or cut across several sectors. They can be looked at geographical level but are international in nature (Bergek et al., 2008 b).

Table 4 Structural components and dynamics of a demand side TIS

Components	Definition
Actors	The actors of the TIS may be comprising firms along the entire value chain, public bodies, influential interest organizations (e.g. industry associations and non-commercial organizations), organizations deciding on standards, end users etc. (Bergek et al., 2008 b). Organizations enter the system contributing with new supporting directions, as for instance bridging organizations that act as meeting places and interest organizations that promote the technology in the public arena (Bergek et al., 2008 a).
Networks	Are connections between actors for sharing information. Networks can be formal and informal. Formal networks are easy to identify whereas informal require discussion with industry experts or other actors or analysis of co-patenting, co-publishing or collaboration (e.g. Joint ventures and joint university-industry projects) (Bergek et al., 2008 b). Some networks are managed to deliver a specific task such as standardization networks, technology platform consortia, public-private partnership or supplier groups holding the same customer. Other networks develop in a less guided way and comprise buyer seller relationship and university-industry links (Bergek et al., 2008 b). Around this some networks are formed around technological tasks or market formation while others have a political agenda for influencing the institutional formation (Bergek et al., 2008 b).
Institutions	A system of formal laws, regulations and routines and informal conventions, customs and norms that shape the socioeconomic activity and behaviour have to be identified (Bergek et al., 2008 b). Usually to diffuse the specific technology, institutions need to be adjusted, or "aligned" to the emerging technology (Freeman & Louca˜, 2002; Bergek et al., 2008 b). This is not an automatic process but a process encountering opposition. Firms compete in the market but also on the nature of the institutional set-up (Van de Ven, 1993; Bergek et al., 2008 b). Analysts require a broad perspective when looking at relevant institutions and sometimes missing institutions is that what is of interest. Sometimes even the lack of institutions is of interest (Bergek et al., 2008 b).

Table Source: Author's own depiction (Partially retrieved from Arseni (2018))

Note: From the table above this study subtracts and uses the elements for the focus of this study and excludes others. All the explanations above were used for better explaining and comprehending the structural elements of the TIS.

Emergent TISs present various uncertainties while identifying the structural components is not easy with the above-mentioned sources difficult to use (Bergek et al., 2008 b). There is a difficulty in such stage where the identification of relevant actors is troubling when directories are scarce, no industry associations exist or if the actors are not aware of belonging to the TIS (Bergek et al., 2008 b). Even more, in an incipient phase networks are not formed properly and/or informal and TIS specific institutions could not exist yet (Bergek et al., 2008 b). In such cases an iterative process is required where mapping of the actors is done by adding additional pieces of information while proceeding with the analysis (Bergek et al., 2008 b).

Formation of networks, institutional alignment and the entry of firms are shaping the emerging TIS with such processes taking place in the formative phase (Bento & Wilson, 2016). These have three characteristics: Firstly, high uncertainty of entrepreneurial actors, investors, and policy makers in terms of technologies, markets, and regulations. Secondly, the time to realize these can be very long, even decades. Third, many changes are required for shaping the elements (Bergek et al., 2008 a). After the arrangement of elements, the TIS evolves into a growth phase (Bergek et al., 2008 a; Carlson & Jacobsson, 1997) and have an impact on the electric vehicle sector.

When the system changes with components starting to modify as for example with new entrants or institutional change, the system moves accordingly creating new actions and reactions. This results in actors and knowledge relations suffering alteration. This creates a chain of reactions as feedbacks brought to life keeping most or all the components of the system (Bergek et al., 2008 a). Market opportunities can create new entrants resulting in positive externalities, institutions being remodelled for fitting the shape of the new system and needs, and universities opening ideas to new research (Porter, 1998). Such connections can be circular and determine "cumulative causations". In their process of forming a new shape, they help the TIS increase its "self-sustained nature" (Bergek et al., 2008 a).

Policy helps to determines the formation of new different TISs that changes in a "self-reinforcing growth system" (Bergek et al., 2008 a). Additionally, it is created a right medium that incentivises and drives entrepreneurial actors to work on sector building even if it is in an early phase of development (Bergek et al., 2008 a). Therefore, system building activities need to be considered by policy makers and entrepreneurs (Johnson & Jacobsson, 2001). As mentioned by Johnson & Jacobsson, 2001, such activities have the purpose to strengthen the facilitating mechanisms and reduce the strength of the blocking ones. Nevertheless, assessing the strength of a positive system is not realizable if there is no reliant point supporting diffusion such as cumulative electric vehicles (or E-cars) (Bergek et al., 2008a; Arseni (2018)) produced, deployed, or/and diffused. Understanding and expressing the present developing rate of technology in the market and finding weaknesses offers information for actors that then better know what measures to take for increasing the technology diffusion. However, finding system strengths and weaknesses is not an easy task that was not much looked at in management, entrepreneurship, and innovation policy research (Bergek et al., 2008 a).

Defining functions

The problem mentioned above is solved with the introduction of a second level of key processes in TIS formation where the gap between structure and performance is linked. Bergek et al., 2008 a, suggests the functional approach to innovation system (e.g., 'meso level approach that is firmly rooted at the micro level') that is seen to improve some parts of these shortcomings. The most important advantage of using functions is the additional layer it brings separating structural components from content (Bergek et al., 2008 a).

Functions can be used to detect suitable ways to push a technology in the market, in conjunction with the need of policy makers, entrepreneurs and/or other actors. The framework contains not only the structural elements of a system, but it also looks at those movements and achievements in terms of key processes, identified here as functions in innovation system (Bergek et al., 2008 a). Such functions can determine the performance of the system under investigation. With the identification of the system's weaknesses and strengths, policy makers and entrepreneurs can better focus on the important blocking factors that need to be improved (Bergek et al., 2008 a).

Functions in institutional framework from the low carbon area where radical change is required, have not been much regarded compared with functions related to actors, markets, and networks (Bergek et al., 2008 a). Additionally, it is found that with research progress new ideas are brought on the dynamics of the innovation system thus functions may be open to continuous improvements (Bergek et al., 2008 a).

Elements of a system may interact without following a specific plan thus not occurring intentionally even if the system is highly developed. The "overall function" is not translated in having all the system's actors operate under the systems' function purpose or that are directed by the function. Actors may have the same or different purposes and when they have the same one, are not necessarily supposed to work together consciously to achieve it (Bergek et al., 2008 b). No specific actors are seen to direct and manage the systems components (Bergek et al., 2008 b).

TIS's common functions and values

The content of this section is primarily taken from *Arseni (2018),* unless otherwise mentioned.

The following functions were identified to be used when mapping key processes in innovation system dynamics.

1. Knowledge development and diffusion through networks is the core function of the TIS. The function involves inventions and theory. It is concerned with the amount and depth of knowledge created in the TIS and the diffusion of it and harmonization with the TIS. It is the learning process between actors (Bergek et al., 2008 a; Bergek et al. 2008 b). According to Lundvall knowledge is the fundamental resource in modern economy with its inherent process that is learning. Knowledge types adopted in this function are broad, ranging from scientific knowledge, through applied knowledge used in productive processes to that on the functioning of markets and strategies for the governance of fields of technical administrative knowledge (Bergek et al., 2008 a; Bergek et al. 2008 b). The fundamental function of networks is the exchange of information which is important in a defined setting and a heterogenous context where the demand side interacts with government, competitors, and market (Hekkert et al., 2007).

2. Influence on the direction of search deals with providing focus to the knowledge development and diffusion process. The important actor here is the government that creates the required environment for research creation but also to business for encouraging experimentation. It comprises incentives and/or pressures for the organizations to recognize and take advantage of the new opportunities. While and once these new opportunities are materializing new combined strengths take form and influence system components. Influencing the direction of search part of a TIS mechanisms like competing technologies, markets, business models etc. are used

(Bergek et al, 2018 a). These mechanisms are also designed by the opportunity view seen by entrepreneurial actors that result in an interactive knowledge exchange between technology producers, technology users etc. Consequently, the influence of technology choice or/and the firm entry is not solely driven by one organization. The influence is component systemic and complex factors that go beyond technology specific factors. Their strength is a combination effect of for instance visions and beliefs in growth (comprising incentives from changing factor and product prices; growth happening in TISs in other countries; changes in the landscape e.g., climate change debate; expectations) actors, regulations and policy, articulations of demand from leading customers (von Hippel, 1988), technical bottleneck etc. Even going beyond the paradigmatic perspective, landscape changes have its specific influences (Bergek et al, 2018 a; Geels, 2002; Waltz et al., 2016).

3. Entrepreneurial experimentation arises where a TIS is under considerable uncertainty regarding technologies, applications, and markets. Uncertainty is a core characteristic of technological and industrial development being found at early but also later stages (Bergek et al., 2008 a). It comprises the heterogenous interaction between R&D and government policies, competitors, and markets. It disguises the new complementary approaches required in the latest technological insights such as standards and long-term policy targets that need to be adjusted to the present society norms and values (Bergek et al., 2008 a). This function is represented by uncertainty that is not happening only in the early phases of technological development but in later ones as well. From a social point of view to overcome the degree of uncertainty, it is important that many entrepreneurial experiments take place. The function looks at how knowledge generated is used to create concrete actions that help shape, realize, and take advantage of new business opportunities (Bergek et al., 2018 a). In such experimental processes, attitudes of consumers, government, competitors, and suppliers can be evaluated, and knowledge can be collected about the technology function found in different contexts (Kemp at al., 1998; Raven, 2005).

4. Market formation for an emerging TIS are accommodating learning spaces where the TIS can find a place to be formed (Kemp et al., 1998). It describes how well developed a market is. If imagining innovation on a linear process, the market formation would expose the stage of the innovation, whether if it is in its pre-commercial faze or in an upscaling or in fully commercial stage (Bergek et al., 2008 a). Forming markets are very much dependent on government support, whereas enterprises are having the role of searching for successful niches in the new market created. For actors to learn and develop new technology can opt to form niche markets for specific applications in favourable identified market segments. Another way is to create competitiveness through regulations. This can refer to activities that influence increasing the demand of the technology (Bergek et al., 2008 a).

5. Resource mobilization are essential to all activates in the innovation system. Therefore, it is important to map the TIS potential to mobilize human capital (using education), financial capital and complementary assets (complementary products, services, network infrastructure etc.) (Bergek et al., 2008 a).

6. Legitimation/counteract resistance to change is essential for the formation of new industries and new TIS. The new technology has a prerequisite of being considered appropriate and desirable in the cluster of relevant institutions as considered by relevant actors so that resources can be mobilized, for demand to form and actors in the TIS gain political power (Bergek et al., 2008 a). Legitimacy influences strategies of organizations as well. The formation of this function may take some time and can be complicated due to the TIS emergence in a competitive setting with already established TIS. Parties holding interests naturally will oppose this creative destruction defending existent established regime and the institutional frameworks related to it (Bergek et al., 2008 a).

Table 5 Functions and indicators for the TIS analysis

Function	Possible indicators
1. Knowledge development and diffusion through networks	- Development: bibliometrics (citations, volume of publications, orientation); assessments by managers and others; learning curves - Diffusion: workshops, conferences, network activities
2. Influence on the direction of search	- Long term targets of governments and industries, expressed visions: o Incentives from changing factor and product prices - alignment of expectations of relevant actors - actors' assessments of the present and future technological opportunities and appropriability conditions - regulations and policy - articulation of demand from leading customers - technical bottlenecks - crises in current business
3. Entrepreneurial experimentation	New entrants, experiments, start-ups, diversification activities
4. Market formation	Readily available facts on market size and customer groups; also, qualitative data on e.g. actors' strategies, the role of standards and purchasing processes The number of niche markets, specific tax regimes, new environmental standards that improve the chance for new environmental technology
5. Resource mobilization	Financial capital: venture capital, public seed money, private investments Physical: natural resources, infrastructure
6. Legitimation/counteract resistance to change	Size and growth of interest groups/advocacy coalitions and their lobby activities, size of network around the technology, actions that legitimize technology, number of exhibitions/workshops, technology platforms

Source: Authors own depiction. Data collected from Wieczorek & Hekkert (2012) and Bergek et al. (2018 b) (Retrieved from Arseni (2018))

It has been observed that none of the literature reviewed from the 1990 – up until the end of the first decade of the 2000s – had used all the functions at the same time, even if they were all mentioned in the "policy and innovation system" literature of that time (Bergek et al., 2010; Bergek et al., 2008 b). Policy researchers seem to have relied their analysis on a few functions or general policy problems to be solved, and often in an unsystematic way showing no reason for their choice (Bergek et al., 2008 b). This delineates the clear difference between the function approach and conventional innovation system analysis with respect to key processes, that importantly states and includes all functions to identify systematically policy issues (Bergek et al., 2008 b), thus a reason to include all functions in such studies. It is specified that the functions need further revision as the research on innovation systems brings additional insights (Bergek et al., 2008 b).

Interaction of functions

Since six functions were defined many interactions are expected possible. Whatsoever, the starting possible points is much smaller. It has been shown that the development of a technology begins with a smaller number of functions that then involve other system functions. These can be labelled as "motor of change" (Hekkert et al., 2007). According to Jacobsson & Johnson the function fulfilment could lead to virtuous cycles of processes of change (or positive feedback loops) that enforce each other leading to the construction of the momentum for creating the process of creative destruction within the incumbent system (Hekkert et al., 2007). Due to this, empirical research should look and reveal data of how the building process of the momentum takes place that could after reveal ways on to guide the innovation in other nations and sectors (Hekkert et al., 2007). For example, a common motor for virtuous cycles is function 2 influences on the direction of search, when problems of the society are identified and government goals are set to limit environmental damage (Hekkert et al., 2007). These goals conduct to new resources that further lead to knowledge development and expectations rise about technological options (Hekkert et al., 2007).

It is required to mention that vicious cycles can also arise. If this will be the case, the negative function will hinder the activities of other functions slowing down and/or stopping the process (Hekkert et al., 2007).

Process approaches method

Function of innovation systems concept is used with the aim of understanding processes of technological change and innovation. The system is changing when specific thresholds of function fulfilment are reached (Hekkert et al., 2007). Therefore, it is needed to find a research approach to arrange and set sequence of all the important processes. Moreover, it is observed that the qualitative aspects of various processes and complexity of the information created is many times disregarded when statistical approaches are utilized (Hekkert et al., 2007).

A better research approach is the process approach or sequence analysis (Poole et al., 2000; Abbot & Tsay, 2000; Wu, 2000). The process approach builds concepts of development and change as sequences of events, explaining outcomes as unfold from the order of events (Hekkert et al., 2007). It comprises causes for continuity and discontinuity, critical incidents, contextual effects, and effects of formative patterns (Pool et al., 2000).

The process method creates a story line of function X inducing technology development concomitant with the other functions. This is different from the variance thinking where function X has a partial role in displaying the development of the emerging technology (Hekkert et al., 2007). The application of such an approach having the process as a basis is the ‘event’. The ‘event’ is the actions of the subject in focus or the changes of them (Hekkert et al., 2007). When drawing the events inside of a technology innovation system it is used a broader research, analysis events at the system level and not analysis all the individual elements in the system. These are preferably collected from newspapers articles and professional journals. Based on such data construct, a historical database is created in which all relevant events related to a specific technology trajectory are mapped (Hekkert et al., 2007).

These events are all then allocated to the functions selected. When many events are difficult to allocate then it’s clear that the functions are not complete or without sense (Hekkert et al, 2007). A function that has a lower number of events it might make the function not reliable in explaining technological change. Events can be categorized as negative and positive according to their influence in the functioning of the innovation system (Hekkert et al., 2007). If we look for example at the guidance of search, the events categorized in this function can be positive or negative in respect to their opinion that can be negative or positive on the regarded technology (Hekkert et al., 2007).

Events that can be categorized in functions can be put in figures that will better reveal the pattern over time (Hekkert et al., 2007). When showing all functions image, a clear drawing can be made of the overall functional pattern of the innovation system under investigation over time (Hekkert, et al., 2007). This way, with a clear visual representation of the functions, will be easier to determine which perform well and which do not, also what periods of system functioning perform better and which not (Hekkert, et al., 2007).

A story line is being built by the process analysis, comprising various pictures with the events plotted in a time frame. This reveals the TIS metamorphization over time having the functions as influencers. From the story, general patterns should be generated (Hekkert et la., 2007). Cross case analysis can then be used to test the patterns if they are case specific or hold more general characteristics. These patterns give the details required for making the first steps for policy guidance for the governance of the in focus TIS (Hekkert et al., 2007).

Driving forces and blocking mechanisms

The content of this section is partly taken from *Arseni (2018),* unless otherwise mentioned.

Every TIS has unique characteristics regarding its structure. The structure is determined by two dimensions: internal processes playing a major role in the TIS structural features and external processes that interact with the internal processes and have an influence on many TIS simultaneously (Bergek et al., 2008 a).

As conceptualized by Geels (2002), the internal dimensions or technology specific elements are named as niches being part of a larger segment, named technological regime. At their turn regimes are part of a larger system identified as landscape, comprised of thorough structural tendencies (Geels, 2002). The landscape in an external factor, structure or context (oil prices, environmental problems, broad political coalitions, etc.) that incorporate regimes. Landscapes change much harder than regimes. Regimes create incremental innovations, and radical innovations are promulged in niches (Geels, 2002). Niches act as "incubation rooms" for novelty creation (Geels, 2002). According to Bergek et al., 2018 a, these differentiations are useful to explain the internal external system influences. In the function and innovation systems the distinction between internal and external influential factors is not so visible but it is there.

The system of functions was aimed at realizing the integration of technology specific and other general factors. To define the borders of a technology system an analysis of the factors that promote and hinder such functions would be required. The factors can be fully technology specific as well as influencing other systems at the same time. "Units of analysis towards delineating this system hence can be technology, industry, nation" (Johnson and Jacobsson 2001, p. 93). Driving forces and opposing factors can consequently be specific to the technology in case (happening inside the TIS borders) or more general (external). For instance, demand from a leading customer may be a technology specific driving force whereas external forces may be climate change, environmental problems that persuade the dominant regime and convey emerging opportunities for new niches (Bergek et al., 2018a). (Paragraph not part of the *Arseni (2018))*

It is primordial to identify blocking factors that block the emergence of a new TIS and the development of strong functions thus advantaging the incumbent technologies, and the prevailing regime (Bergek et al., 2008 a). Poor developed networks can be a weakness mechanism inhibiting knowledge diffusion and legitimation. External barriers may be highly organized incumbents that strongly defend their markets and investments and importantly keeping institutions on the side of the dominant technologies (Bergek el al., 2018 a). (Paragraph not part of the *Arseni (2018))*

3 Research design, materials, and methods

This section presents a short underlining of the methodological approach used to achieve the research aim. Thus, the aim of the chapter is to present the research design and analytical framework. It will comprise a justification of the choices made.

3.1 Methodology

The research begins from a post-positivism paradigm to scientific inquiry that ontologically assumes that reality can be approximated and adjusted. Post-positivists think that reality can be known in an imperfect (Miller, 2007) manner and drawn with probabilities (Robson, 2002) thus never entirely known (Denzin & Lincoln, 2008). Critical realism is one of the most common forms of post-positivism. It is explained in the parallel between positivism and post-positivist thinking. Positivists think that the reality, the natural order in social events and discourse it is recognized whereas the critical view requires investigation to discover the error and correct it. Post-positivists try to understand how their axiology influenced their research, including choice of measures, populations, questions furthered with analysis and interpretation (Miller, 2007). Thus, the detection of patterns of events using simple observation is not achievable (Walliman, 2015). Therefore, only through meticulous research the reality can be approximate and avoid possible errors. Not so ever, through such detailed research work, the ideals of objectivity and generalizability of results are seen (Ellingson, 2013) useful and applied.

The epistemological view is concerned with how we know things and what is regarded as acceptable. The knowledge in the present research is gained using inductive reasoning (Walliman, 2015). The knowledge is derived from specific observations and derives general conclusions from them. These generalizations are considered legitimate if there are many observations statements, the observations are repeated under a large range of circumstances and conditions and no observation statement contradicts the derived generalization (Walliman, 2015). Human knowledge is relying on investigation done more on human conjecture than a previous investigation done objectively. The conjecture assertions are warranted or more precisely noted are justified by a set of warrants that can be changed or withdrawn after additional investigation is done. The research starts with a question and inductive research is used to develop a statement from a position in which we don't know what might turn to be helpful about the subject of interest (6 & Bellamy, 2012).

The type of analysis used is a between case and within case analysis. The research compares a modest number of cases on several perspectives or factors and also do within case analysis on each of them thus it is making use of a case-oriented research approach called also comparative case research (looking into India, China and UK cases and then comparing them on how E-cars are being market diffused, using government policies mechanisms). This design makes a comparison between a small number of cases, comparing the theoretically important variables across cases, and also using within research to explore how these similarities and differences relate to the specifics of context and dynamics of the case in focus (6 & Bellamy, 2012). As an analytic procedure the study uses a descriptive explanatory design, where a multi country review of trends is described and an explanatory process tracing is exposed.

3.2 Research design

The research question is answered using a case study approach around which the study evolves. The study is constructed from a literature review including reports of several single case studies of cities that have successfully introduced EVs. Qualitative research methods are adopted for looking at the phenomena of the study and are used for collecting and analysing the data. The qualitative research is focused naturally on seeking the novel or unpredictable findings providing the means to change or improve present studies as answers to these discoveries by chance. For the present paper the qualitative research is used to explore policy initiatives of different cities and then after for identifying relevant aspects that can be adopted in another urban context. The case studies are three countries and three cities selected from each of these countries that are then analysed at national and city level.

The collection of data is made through a literature review of different sources. The data sources are academics such as journal articles and grey literature that are used to support the analysis.

3.2.1 Case oriented research design

Case based oriented research (COR) implies using multiple case studies with a moderate size N (number of cases) looking at various variables' effects within and between cases (Ragin 1994; 6 & Bellamy, 2012). The context plays a primordial role when selecting cases making it possible to effectuate within case analysis but also set comparisons of specific variables or patterns analysis between cases (6 & Bellamy, 2012). According to Ragin (1994) COR is best used with qualitative methods ideal for smaller number of cases. It is stated that when qualitative methods are used for COR, instruments and analytical frameworks are developed or amended during the research (Ragin, 1994).

COR design comprises data collection, data analysis and provisional theoretical inferences that are used in an iterative connection (6 & Bellamy, 2012). Data is being coded systematically to set variables behaviour and determining the results (using chronological timelines, tables, matrices etc.) that show patterns within and between cases. As a result, various questions arise regarding the patterns generated and most importantly about abnormal behaviours. Responses to these questions create temporary answers for the research questions or refine the hypotheses (6 & Bellamy, 2012).

When comparing cases from different geographical, historical, or cultural backgrounds particular challenges arise being not easy to establish if the same phenomena is being studied (6 & Bellamy, 2012). When seeing similarities in things and behaviours permit the creations of general hypotheses. Nonetheless, differences allow the definition of more precise boundaries between situations and occasions where patterns can apply or not (6 & Bellamy, 2012). Thus, the main presumption of all comparative studies is firstly differences in outcomes among relevant similar cases that lead to searching for explanation by differences in causal forces. Secondly the similarities in outcomes in similar relevant cases are expected to show similarities in causal forces until the opposite is shown (6 & Bellamy, 2012). For instance, a policy scheme may create different outcomes in practice when applied in multiple cases depending on the various factors from the specific contexts. COR can be controlled to choose only relevant similar cases and in isolating differences and similarities that are possibly carrying explanatory weight.

The *method of agreement* is one of the ways used to make valid comparisons capable of generating theoretically useful inferences. Part of this method two or more cases are selected containing similar outcomes or dependent variables. After possible causes are pointed out (these are called independent variables (IVs)) being studied to determine if there is a connection with the outcomes in between the cases (6 & Bellamy, 2012). It is considered to eliminate most of the IVs, leaving ideally only one standing IV, that will be then considered as the principal cause (6 & Bellamy, 2012). Part of COR this method is applied in 'most similar case' or cross-national research, most similar country design. It involves choosing few, carefully selected cases, where IVs are similar in most respects, being different in a way or few ways, that are important to the theory. This allows to focus on the relation between a dependent variable and few IVs that are particularly significant (6 & Bellamy, 2012).

Ragin has explained some limitations in the method of agreement. As a result of these limitations the *indirect method of difference* emerged as a more appropriate tool to be used involving the double use of the method of agreement (6 & Bellamy, 2012). Unlike the agreement method this method reveals negative cases identifying the absence of an outcome. The cases can also be subdivided allowing useful questions to be created regarding the motive why countries fall into specific categories for instance (6 & Bellamy, 2012). These categories can be arranged in a matrix of variables around present and absent outcomes typologies for example. Organizing cases and different groups or classes allows to identify interesting patterns between and among these cases (6 & Bellamy, 2012).

The *joint method of agreement and difference* explains, as the name suggests, the combination of both methods (6 & Bellamy, 2012). The method eliminates the limitations found in the use of the separate methods and unites them in a complementary approach (6 & Bellamy, 2012).

3.3 Methods used to collect data

Sampling

Depending on the number of cases used, case-oriented research (COR) allows different degrees of achievement of "inferential leverage on a hypothesized causal relationship" (6 & Bellamy, 2012). A type A design is used where a few cases, are carefully selected for showing what is already known about a larger population of cases, regarding similarities and a few potentially very important differences. From such research design we might be able to say that the hypothesis tends to be supported by the evidence found (6 & Bellamy, 2012). A type A design can be used by selecting few authorities with similar design and outcomes for EV diffusion. The differences can be controlled by choosing the authorities with similar political context and consumer perspective for instance, if after conducting literature review, we find out that these factors are important where similarity matters (6 & Bellamy, 2012).

There are situations when selecting cases only on the IV (in the present case examples of IV are infrastructure, subsidies, public procurement measures, consumer willingness to pay etc.) is not the best choice and is advisable to include also selecting on the depended variable (the demand for innovation) (6 & Bellamy, 2012). For falsifying a certain condition hypothesis, it is advisable to select cases that could lead to the same outcome. This way it is stated we can see if the supposed necessary condition was behaving similarly in all the cases. However, there are some cases where a hypothesis needs us to draw a sample from information of known outcomes. This is applied in the causal relations, where we find different kinds of causations that might be needed to investigate (6 & Bellamy, 2012) (for instance continuous subsidies for electric vehicles lead to an increasing confidence of both manufacturers and consumers to produce and buy more EVs).

According to 6 & Bellamy, 2012 there are four different types of causation where the samples are effectuated. Type 2 and 3 are identified as optimal directions for comparative studies, thus suitable in the present work. In type 2 it is described the term *equifinality*, meaning different forces can produce the same outcome (such as the use of subsidies, waivers, environmental policies etc in the UK and China used to help E-cars diffuse in India). Type 3 translates in detecting the same scheme that leads to multiple outcomes, named *divergent* causation (for instance the lack of infrastructure development for E-cars leads to lower consumer demand, manufacturing, stakeholders interest and engagement, decreased innovation, even political will at some degrees, affecting E-cars market development). The idea to draw multiple effects from the same cause has been called *mulitfinality* (6 & Bellamy, 2012). Type 1 is a linear construct were A leads to B, with the independent variable not changing its values and it is considered too simple. Type 4 uses different values both the dependent and independent variables making it too unclear to use, especially for small N cases (6 & Bellamy, 2012).

3.4 Materials collected

The research relies on a literature synthesis and data is being collected through empirical approaches such as literature review and online sources. The literature review is covering the background and core information on electric vehicles and policies complemented with various online sources such as websites and corporate reports published on the companies' websites. Grey literature is also used to investigate the cases context and specifics such as policy documents and government websites information.

The literature review involves activities such as identifying, understanding, and transmitting information. The literature review process is actualized by data collection from various websites, government documents, policies, e-news.

3.5 Analysis

The centre of the analysis directly answering the research question is structured around the main research framework that has been found suitable for this study, that is the TIS framework. The Environmental Evaluation Framework is used in a secondary base, including only certain elements and observations to frame the key reasons for chasing E-cars. The in-depth use of the Environmental Evaluation Framework is skipped due to the complexity it brings, would need to better be evaluated in depth in a different study that could offer such time and space for a thorough focus of the framework's elements. The frameworks, especially with the TIS in focus, are integrating data collected during the literature review and synthesis. The data is arranged and discussed for each of the TIS functions and then recommendations are suggested from each of the cases presented for comparability to the case being studied. The recommendations are targeting barriers that have been identified in the case study of India and support the new technology to diffuse.

The TIS was chosen as a main framework due to its complexity, offering a detailed structure to follow when arranging the data and bringing an approach that can easier align specific factors that can be analysed in specific movements, transformation, and circumstances. The framework confers an ideal environment to answer the research question posed and subsequent tasks thus by using the TIS in its complexity offers enough potential to give a reliable answer to the RQ, without the requirement of necessarily using other frameworks.

For setting the comparability degree between cases, the joint method of agreement and difference is applied. The method reveals if the comparability between cases can be set and why only specific measures can be accurate to present as functionality recommendations for India.

4 Findings and analysis

4.1 Findings

This section describes the findings of the study. Data such as facts, figures, opinions etc. collected during the research work is compiled. These items are presented in a structural fashion following the analytical framework logic, already introduced in section 2, where structural components and dynamics are presented, however without reflecting in depth or discussing them here. The data is arranged and presented in a clear segmented structure allowing an easier drawing of the data to clearly serve the research question and tasks.

4.1.1 E-car and E-bus in China

Political context

China is an authoritarian state governed by a single-party regime that maintains an extensive presence in economic governance. In other words, China is a centralized unitary state completely managed by the Chinese Communist Party with a national administration that is authoritative in its structure and ideology (Malesky, E., & London, J., 2014). The political actors include a ministerial bureaucracy; provincial and local officials; a growing body of officials and quasi-official policy research groups and think tanks that feed proposal directly into the policy process; a collection of state sector, multinational, and even private business interests that bring more pressure to bear on policy decisions; a vigorous academic and university community; a divers media that is increasingly vocal and better-informed citizenry who are demanding more transparency and accountability from government (Dumbaugh, K., 2010).

China is at the present the largest auto market and the fastest growing, with more than 23.6 million vehicles sold in 2016 (NBR, 2017). This followed because of the 1990s government decision to declare the automobile industry as an important reliant of the economy development and allowed citizens to buy private cars (Altenburg et al., 2012). By 2020 China projected to have around 300 million automobiles, going in front of the present U.S. fleet of 265 million (Perkowski, 2016; NBR, 2017). Such growth increases jobs and economic output and supports mobility for the Chinese population but also significantly contributes to the countries air pollution problems, that are found to be highly unmitigated (NBR, 2017). Several cities for instance in the north of Beijing, Tianjin and Hebei were covered with severe smog again on April 2017, and Beijing updated its air pollution alert to orange, the second highest level (Xinhua, 2017; NBR, 2017).

Recently China reaffirmed its commitment to the UN Paris Climate Agreement. Due to the high scale of overall demand and the ongoing need to promote sustainable development, the tremendous growth in the auto sector could affect China's desire to decrease its carbon dioxide emissions by 2030. The carbon emissions especially from vehicles are prognosed to rise with 80% by 2030, that means to around 1.3 billion tons of carbon dioxide emissions from an approximated level of 730 million tons found in 2014 (Zheng, 2015). Thus recent measures in China demonstrate the importance of transportation sector as an important element in the countries efforts to meet its carbon emissions goals (Zheng, Jie; Mehndiratta, Shomik; Guo, Jessica Y; Liu, Zhi 2012)

The present E-cars strategy for China is to make its indigenous market stronger and strive for the international competitiveness automobile market. In recent times, larger Chinese owned companies appeared holding generally a regional government support, that were striving to simplify production processes and make production cheaper posing this way a challenge for the joint ventures and other foreign automobile companies in the make (Altenburg et al., 2012). Even more many of the large companies are state owned and thus given a major priority. These industrial characteristics of China are market as well in the national electric vehicle initiatives. With this protectionism approach, with "competition under hierarchy" China has showed strengths such as reaching production targets faster than expected due to an acceleration in the industry triggered by policy and local initiatives. This was followed by reduced prices due to high competition and weaknesses such as technological leadership failure with policies unable to support big gains in innovation capacities of China's automobile industry. However, some technology issues exists and hence the need of relying on foreign technology (Altenburg et al., 2012).

Antimonopoly law in China and E-cars

The Chinese Anti-Monopoly Law was adopted in 2007 and is very much compatible with the Antitrust Law in the European Union (EU), the United States and other jurisdictions. Enforcement activity is similar to the one in the EU (Mariniello, 2013). The Chinese Antitrust Law has already three antitrust agencies (Foer, 2012). Nevertheless, the Chinese law favours the competition policy to sustain the industrial policy objectives (Mariniello, 2013). This policy contribution encloses information that reveals its use favouring domestic companies to foreign companies, however with no evidence found for such actions (Mariniello, 2013). Fines between 1 and 10 percent from the revenue of a company are included in the Antimonopoly Law if there are anti-competitive practices (Miller & Kubota, 2014). It is found that the law has been however used more towards foreign companies than local ones, but the officials deny this, claiming the law has been used both sides for protecting consumers (Miller & Kubota, 2014).

E-car policy in China

Ministry of Environment Protection and Ministry of Industry and Information Technology work to build policies that cut vehicles emission such as: vehicles emissions standards, a cap-and-trade system, and the overall promotion of E-cars (NBR, 2017). China's policies on E-cars have as a distinct characteristic their potential to reduce emissions and impact foreign manufacturers of E-cars. China is working on a plan to ban conventional car manufacturing and sales (NBR, 2017). The Chinese government has prioritized E-cars manufacturing (including plug-in hybrid electric vehicles, battery electric vehicles, and fuel-cell electric which are particularly important due to their potential to cut emissions considerably and impact foreign E-car manufacturers), using environmental and economic reasons and creating an innovation lead economy (NBR, 2017). There is a threat of that the E-car industry will keep foreign manufacturers away cutting them out from a critical market, mandating technology transfer that risk intellectual property or reducing the price of E-cars below competitive market (NBR, 2017).

There is no single policy addressing only electric mobility in China at the present, neither in other countries (Tagscherer, 2015). In recent years the strategy of the Chinese government was supported by three policy directions: support for R&D, support for the related industry, and support for private and public consumption (Bloomberg News, 2018). Most of the policies are industrial policies and are set by the highest levels in the government (Shukla et al., 2014). China's five key policy support tools for E-cars comprise advantages of reduced taxes, direct subsidies to manufacturers, consumer subsidies, mandate government procurement, and the industrial policy *Made in China 2025* (NBR, 2017). Thus, we have:

- In 2008 China's Ministry of Finance and the Taxation Services General Office declared that E-cars will benefit consumers from an *exemption of standard consumption tax that consumers pay on new automobiles* (NBR, 2017). In 2009, the report "Guidelines for Adjusting and Promoting the Automobile Industry" exposed a plan for a period of three years using a system of taxes and fees to build the E-car infrastructure (Tang, 2012).

- Second policy tool, *manufacturers subsidies for promoting EV* (E-car) *development*. China has invested many years billions of dollars in direct subsidies to manufacture as for instance: BYD received a subsidy totalling $435 million between 2010 and 2015, being the largest subsidised company in China for electric and hybrid vehicles (NBR, 2017). Even more, under the China's 2012 "Energy-Saving and New Energy Vehicle Industry Development Plan (2012–2020)" $15 billions were allocated for supporting the development of energy-efficient vehicles and E-cars, pilot car projects (create local experiments) and E-car infrastructure (Altenburg et al., 2012; U.S. Energy Information Administration, 2014). The draft defines the industry structure and by 2020 is aiming for the development of larger companies specialized in different components of the industry value chain such as vehicle parts, battery, raw materials also motor and automatic gearing production (Altenburg et al., 2012).

- In the third place, the government began a *consumer subsidy program* in 2010, that allocated 60,000 Chinese Yuan (approx. $8,700) and 50,000 Chinese Yuan (approx. $7,250) per battery E-cars and plug in hybrid cars, cutting with 40-60% the vehicle purchase price (Shukla et al., 2014; NBR, 2017). To qualify for the subsidy the car models must incorporate government approved E-car battery types (in the past this policy supported Chinese lithium-ion phosphate batteries over foreign "ternary" lithium-ion batteries (NBR, 2017). Local governments also launched their own subsidy program offering additional discounts for EVs purchase through cash subsidies, free parking and/or free license plates (Altenburg et al., 2012; NBR, 2017; Jieyi, 2018). For instance, in Shanghai, E-cars get cash subsidies, and the license plate fee is waived that can be actioned at around $14,000 (around 100,000 Chinese Yuan) being a large incentive (NBR, 2017). Beijing initiated a program in 2014 through which the government offers incentives that are equal to those of the central government, discounting the cost of the vehicle up to 60% of its cost (NBR, 2017).

- The fourth government action policy for E-cars is to *increase demand through government procurement arrangements* that mandate governments to include a specific proportion of E-cars. In 2014 the government urged a minimum of 30% of its vehicle purchase to be E-cars by 2016. The figure was increased to 50% in 2016 (NBR, 2017). This encouraged E-car production that was supported by subsidies to manufacturers.

- The last driver policy for E-cars is the MIC2025 (made in China) industrial policy, that supports the indigenous technology. MIC2025 was adopted in 2015 to support the development of ten key local strategic industries, accounting also for energy saving and E-cars. The policy is rooted in the China's "indigenous innovation" policy that first emerged in the State Council's 2006 "National Medium- and Long-Term Science and Technology Development Plan," which included electric vehicle development as a pillar of domestic technological innovation (NBR, 2017).

An older but important policy in the development of the automotive industry in China is the "Auto Industry Restructuring and Revitalization Plan" introduced in March 2009 (Tagscherer, 2012). Besides the self-explanatory function, the policy was also aimed at contributing to increasing the number of new energy technology vehicles with a target of 500,000 electric cars to be produced by 2012 (Tagscherer, 2012). The Automobile Industry Development Institute of China has mentioned that in the first nine months were realized 2482 and after technical updates and corporate development the number reached 100,000 cars thus a low number in contrast with what was targeted (Zhang et al., 2014). According to the Ministry of Industry and Information Technology, 10,000 E-cars were sold in 25 pilot cities by July 2011 (with a split of 10% bought by families and the rest as business cars for enterprise use and government).

It is important to mention that China has also found a technology condition to help the transition towards electric vehicles. The main support opportunity is provided by the potential of the market to produce battery technology, especially lithium-ion batteries found in the electronics industry, which is expected to substantially contribute to lowering costs as the industry scales up reaching mass production of batteries for EVs.

Consumer perspective

The purchase price of E-cars (plug in and battery electric cars) is the most important for consumers, and the purchase cost of an E-car compared with conventional vehicles is much higher (Jieyi, 2018). The high purchase price of an E-car is an important impediment for consumers to buy E-cars. In 2016, the cost of E-cars was found to be on an average $15,000 more than conventional vehicles. It is forecast that E-cars will not match the price of conventional vehicles until 2025 (Jieyi, 2018). Thus, financial subsidies are primordial as economic supporting policies, and are offered largely by national and local governments (Zheng et la., 2018). Some other barriers such as limited charging stations, low charging time, and a limited travel range disadvantage the attractiveness of E-cars (Jieyi, 2018).

According to Li et al. (2015) and Li et al. (2016) financial incentives had a positive effect in China for supporting manufacturing of battery E-cars and increasing consumer acceptance. However, the E-car industry in China is different from other countries such as the developed countries. In these countries, even if there is a strong government subsidy, with a low environmental preference consumers' willingness to pay for E-cars stays low (including passenger and commercial cars) compared to conventional vehicles (Zheng et al., 2018). Governments must take in consideration environmental aspects for achieving social welfare and profit of companies while minimizing environmental impacts. Thus, subsidies can be used accordingly to create the right setting for manufacturers to produce E-cars and achieve economic, environmental, and social benefits ('triple win for remanufacturing') (Zheng et al., 2018).

Despite the abundance of subsidies given by the Chinese government, that determined companies to invest in this sector many new entrants encountered various obstacles. The decision to start producing E-cars is difficult considering the present subsidy policy in China and due to the infant E-car market. The finance policy support is instable due to the government's changes. Also, large upfront investments are made in conventional vehicle production. It is well noted that profitability is the main purpose of manufacturers thus all of these bring difficulty for manufacturer to completely shift to E-cars (Zheng et al., 2018).

Incentives for E-cars in China

Measures that China is taking are intensively sustaining E-cars uptake. Such measures are financial tax credits and tax exemptions, affecting upfront costs of E-cars while supporting the adoption of the technology (Jieyi, 2018). In between 2014 and 2017 there were no purchase taxes for E-cars, and this was extended until 2020. Additionally, a consumer subsidy program was initiated by the central government. The subsidy is updated, decreasing the amount offered after every two or three years and increasing the eligibility threshold (Jieyi, 2018). In 2010 a subsidy of 9530 USD (60,000 Chinese Yuan) was offered for battery E-cars, amounting 40 to 60% of the E-cars cost. In 2012 the subsidy programme expired, and the government renewed it in six months. In 2013 subsides for E-cars were adjusted to 5200 USD (35,000 Chinese Yuan) to around 8800 USD (60,000 Chinese Yuan) based on the vehicle's driving range (Jieyi, 2018). The subsidies decreased by 5% in 2014 and by 10% in 2015 as from 2013. In 2016 the subsidy was changed to approx. 8200 USD (55,000 Chinese Yuan) for each E-car. In 2017 and 2018 it decreased by 20% as of 2016's values, and by 40% in 2019 and in 2020 based on 2016 values. The plan followed by China is to eliminate all subsidy dependence for E-cars by 2020 (Jieyi, 2018).

Table 6 Financial incentives for E-cars in China

China's financial incentives for E-cars
Between 2014-2017 purchase tax 0, extended until 2020
Consumer subsidy program (renewed every 2-3 years)
In 2010 - 60,000 Chinese Yuan (9000 USD) subsidy offered for each battery E-car

Subsidies covered 40-60% of E-car costs
In 2013 – 35,000 (around 5200 USD) to 60,000 (9000 USD) Chinese Yuan subsidy based on E-car driving range
In 2014 – 5% decrease as of 2013
In 2015 – 10% decrease as of 2013
In 2016 – subsidy program was renewed to 55,000 Chinese Yuan (8200 USD) / each battery E-car
In 2017 and 2018 – subsidy is decreasing by 20% as of 2016 values
In 2019 and 2020 – subsidy is decreasing by 40% as of 2016 values
In 2020 - China plans to phase out subsidy

Source: Author's own depiction. Data retrieved from Jieyi (2018)

See also the China's five key policy support tools for E-cars highlighted already above in the E-car Policy section for additional incentives measures.

In some provinces in China, E-cars are not restricted by traffic control measures (such as policies that restrict the number of cars on the road during a prescribed period) and are allowed to drive on bus lanes, and benefit from free parking (Jieyi, 2018). However, the main enablers of the car market (both E-cars and conventional vehicles) in China were to keep the costs of production and indirect taxation low (Chhibber & Dhawan, 2019). The VAT in China is now 13% (reduced in early 2019 from 16%), with 40% fuel taxes and lower real interest rates (2%) resulting in a vehicles ownership cost per capita income of 97% in China (Chhibber & Dhawan, 2019). China leapfrogged from 0.7 million car sales per year in 2000 to 23mn car sales in 2018 (Chhibber & Dhawan, 2019).

Charging stations for E-cars

The limited battery capacity and travel range are still a major obstacle for E-car market uptake. The infrastructure for E-cars needs expansion with new stations and ideas for improvements (Ji & Huang, 2018). Policy tools used for installing charging infrastructure include subsidies via tax credits, grants and low-cost loans-as well as mandates and standards (Hove & Sandalow, 2019). By 2014 31,000 distributed chargers and 780 centralized charging and battery swapping stations were deployed (Ji & Huang, 2018). As of 2017 China has in place 213,903 charging stations and sets a target for 12,000 additional charging stations and more than 4,800,000 new chargers, integrating slow/fast charging and private/public charging options (Ji & Huang, 2018) to be in place by 2020 accommodating a 5 million E-cars (Ji & Huang, 2018).

For this local governments could get around 14 million USD (90 million Chinese Yuan) for setting the charging station infrastructure after some conditions are met, such as having a certain number of E-car purchases (Jieyi, 2018). The Chinese provinces and cities expressed their willingness to support charging stations via subsidies. The biggest subsidy could arrive at a 30% from the total investment (Jieyi, 2018). According to the National Energy Administration (NEA) of China, a total number of public and private chargers is amounting 277,000 and 450,000 by the end of 2016 and 2017 (National Energy Administration of China, 2016; Ji & Huang, 2018).

Building an adequate charging infrastructure coupled with the right market diffusion of E-cars is a main supporter of E-car industry development. The central Government of China has released a series of policies to develop the national charging network, considered the largest deployment program in the world (Ji & Huang, 2018). For this China launched the Guideline for Accelerating the Plug-in Electric Vehicle Charging Infrastructure Deployment (Guidelines) in October 2015 for enabling an adequate charging network (Ji & Huang, 2018). This aim at reducing the range anxiety of plug in E-cars users, encourage potential plug in E-car adoption, and increase the electric miles driven by plug in E-cars (Ji & Huang, 2018).

Standardization of charging infrastructure

With the New Energy Vehicles policy China intends to build E-cars being an initiative part of the electric vehicle (E-car) standardization project (Voelker, 2018). To become a global leader in E-car manufacturing China plans to standardize E-car technology nationally. National E-car charging plug standards in China is comprised of both slow and fast charging (Hove & Sandalow, 2019).

China must deal with a problem currently in variations of standards from region to region, sometimes even city to city (Voelker, 2018). This is due to city and state governments that frequently owned stakes in car maker companies within their region. This encouraged them to use laws to support the local manufacturers thus encouraging a protectionist approach. For instance, the cars made in Shanghai could not use the charging stations in Shenzhen (Voelker, 2018). The government must support the creation of a standardized version of charging infrastructure for creating an environment conducive to sale of E-cars.

At national level the government formed state alliances allowing for the large enterprises to cooperate along the electric vehicle value chain and even get better access to financial support (Altenburg et al., 2012). Nevertheless, through these stationed alliances an additional purpose is to better realise future electric vehicle standards (Altenburg et al., 2012).

At the present China has one nationwide DC fast charging, known as China GB/T released in 2015 after several years of development (Hove & Sandalow, 2019). The standard is now mandatory for all new electric vehicles sold in the country. International automakers that sell in China such as Tesla, Nissan, and BMW, have also adopted the GB/T standard. Currently GB/T allows fast charging at a maximum of 237.5 kW of output (at 950 V and 250 amps), though many DC fast chargers offer 50 kW charging (Hove & Sandalow, 2019).

China has a great deal of E-car charging taking place at 220 volts. When charging at 220-240 volts, a typical 30kWh battery takes approximately 6 hours to go from 20% to nearly a full charge (Hove & Sandalow, 2019). China has growing networks of DC fast chargers, commonly using 24 kW, 50 kW, 100 kW or 120 kW of power. Some stations may offer 350kW or even 400 kW of power. These DC fast chargers can charge a battery power from 20% to a nearly full charge in times ranging from roughly one hour to as little as 10 minutes (Hove & Sandalow, 2019). A new GB/T is to be realised in 2019 or 2020, including charging up to 900 kW for larger commercial vehicles. GB/T is China's-only standard with few China-made E-cars exported abroad that use other standards (Hove & Sandalow, 2019).

In Augurs 2018, China Electric Council (CEC) revealed a memorandum of understanding with CHAdeMO network, based in Japan, to develop together ultra-fast charging. This goal is possible to achieve due to the compatibility between GB/T and CHAdeMO for fast charging. The two organizations partner to expand the standards in countries beyond China and Japan (Hove & Sandalow, 2019).

In January 2016 five new national standards for electric vehicles charging interfaces and communications protocols were adopted. The standards were released in late 2015 by the National Standards Committee, the Ministry of Industry and Information Technology and others (Hove & Sandalow, 2019).

In July 2016, NDRC published a Notice on Accelerating Residential E-car Charging Infrastructure Construction, where it sets standards and procedures for residential charging and chooses the Jing-Jin-Ji, Yangtze River Delta, and Pearl River Delta regions as demonstration zones for residential charging infrastructure development (Hove & Sandalow, 2019).

E-car and E-bus fleet procurement

Government procurement of E-cars has a major importance in China. Therefore, a 30% target was instituted for central government, some cities, and public organizations to have their car fleets electric by 2016 starting from 2014. In 2016 this goal was increased with 50% E-cars helping to create a critical mass in the marketplace (Jieyi, 2018).

Public fleets, especially bus fleets, could represent the first wave of electric vehicle adoption in China (McKinsey & Company, 2012). Because China is the largest producer of buses in the world has the capacity to reduce costs on large scale production orders of these vehicles. Due to their increased size buses can offer extra space for storing extra batteries and address current limitations of electric vehicle battery life (McKinsey & Company, 2012). Incentivizing and offering subsidies for public fleets demonstrated to give better results than stimulating the private purchase. A central government subsidy program for public transport has been in place since 2009 and helped to reach a 0.3 percent of new sales in the bus market in 2011. This was found to be ten times more than the market uptake in the passenger car segment (McKinsey & Company, 2012). The increase of E-bus fleets paves the way for broader consumer adoption in the future. Sales increase in the commercial market canalizes China for achieving mass manufacturing scale. This would influence the value chain to increase its capacity and improve capabilities (McKinsey & Company, 2012). These developments concomitantly will decrease costs, create better performance, and drive the development of charging infrastructure (McKinsey & Company, 2012).

In 2017 the Chinse market sold approximately 89,546 buses which had a decrease of 23% from 2016 mainly due to changes in E-bus subsidies. The E-bus market in China is primarily formed by BYD, the leading E-bus manufacturer and Yutong that is the largest bus manufacturer in the country (Clean Technica, 2018).

EVs (E-car, E-taxi, and E-bus) and BYD manufacturing transition in Shenzhen city

Shenzhen is situated in the coastal area in the southeast of China (Huang & Li, 2019). Shenzhen had a rapid urban development since its designation as a protected economic area in 1979. Shenzhen has a population of 12,52 million people in 2017. Shenzhen is a pioneer city in EV development and in 2009 was selected as one of the 13 national EV (including E-car and E-bus) demonstration cities, where most of them have a strong industrial automotive sector. This was a departing point for Shenzhen to adopt more proactive actions to facilitate EV implementation and becoming one of the most successful demonstration cities (Huang & Li, 2019). As of 2017, with respect to the share of EVs the city was on the second place among other 13 demonstration cities in China with a total ownership of 156,726 E-cars and "having the most E-buses, E-taxi and electric logistic vehicles among cities around the world" (Huang & Li, 2019).

Shenzhen has reconfigured its transportation system, especially the public transportation system (Huang & Li, 2019). All bus fleet of around 16,000 units in Shenzhen became all electric at the end of 2017 (Dmitry & Pontes, 2018) being the first city to electrify 100% of its public buses. Also, the E-taxi fleet is the largest in the world with 12,498 E-taxies at end of 2017 with plans to achieve an 100% electric taxi system by 2020 (Huang & Li, 2019). In support of the acceleration growth of EVs Shenzhen invested its efforts in rapidly building a charging infrastructure. By 2017, 173 charging stations and 36,550 charging piles for E-cars had been made available to the public (Huang & Li, 2019). Also, to fuel its electric buses 510 charging points equipped with 8000 charging poles have been built (Gray, 2018). EVs have also played an important part in the development of the Shenzhen's economy, Shenzhen being the centre of the largest EV manufacturer in China, Build Your Dreams (BYD). Starting from 2009 the annual growth rate of Shenzhen's EV industry went over 100% (Huang & Li, 2019).

In Shenzhen, generally three types of actors are part of the implementation of EVs: government, industry actors and end-users, being the principal stakeholders during the transition process (Huang & Li, 2019). Multilevel governments have strong incentives and capacities to shape urban energy transitions, through for example regulatory and economic policy instruments. The EV industry can provide energy security and promote industrial upgrading for the central government (Huang & Li, 2019). In China there are strong political motivations for local governments to follow national strategies. Most particularly the top-down implementation policy showed to have a key role in the implementation of new energy technologies, especially at urban level (Huang & Li, 2019).

Next to the political motivations, there are as well environmental and economic incentives to trigger EV development. The promotion of technologies as E-cars and E-buses can improve the urban environment but as well boost the urban economy by developing local enterprises such as BYD (Li et al., 2016). For this achievement consensus must be reached between different departments within the municipality. The main department responsible for EV implementation is the Shenzhen Development and Reform Commission (Shenzhen DRC) (Huang & Li, 2019). The Transport Commission of Shenzhen Municipality (TCSM), the department responsible for the management of urban public transportation, at the first was a bit sceptical about the large-scale application of E-buses and E-taxies in Shenzhen. This was due to its concern over the management cost increases and the potential financial burden for the public transport operators (Huang & Li, 2019). Even more, the charging infrastructure for EVs such as E-cars and E-buses, would complete the urban materiality, that needs the collaboration of departments such as the Urban Planning, Land and Resources Commission of Shenzhen Municipality (Shenzhen UPLRC) (Huang & Li, 2019).

The private sector has important transition capacities and enterprises actively get involved in urban transitions when strong economic incentives are provided. Looking at BYD development is inseparable from the favourable policies and public resources offered by multilevel governments (Huang & Li, 2019). With this support it is found that 90% of the E-buses were manufactured by BYD.

Subsidies for private owners in Shenzhen

Between many incentives, multilevel governments consider subsidies an effective instrument, that is important for opening a niche market for privately owned E-cars (Huang & Li, 2019). Shenzhen was one of the cities selected as one of the five pilot cities for the provision of subsidies for privately purchased E-cars (Huang & Li, 2019). The subsidy package was comprising both national and local subsidies where subsidies are directly offered to E-car enterprises, that are then able to cut in prices of the marketed product (Huang & Li, 2019). The purchase price has been reduced by the government with about 17,640 USD (120,000 RMB) for every vehicle. The price for a E-car produced by BYD, for instance was almost halved from about 24,961 USD (169,000 RMB) to about 13,201 USD (9,900 RMB), making the E-car more affordable for buyers (Huang & Li, 2019). Nevertheless, there are also some problems involved with this. The most highly contentious issue is subsidy fraud, which was quite prevalent happening not only in small enterprises but also in some large manufacturers. For this reason, in 2016 the central government launched a fraud investigation, during which five E-car enterprises, were exposed and fined (Huang & Li, 2019). About 0.25 billion USD (1.67 billion RMB) of subsidy has been lost in such fraudulent instances where E-cars illegally acquired them. This results in short term benefits and sacrificing long term development of the industry (Huang & Li, 2019).

Next to subsidies, Shenzhen municipal government has also limited ICE-cars ownership by license plate control ownership. From January 2015, the number of vehicle license plates issued each year has been diminished to 100,000 of which 20,000 are exclusively allocated to EVs (Huang & Li, 2019). With these measures, the growth rate of E-cars has increased from 50.36% in 2014 to 272.92% in 2015 (Huang & Li, 2019).

There are multiple governance efforts spotted that have been made for establishing a feed up market niche while deconstructing the incumbent regime of ICEs. This is done not only by the multilevel governments but also through coordination between local governments and other actors, especially industry actors (Huang & Li, 2019).

Charging infrastructure in Shenzhen

During the reconfiguration of the urban design to accommodate the implementation of EVs in Shenzhen there was a dynamic politics around it (Huang & Li, 2019). A key part of the elements required for EVs is charging infrastructure. Further implementation of EVs (E-car, E-taxi, E-bus) are hindered by the lack of an appropriate charging infrastructure, a barrier for scaling up the private market, plus the small EV market gives low incentives for manufacturers to invest in building a charging infrastructure (Huang & Li, 2019). The municipality took action to build charging points however the total land area that could be used for it was insufficient. Shenzhen has more than 70% a mountainous land and not developable. This diminishes the space available and makes it extremely difficult to allocate land for charging stations.

It is also found that the difficulty stands also at an institutional level. The land use for the construction of charging points is not included in urban land use planning and it is not easy to make amendments to land use plans that have been approved by national and provincial governments (Huang & Li, 2019). This challenge was specifically acute for the construction of bus charging stations, that need larger tracts of land and involve governments coordination. After pressures from the central government and various discussions, even if the agreement is reached between the departments in the municipal government, issues are encountered when facing social stakeholders. This was revealed during a project to construct a bus charging station in a residential neighbourhood, where it faced opposition by the residents that worried about safety potential issues (Huang & Li, 2019).

Moreover, due to EVs much higher prices than the conventional vehicles, radical adoption of EVs most specifically in the public transport, constitutes difficulties for urban management (Huang & Li, 2019). For helping these issues, various measures have been conceived. A business model used is the financial leasing separating vehicle and battery and combining charging and maintenance model. This was proposed by Li Neng Company and the municipal government. The Shenzhen Bus Group supports the same cost as for an internal combustion bus and then Li Neng pays the remaining part of the price and leases the bus to the Shenzhen Bus Group, keeping ownership of the battery and providing an 8-year warranty. Then the Shenzhen Bus Group is paying Li Neng the money they normally spend on oil as charging fees. Then Li Neng makes a profit from the price difference between electricity and oil (Huang & Li, 2019). This business model reduces the financial burden on the bus company and has been reported of high success in Shenzhen (Huang & Li, 2019).

4.1.2 EVs in the United Kingdom

The content of this section is primarily taken from *Arseni (2018), Project in Innovation and Management of Innovation*, unless otherwise mentioned.

Political context

The UK made a commitment to limit its GHG emissions under 16% by 2020 from its 2005 levels (Hübner et al. 2013) alongside with industrial development (Mazur et al., 2014). It is seen that electric vehicles help to achieve such targets for the UK, reducing massive GHG emissions due to transport being the largest emitting sector. This brings also large reductions in air pollution, the second cause of avoidable mortality in UK (House of Commons, 2018). This is also an industry that can bring significant export opportunities for the UK. E-cars are diagnosed to reach price equivalency with ICE-cars by mid 2020s and to surpass conventional vehicle sales by 2030 (House of Commons, 2018). Considering these the UK has plenty of reasons to push its E-cars industry and lead by achieving the shift from ICE-cars on roads while being a strong player in the international market (House of Commons, 2018).

The government in the UK has the ambitions to follow the recommendation of the Committee on Climate Change to have 100% of the cars electric at least by 2035 to meet its target for net zero greenhouse gas emission by 2050 and become the world leader in EV and battery technology for EVs (House of Commons, 2018; House of Common, 2020). In the recent years environmental issues have become more problematic and were pointed out on political agendas much more often than before. This is found in the Governments 25 Year Environmental Plan, issued in January 2018 and the Clean Air Strategy (Political Intelligence, 2018). In this context the UK political parties have thought of actions to set out policies for supporting the E-car uptake and its required infrastructure development (Political Intelligence, 2018).

The United Kingdom has a 1.98 trillion euros GDP being the third largest economy in Europe and the third largest electric vehicle buyer in Europe (This is Money, 2016; Tietge, 2016). Its own industry contributes with a 5th of the GDP which includes car manufacturers such as Vauxhall, Mini, Land Rover, and smaller companies. Additionally, the UK holds assembly plants of Nissan, Honda, Toyota, and Ford, among other foreign vehicles manufacturers (Tietge, 2016). Due to its import dependency on fossil fuels, the UK government has announced that electrification of road transport is a key measure to reduce dependence on fossil fuel imports, lower CO_2 emissions and mitigate climate change (Tietge, 2016).

Competition Act in the United Kingdom

Not complying with the UK or EU competition law will have serious potential consequences. Companies that engage in anti-competitive activities run the risk to louse their agreements and receive fines of up to 10% of the group's global turnover (Out-law, 2005). Additionally, directors might be disqualified or even receive criminal sanctions when serious violation of the competition law has been made (Out-law, 2005). As of this any business must be aware of the competition law, to meet its obligations but also to request its own rights and protect its position in the market (Out-law, 2005).

In the UK two sets of competition rules are applied at the same time. The Competition Act 1998, chapters I and II and the Enterprise act 2002 forbid anti-competitive actions influencing trade in the UK (Out-law, 2005). Anti-competitive behaviour comprising the outside of the UK with the EU countries it is prohibited by Article 191 and 102 of the European Union Trade on the Functioning (TFEU) (Out-law, 2005). The most important activities prohibited in the EU and UK are anti-competitive agreements (found in Chapter I/ Article 101 prohibitions) and taking advantage of a strong market position (found under the Chapter II/ article 102 prohibitions (Out-law, 2005). EU and UK competition law act similarly not allowing agreements, arrangements and concerted business practices that aim or achieve to restrict, distort, or prevent competition with an effect on trade in the UK and EU (Out-law, 2005).

An agreement might not fit precisely within a block exemption and can be still not automatically unlawful or unenforceable. In the competition law it is also stipulated that an agreement can pe exempted if the benefits are higher than the impose restrictions (Out-law, 2005). For example, vehicle manufacturers can pool together to act jointly to meet EU emissions targets. With this allowance vehicle manufacturers can sell CO_2 credits to the other manufacturers in the pool (Bird & Bird LLP, 2018). This is done by respective the competition law and limiting the information shared to average specific emissions of CO_2, certain targets of emissions and the sum of vehicles registered (Bird & Bird LLP, 2018).

E-car policy in UK

The United Kingdom is the second largest car market in Europe with a 2.5 million car registrations in 2014 and with one fifth of new cars registered in the EU (Tietge, 2016). Emissions from the new car fleet in UK account for 125 CO_2/km on average, a number slightly above the EU average of 123g CO_2/km. E-cars represent only 0.6% of the new passenger car market with the companies Mitsubishi Outlander and Nissan Leaf the most present models on the market accounting a total of 60% of new E-cars registrations in 2014 (Tietge, 2016). A study has highlighted the fast adoption character of the current policies in the UK to decrease GHG emissions for the production and diffusion of low emission vehicles while keeping the indigenous manufacturing and its competitiveness (Shukla et al., 2014).

The Business, Energy, and Industrial Strategy Committee's report 'Electric vehicles: driving the transition' published on 19 October 2018 was well received by the Government, that is supporting the Committee's viewpoint of electric vehicles being a technology with the potential to reduce GHGs, air pollution and bringing an economic potential for the country (Parliament, 2019). However, industry and consumers are to be involved concomitantly, for a large shift to take place at a minimum low cost (Parliament, 2019). (Paragraph partially retrieved from Arseni (2018))

The industry strategy of the UK was release in November 2017, targeting a green, productive economy in the UK. The Plan for Tackling Roadside Nitrogen Dioxide Concentrations was released in July 2017 and the Clean Growth Strategy in October 2017. These are working together to minimize sir exposure, reduce GHGs and improve energy security (Parliament, 2019). (Paragraph partially retrieved from Arseni (2018))

The Road to Zero Strategy from July 2018, was built on these previous actions, bringing new measures for greener road transport together with manufacturing of clean vehicles (Parliament, 2019). (Paragraph partially retrieved from Arseni (2018))

Working in partnerships, the government collaborates with industry, local governments, and consumers to realize all the above. The government is working together with the international community to accelerate the change to cleaner transport and is playing an active leadership role (Parliament, 2019). UK gathered governments and industry representatives from all over the world to share and discuss the global development of E-car market. This was done at the Prime Minister's Zero Emission Summit in September 2018 when the Birmingham Declaration was signed (Parliament, 2019).

Furthermore, the UK government has voiced a pledge to end the sale of internal combustion engine vehicles by 2040 (van Dorn, 2017). This aims to contribute at reducing emissions and reducing global climate change. Next to the pledge voicing to cut petrol and diesel cars and trucks, the plan also makes available £255 million (£40 million available immediately) for local governments to support feasibility studies and build local plans for tackling pollution (van Dorn, 2017). This goes next to the £100 million in funding that was previously declared for the retrofit and purchase of new low emission buses (van Dorn, 2017).

Consumer perspective

E-cars represent less than one per cent of all cars registered in the country despite a 55% increase every year in consumers choices. Experts predict that E-cars are going to set price par with petrol and diesel cars around 2024 (Express, 2019). Consumers see costs essential and thus one of the main reasons why motorists have yet to make the switch and range is another one. Range anxiety is an important concern of consumers due to doubting an E-car would suit their longer km drive needs (Express, 2019).

Studies suggest that consumers would start considering E-cars as a second car choice if they had a range of 100 miles, and as main cars if they had a range of 150 miles. As well consumers were found to be willing to pay a modest premium over the cost of conventional vehicles with a 3-year run cost equivalency (Skippon, 2011).

Incentives

The upfront cost of purchasing an E-car remains very high compared with ICE-cars (House of Commons, 2018). Fiscal incentives are significantly used in the UK being the most important driver for E-car uptake. However, in the UK, the fiscal incentive has a less clear share in the EV market, indicating that other factors must be also considered (Tietge, 2016). Significant additional deterrents to E-cars include 'range anxiety' (not sufficient charge stations for an E-car to complete a given journey) and the limited choice of vehicle models (House of Commons, 2018). In the UK the evidence shows that well-coordinated actions of financial and non-financial incentives may be the most effective means for increasing E-cars uptake (Lyndhurst, 2015). Fiscal incentives alone are not enough to maximize market uptake of E-cars.

There are three financial incentives in the UK that provide direct financial incentives for E-cars. They include the: Plug-in Car Grant, CO_2 -based annual ownership taxes, and reduced taxes on the private use of company cars with low CO_2 emissions (Tietge, 2016).

The Plug-in-Car Grant subsidy was introduced in 2011 and covered 25% of the eligible cars with a value of 5,000 pounds (approx. 6,200 euros) for the purchase of the vehicle (Tietge, 2016). This incentive got higher reaching 35% of the vehicle's value. However, the incentive was still capped at 5,000 pounds, setting an advantage for lower price E-cars (Tietge, 2016). E-cars are included as eligible cars with a CO_2 emission limit set at 75 g/km or lower.

The Plug-in-Van Grant is a subsidy for light commercial vehicles with a 20% cover of the price up to 8000 pounds (approx. 9920 euros). In 2015, 27 car and nine van models were eligible for the grants. The Plug in Car Grant had initially to cover 50,000 grants or a time frame up to 2017. However, the scheme was extended after the 50,000-grant threshold was reached in 2015. The policy was extended to 2018 and the grant level was reduced to 4500 pounds (approx. 5200 euro) for category 1 vehicles, for category 2 and 3 vehicles the subsidy was 2500 pounds (approx. 2900 euro). It is said that 200 million pounds (approx. 232 million) were secured for the Plug-in Car Grant for the period 2015 to 2020 (Tietge, 2016, Office for Low Emission Vehicles, 2015c).

However, the Government has announced sudden and substantial cuts to the Plug-in Grant Scheme, going contrary of the advice given by the Committee on Climate Change and witnesses to the Parliament's House of Commons inquiry (House of Commons, 2018). Purchase support needs to be continued until E-cars reach same price with ICE-cars (House of Commons, 2018). Moreover, the existent grants are found to be accessible only to wealthier motorists. It is recommended that the government should explore more and better options to ensure that all motorists can afford getting access and buying E-cars, for instance through car clubs and the second-hand market (House of Commons, 2018).

Other incentives are related to CO_2 vehicle taxes. There is an annual ownership tax on private cars of 600 euros, but cars with CO_2 emissions of up to 100 g/km are exempt from these annual taxes (Tietge, 2016). There is a higher ownership tax applied in the first year after the first registration; and this tax as well is reduced for low-carbon vehicles. The taxes for the private use of company cars are as well determined based on the vehicle's CO2 emission value (Tietge, 2016). In 2015, the taxable income derived from the private use of company cars ranged from 5% of the car's list price for vehicles with CO_2 value below 50 g/km to 37% for high-emitting cars (Tietge, 2016).

The vehicle price and VAT are generally the most important cost components for both E-cars and conventional vehicles and the tax for owning a vehicle is comparatively low (Tietge, 2016). Regarding fiscal incentives, the Plug-in Car Grant is the most important incentive for private cars and in some cases such as battery E-cars, reduces the total cost of E-cars purchase bellow the cost of conventional cars (Tietge, 2016). The reduced company car tax can as well offer an important car incentive for the purchasing consumer of E-cars (Tietge, 2016).

Whatsoever, the fiscal scheme used for E-cars presents some flows to reach the targets set, therefore it is suggested to amend fiscal changes better aligned with the zero emissions targets (House of Commons, 2018). E-cars need to be promoted by preferential Vehicle Excise Duty rates and other incentives, and preferential rates on company car tax for E-cars that is primordial to be brought forward fastest (House of Commons, 2018).

Charging infrastructure for E-cars

Availability of charging infrastructure helps to maximize consumers trust in E-cars and decrease range anxiety (Tietge et al., 2016). It is calculated that for 1000 cars registered in Great Britain it corresponds a 0.31 charging points that are available (Tietge et al., 2016). The Electric Vehicle Home Charge Scheme is offering the subsidies support for the private chargers in the UK. The subsidy covers a maximum of 75% or 700 pounds (approx. 873 euros) of the total installation cost, a subsidy for which E-car owners can apply for (Tietge et al., 2016; Office for Low Emission Vehicles, 2014a). To show eligibility they need to show proof of being the registered owner or primary user of an eligible E-car. This grant was set until the end of 2016, until the scheme budget was exhausted (Tietge et al., 2016). The Plugged-in Places program came as a complement for the subsidy of home chargers offering funds for public and semi-public charging infrastructure set until 2013. Private investment and public funds were matched under this program. The program focused on eight regions of the UK from which three of them, Northeast England, London, and Scotland, have a distinctly higher density of charging points compared with the rest of the UK (Tietge et al., 2016). About 5,500 charging points were installed through the Plugged-in Places program, 65% of them being publicly accessible (Office for Low Emission Vehicles, 2013a, 2013b).

The charging infrastructure is seen to lack behind in terms of size and coverage, with large difference of charging stations offered across the country. This is one of the most important impediments for E-cars to develop (House of Commons, 2018). There are system flows identified where the national governments meet the local ones and to whom to leave the decision authority (House of Commons, 2018). The overarching system view is required to spot flows and make solutions for improve functionalities while keeping a low cost. This could set the right dispatch of charging stations in whole of the UK (House of Commons, 2018). The Government was required to take adequate actions at a least cost to deploy the charging stations at a low cost by December 2019 (House of Commons, 2018). (Paragraph not part of *Arseni (2018))*

Moreover, the government is advised to review the financial and technical support it provides to local authorities for developing a charging infrastructure. A recommendation is given to support with adequate strategies the local authorities that were not able to access corresponding funds for introducing E-cars so far by 2021. The Government must work close with all needed stakeholders to create and identify proper solutions for the charging infrastructure aimed at motorists without street parking slots. A flexibility introduction of funding is suggested to allow local authorities to install charging infrastructure appropriate for the local priorities (House of Commons, 2018).

Nevertheless, the subsidies provided by the government for the purchase of E-cars and home chargers will end at some point. It is found unclear if consumers will be willing to pay the full price of a home charger in the future (PwC, 2018). In this circumstances automotive OEMs could have a role to intervene and consider moving down the value chain to make sure their E-cars are sold by providing their own installation services and/or discounting the cost of the hardware (PwC, 2018).

Standardization of charging infrastructure

The government needs to make full use of powers introduced in the Automated and Electric Vehicles Act 2018 to support regulations to provide an extensive, reliable, and standardized public charging network (House of Commons, 2018). Actors present in the energy sector and charging technology expressed concerns regarding standards and data sharing in the charging infrastructure. (Part retrieved from Arseni (2018)) Because standards were missing resulted in a poor interoperability. This is presented as varied physical charging connections, network memberships and payment methods restricting UK motorists to access the entire charging network easily (House of Commons, 2018). (Paragraph partially retrieved from Arseni (2018))

A need for information sharing to motorists is required and requested by the Innovate UK and Zero Carbon Future, to include adequate location, capacity, pricing, and availability of charging stations. Next to this a need for a common recognizable design for charging points is important for motorists to easily recognize them.

The Automated and Electric Vehicle Bill, that was passed in Parliament, includes solutions for E-car charging points, supporting the government to create a better experience of using charging points, place charging stations at key locations (motorway services and large fuel retailers), encourage smart capabilities usage and create the essentials for charge point data (e.g., energy consumption and geographical location) transmission to users' persons (e.g. National Grid or the DNOs). These provisions were specified as the main concerns about charging infrastructure that were welcomed by the industry witnesses (House of Commons, 2018).

The E-car charging can happen at various speeds depending on the vehicle type, the usage frequency of the location and type of charge point. In the table below it can be seen the charging types, their location and indicative charging time (HM Government, 2019).

Table 7 E-car Charging standards in the UK

Charge Point Power	Current	Connector	Typical Location	Example of charging time
3.6kW	AC	Type 1/Type 2	Homes, on street locations, destinations	c. 11 hours
7kW	AC	Type 1/Type 2	Homes, on street locations, destinations	c. 5 - 7 hours
22kW	AC	Type 1/Type 2	Destinations	c. 2 hours
50kW	DC	CCS/CHAdeMO	Motorway Service Areas / destinations	<1 hour
150kW+	DC	CCS/CHAdeMO	Motorway Service Areas / destinations	<30 minutes

Source: Table retrieved from HM Government (2019)

The charging type in UK is presently alternative current (AC), supplied to the vehicles that transforms it in direct current (DC) for charging the battery. The current is DC when it is transformed already in the charging machine before being alimented to the vehicle (HM Government, 2019). Standards of the connectors can be different according to the vehicle and to the type of power they use AC or DC. DC are represented by CHAdeMO and CCS connectors, and the Type 2 and Type 1 chargers are AC. European vehicles have a CCS connection for instance (e.g., Volvo, VW, Audi) and Asian kinds use CHAdeMO (e.g., Nissan, Mitsubishi). (Paragraph not part of the *Arseni (2018))*

Industrial automotive activities

The automotive sector is one of the major contributors in the UK economy. For this reason, the industry is advised to move at the same time and even faster for the transition to E-cars that is already happening globally, if the UK plans to retain its share in the global market (House of Commons, 2018). For this to happen the government needs to create an attractive investment environment to encourage manufacturers to locate new E-car facilities in the UK, and most importantly to repurpose existing ICE-car production lines for E-cars rather than retiring them (House of Commons, 2018). Longer term year 10-year support with a strategical focus on high-value niche areas where there is already a comparative advantage has been seen as the best approach for taking a leading edge in battery supply chains (House of Commons, 2018).

The case of Sunderland city and Nissan manufacturer

Sunderland is in East England region and was selected due to its high density of charging infrastructure for E-cars which can enable a good comparability and provide good examples that Maharashtra state and Mumbai city could learn from.

Nissan LEAF and Lithium-ion batteries are made by Nissan located in the Northeast England, being leader in the UK (Hübner, 2013). Sunderland has earned a reputation of the best place in the UK where you find E-car charging stations. For each 1460 license holders, in Sunderland were built charging stations since 2010 (Hübner, 2013; Make it Sunderland, 2019). It also become an important centre for vehicle and battery R&D, manufacturing, and training, in the electric car supply chain (Hübner, 2013). (Paragraph not part of Arseni (2018))

The Plugged in Places (PIP) government funded program was used to set the charging stations in Sunderland. This was operated by the Office for Low Emission Vehicles (PLEV) that allocated funds to eight areas, for such charging points installation (Hübner, 2013). The program collects feedback of these charging points to improve future policy decisions at all levels in the UK (Hübner, 2013). These include standards development, technology improvement and local incentives. It also comprises analysing user's behaviour and understand its impact on infrastructure (Hübner, 2013). (Paragraph not part of Arseni (2018))

The Northeast England's Plugged in Places project named Charge Your Car, help to construct E-car charging points on an area of 8600 km2. This made it easier for E-car user to travel across neighbouring regions in the UK and Europe (Hübner, 2013). 1163 charging stations were installed by June 2013, in areas such as public places, workplaces and homes of E-car owners in the region (Hübner, 2013). The Charge Your Car had chargers ranging from 3.7 to 22 kW AC. These charger types were firstly installed in the northeast with a network of 50 kW DC quick charger points allowing E-cars to charge to 80% in 30 mins. 12 of the fast chargers were planted at key points with the help of PIP project (Hübner, 2013). (Paragraph not part of Arseni (2018))

1 from 8 zero emissions cars that are acquired in Europe originate from Nissan in Sunderland (GOV UK, 2018). Nissan in Sunderland has one of the fastest selling electric vehicles in Europe (the Nissan Leaf). In 2016, a fifth from all the electric vehicles sold in Europe were produced at the Nissan plant in Sunderland (Kumar & Bente, 2018). Nissan have invested in production of the next generation of the Nissan LEAF at Sunderland, which also makes E-car batteries for the LEAF and eNV200 electric van. Nissan has invested more than £400m in electric vehicles and lithium-ion battery production at Sunderland (Kumar & Bente, 2018).

The European Investment Bank has come to an agreement to support the production of Nissan's first electric car to be built in Europe and the companies' first production of electric vehicle batteries in Europe. An agreement of 220 m funding from the long-term lending institution was signed (European Investment Bank, 2011). Nissan LEAF is the first affordable, mass market pure electric car in the world.

A manufacture production point for lithium-ion electric cars was also financed from this fund. The total investment is accounted at £420m investment by Nissan, promising to create 2250 jobs at Nissan and across the UK supply chain. The investment is also supported by the UK Government with a £20.7m Grant for Business Investment (European Investment Bank, 2011). Nissan Senior Vice President for Manufacturing Trevor Mann said: "The Nissan LEAF has already made history as the world's first affordable, mass-market, pure E-car and we are all very excited about battery and LEAF production beginning at Sunderland for our European market" (European Investment Bank, 2011).

Charging infrastructure in Sunderland

Next to this a comprehensive charging network was developed in Sunderland, with quick chargers (approx. 30 minutes) (European Investment Bank, 2011). In September 2013, Sunderland Echo was publishing an article stating that public charging points are sitting empty with some being used just few times. This was a call for reducing the purchase price of E-cars: "Cost is the key. While electric cars like the Leaf remain highly priced, they will not be able to compete against an already excellent product in the petrol and diesel vehicle" (Sunderland Echo, 2013). This determined Nissan to change the pricing model, with leased battery sold cars. This was translated in a reduction in price of £15,990 – £6000 less than previously (Sunderland Echo, 2013). However, Mr. Rhys said that the reduction will still not be enough: "Even with all the subsidies, most people are not going to buy them while they can buy a petrol or diesel car cheaper." Further it is expected that the number of E-cars will grow especially with the employees of Nissan changing to E-cars acquired from Nissan (Sunderland Echo, 2013). At two council managed facilities that are business and workplace locations had four charging points installed (Sunderland Echo, 2013). These were realized under the government grant fund developing the Northeast region as the "most E-car connected charging region in UK" (Sunderland Echo, 2013). As a leading region the Northeast had around 10% of the E-cars on the roads in the UK in 2018 (Chronicle Live, 2018).

A £4 million scheme for charging stations for electric cars was announced for the Northeast UK region comprising also Sunderland. The city canters are seen easy access locations that will allow E-cars to charge faster than at home (Chronicle Live, 2018). This so called 'filling station' is no different from the others, just that is only for electric vehicles use. It is notable stated that "more plug-in points mean more confidence for drivers to adopt cleaner and greener vehicles" (Chronicle Live, 2018). With the Road to Zero strategy providing the useful guidance to reach the 2040 goal of having all new cars purchased with ultra-low emissions, this new 'filling point' will provide additional answers on what infrastructure is required by current users and potential future users (Chronicle Live, 2018). The scheme has been funded from the European Regional Development Fund, the UK Collaboratorium for Research in Infrastructure and Cities project and Department for Transport Office for Low Emission Vehicles.

4.1.3 EVs in India

Political context

The political economy of India has rapidly changed after the liberalization of its economy in 1990. Presently it has a market-based system and is the world's second fastest growing economy after China (Kotwal et al., 2011). India is recognized to be the biggest democracy on the globe. Liberalization has affected regions changing the direct involvement of the government in the economic management of the states (Shaw, 1999). States are free to pursue their own economic goals, while showing competing behaviour between others (Shaw, 1999).

The Indian automobile industry is currently the fourth largest in the world with increasing sales. The automobile industry is expected to reach $250-$280 billion by 2026 with a high potential of growth (IBEF, 2019). However, the sector is in a very early stage of development with non-motorized and public transportation accounting for most of the trips (66% in 2007) (Agrawal, 2018). Growth of the automobile sector is present for a long time however the ownership of automobile per capita has stayed low with only 22 per 1000 people owning a vehicle, compared with for example China having 164 motor vehicles per 1000 people and 850 per 1000 individuals owning a vehicle in UK (Abbas, 2018). This brings opportunities as well challenges for India plus the carbon emissions and energy security stresses. Studies show the effect of EVs on power utilities is positive and it improves energy security (Chao & Berkley, 2017). As stated by WHO India has one of the most polluted cities in the world and Delhi, the capital, was found to be the most polluted city in the world in 2014 due to the use of fossil fuels vehicles. In India consumers have roughly 10 electric/hybrid car variants to choose from, compared to over 100 in China (Rachana & Prasanna, 2018).

India has been lagging in electrifying its automobiles sector, with no clear policy guidance, as for instance with comparison to China that offered good programs of subsidies and incentives for promoting electric cars while reducing its foreign oil dependency (Agrawal, 2018). Making a comparison during a car's life, the ICE-cars release more GHGs emissions than battery E-cars and hybrid plug in E-cars. The impact generated changes according to the size of the OCE vehicle (EV Outlook, 2019).

The Indian minister in charge of energy and power voiced its support for electric vehicles in an ambitious target desiring that by 2030 to phase out selling of petrol and diesel cars in the country (Wald, 2017). Many governments in the world call for transitioning to a non-fossil fuel economy however neither has adopted such an ambitious target to be reached by transportation so early (Wald, 2017). There is an underlying assumption under this that hints at an economic protectionism posturing. Next to the assumption of a need to keep air pollution in control, the Indian government aims at minimizing its petroleum dependency and the cost implied by vehicles (Wald, 2017). India does not have major petroleum reserves but is a country rich in natural resources such as metals and coal (Wald, 2017). Thus, for sufficing its petroleum needs India must rely on foreign countries and businesses (Wald, 2017). Even more, India has an interest in expanding its natural gas industry, even higher after the 2016 gas discovery in the Bay of Bengal (Wald, 2017). Thereby, the unrealistic target set is not due to environmentalism concerns but to protectionism reasons due to India's culture and history (Wald, 2017). To operate in India, foreign companies need to enter partnerships with local companies, with foreign firms for decades not being allowed to own more than 49% stake (Wald, 2017).

Antitrust law

Antitrust India's law, The Competition Act 2002 adopted in 2009, replaced the Monopolistic and Restrictive Trade Act of 1969 (Singh, 2018). The role of the Competition Act is to ensure that economics activities monopolizing competition in the market are slowed down, to leave place for smaller companies to develop, respect freedom of trade and protect consumers. Even more, it makes sure that regulations for acquisitions, mergers and combinations are properly made (Singh, 2018).

In India, a dominant position of a company is not forbidden however the company is not allowed to use its power and manipulate, exclude, exploit its competitors or consumers to gain an advantage (Singh, 2018). And here comes the role of the Competition Act, ensuring that such enterprises do not profit from their dominant position in an unappropriated way such as controlling the supply, changing purchase prices, or restrict other companies market access (Singh, 2018). There is a certain monetary value that need not to be exceeded by turnover and assets, otherwise the company falls under the Competition Commission of India jurisdiction (Singh, 2018).

EV Policy in India

A new policy was discussed in May 2017 with the National Council of Applied Economic Research, for turning electric all new cars in India by 2030. This was proposed to be done mainly by using subsidies for purchasers (Jadhav & Shah, 2019). This proposal was opposed by car manufacturers and auto parts companies implying that "the change is too ambitious and sudden" (Jadhav & Shah, 2019). This moved the target back to 30% (Jadhav & Shah, 2019). India is working to release a new policy that will offer incentives for investing in electric car manufacturing, also for batteries and smart charging, instead of just advantaging sales (Jadhav & Shah, 2019). It is aimed that E-cars will be moved for the use of public, currently having only E-3wheelers autorickshaws available for public use (Jadhav & Shah, 2019).

The policy and incentives are planned to be in place for a longer time for making E-cars more attractive and affordable than giving subsidies to individual customers (Jadhav & Shah, 2019).

Some car manufacturers are making tests to determine if to start selling such electric cars in the country, even by 2020 by some producers (Jadhav & Shah, 2019).

The Electric Vehicles Initiative (EVI) is a forum comprising multiple governments that work at advancing EVs (electric passenger cars, light commercial vans, E-buses and E-trucks, including battery-E-cars, PHEVs, and fuel cell vehicle types) deployment. The EVI forum was instituted in 2009 with the aim of helping EVs to diffuse faster worldwide and facilitate the exchange of information between policy makers and related stakeholders (Tata Power, 2019). India is part of EVI next to other countries such as Canada, China, Finland, France, Germany, Japan, Mexico, the Netherlands, Norway, Sweden, the UK and the US. Countries leading this are Canada and China while the International Energy Agency (IEA) coordinates the EVI (Tata Power, 2019). Part of EVI a campaign for EVs was started in 2017, encouraging all EVI members to have 30% of all vehicle's sales electric (GNCTD, 2018).

Moreover, in October 2015 India released the Intended nationally determined contributions (INDCs, NDCs), stipulating to cut emissions intensity of about 33-35% from GDP in between 2005 to 2030 (Singh & Kamal, 2015).

In 2013 India launched the National Electric Mobility Mission Plan (NEMMP) 2020, under which the scheme for Faster Adoption and Manufacturing of Electric Vehicles (FAME) in India was launched in March 2015, with two years as Phase-I, which extended until the end of March 2019 (GNCTD,2018; GoI, 2015). The Phase I of the scheme is considered 'a sort of a pilot project' for testing and seeing the consumer reaction to electric vehicles (National Automotive Board, 2019). Thus, it is applicable in certain areas notified separately covering: Cities under "smart Cities" initiative; Major metro agglomerations – Delhi NCR, Greater Mumbai, Kolkata, Chennai, Bengaluru, Hyderabad, Ahmedabad; All State Capitals and other Urban Agglomerations/Cities with 1 Million + population (as per 2011 census); Cities of the North Eastern States (National Automotive Board, 2019). If this is successful in the next phase will be applicable throughout the country. Phase II of the scheme was approved for starting on 1st of April with a total of approx. 1 billion and 400 million USD (10,000 crore) outlay comprising a share for 55,000 E-4wheelers. The scheme addresses public transport, including shared transport and proposes to establish charging infrastructure with 2,700 charging stations set ups (IANS, 2019; PIB, 2019). Moreover, several states announced an EV policy to complement the national policy with actions that address specific state needs (GNCTD, 2018). Despite these measures, EV penetration stays currently low in India, with 0.1% for E-cars. Underlying issues are identified in high upfront costs, low number of public charging stations, lack of products in comparison with ICEs and low level of investments in EV manufacturing capacity (GNCTD,2018).

Energy Efficiency Services Limited (EESL) is responsible for implementing the National Electric Mobility Programme (NEMP), that creates the proper environment for demand to increase for electric vehicles in India, using public procurement. For this EESL makes use of a business model involving "bulk procurement", helping its demand to aggregate. This was done in 2017 when 10,000 E-cars were procured, followed by another procurement of 10,000 in March 2018 conducted under FAME (Power Technology, 2018). These cars have the role to replace old vehicles in the future that were in use by the government and his agencies, amounting around 500,000 vehicles. EESL also make sure to select a service provider agency for managing the fleet in all its stages, end to end (Power Technology, 2018). EESL next to demand aggregation, has also to handle the selected agencies collaboration and coordination, dealing with monitoring and supervision, payments, and complaints (Power Technology, 2018).

The present government fleet is comprised of Mahindra E-Verito and Tata Tigor E-car, that delivered their pack of E-cars part of EESL's program of procuring 10,000 E-cars in 2017

(Power Technology, 2018). Other manufacturers working to electrify their automobiles are Hyundai, promising a debut in 2019, Maruti Suzuki announcing its first E-car in India by 2020 (Power Technology, 2018). In India there are 10 electric/hybrid types of cars while in the US are 54 and in China 100 (Agrawal, 2018).

Even though plans as shown before are strongly inclined to support E-cars, India has some inconsistencies among its visions and set targets are not realizing as promised. This could imply a weak coordination when moving forward to E-car deployment (Power Technology, 2018) (see table below for a yearly overview of the E-car situation). Regarding this, an Indian think tank changed its target from 100% E-car sales to 30% after one year of releasing this message (Power Technology, 2018).

Table 7 Electric cars yearly situation in India

	Electric car stock (in thousands)	New electric car sales (BEV and PHEV) (in thousands)	Market share of electric cars (BEV and PHEV)	Publicly accessible chargers (all kinds)
2008	0.37	0.37	0.02%	-
2009	0.53	0.16	0.01%	-
2010	0.88	0.35	0.02%	-
2011	1.33	0.45	0.02%	-
2012	2.76	1.43	0.05%	-
2013	2.95	0.19	0.01%	-
2014	3.35	0.41	0.02%	-
2015	4.35	1	0.04%	25
2016	4.8	0.45	0.02%	22
2017	6.8	2	0.06%	222
2018	-	12	-	650
2019	-	36	-	-

Source: Table adapted after Global EV Outlook 2018 and Marketsandmarkets (2019)

The transport sector is one of the largest air polluters in India with vehicles running predominantly on fossil fuels. This produces extremely high levels of air pollution in urban areas mostly in the form of CO_2, SO_2, NO_2, PM and RSPM (Respirable Suspended Particulate Matter).

Even more, the consumption of crude oil produces a large bill on India's oil import. India imported 83% of its crude oil in 2015-2016, implying a cost of around 60.3 billion USD (INR

4160 billion). These figures stand as fundamental in the requirement for a mobility transformation. A Niti Aayog report in 2017 exposed that India has the potential to reduce 64% of its energy demand and 37% of CO_2 in 2030, if following an adequate shared, electric, and connected passenger mobility (Juyal et al., 2017; Agrawal, 2018). For that year 156 million tons of oil in diesel and petrol could be reduced, amounting in $52/bbl. of crude oil, driving a net saving of $60 billion by 2030 (Agrawal, 2018).

Consumer perception (demand and EV price)

Consumers in India perceive different problems that impede E-car purchase. Charging time, driving range, battery replacement costs, top speed, and acceleration as key barriers for buying E-cars (GoI, 2012; Dhar et al., 2017). A further analysis made by Painuly (2001) and Boldt et al., 2012 expose that battery is the source cause of most of these barriers (Dhar et al., 2017). The cost of batteries has however declined from approximately USD 1000/kWh in 2007 to approx. USD 300/kWh in 2015 (Nykvist & Nilsson, 2015; Dhar et al., 2017). Hence, the battery is being improved to address costs, driving range and speed related barriers (Dhar et la., 2017).

Ownership of cars has a rapid increase both in rural and urban areas. Internal combustion engine fuelled by petrol and diesel has been dominated historically but in the last decade compressed natural gas has grown in use as an alternative due to the development of the gas distribution infrastructure in several cities (Dhar & Shukla, 2010; Dhar et la., 2017). The E-cars have a small market share presently in India of less than 1% due to the lack of charging infrastructure and high cost of batteries (Mukherjee & Varadhan, 2019). 40% of consumers want E-cars to be price bellow of the price of a conventional vehicle (Research and Markets, 2019). In the reference scenario, (see Dhar et al., 2017) that considers 'rapid economic growth accompanied by decoupling of economic growth from CO_2 emissions in line with current INDC and FAME India program', small E-cars having lower price than USD 15,000 would become competitive after 2040 except the E-cars having a large battery, payload capacity and longer driving range. In 2050 the demand carried by E-cars is 635bpkm (Dhar et al., 2017). Under the EV scenario (see Dhar et al., 2017) are included assumptions that national and local governments recognize the benefits of E-cars for better air quality in cities, energy security etc. Thus, this scenario assumes significant policy support for electric vehicles that results in an increased competitiveness of electric vehicles. Under this scenario costs of E-cars (and E-2wheelers) go down with 30% in 2020 compared to the reference scenario (Dhar et al., 2017). The diffusion of E-cars is limited by driving range, payload limitations and subsidy burden. There is no subsidy support for E-cars beyond 2035 resulting in E-car growth to slow down and for its share to decline in 2040 (Dhar et al., 2017). The 2 Celsius degrees scenario goes even further, including and aligning to the UNFCCC climate goals and targets thus including a carbon price. The price of CO_2 is considered from 2020 onwards starting from 13.9 per tCO_2 then increasing to reach USD 200 per tCO_2 in 2045 (Dhar et al., 2017).

The current E-car running cost (2018) are found to head lower than a similar conventional car use. For instance, the cost of operating a small internal combustion car (Hyundai i10, Maruti Celerio Automatic or equivalent) during 4 years of use has an average cost of around 4500 USD (Rs 306,640) (Plug in India, 2018). The cost for operating a small E-car (for instance e2o Classic, e2o Plus) after 4 years is around 570 USD (Rs 39,000). The data includes fuel cost and maintenance costs, for lithium-ion E-cars. Replacement of batteries for an E-cars are required after 8 or 9 years while for conventional cars 5 or 6 years. These were not included in the above calculations (Plug in India, 2018). Looking at the total cost of ownership (TCO) over many years for both ICE-cars and E-cars will reveal the price differences between the two and the convenience of owning an electric car due to its low operating costs (Plug in India, 2018).

Moreover, due to the consumers perception on electric vehicle technology, range anxiety, and value addition offered by electric models had a negative impact on sales growth of EVs (including E-2wheeler, E-3wheeler, E-cars). Therefore, OEMs started to standardize fast chargers for every EV model and looking for opportunities in vehicles with longer range and offering competitive pricing as compared to conventional vehicles (Research and Markets, 2019). It is found that 100 km driving range for an EV will meet the range requirements of 90% of Indian consumers and about 75% of them are willing to pay more for the benefits but are concerned about certain factors such as high maintenance cost (Research and Markets, 2019). Even more, customers welcome the idea of battery leasing scheme (due to its lower initial cost) and free quick-charging points in all petrol stations (Research and Markets, 2019).

Incentives

FAME I

The total investment amount is approx. 1,2 billion USD (Rs. 895 Crore) a grew from an initial approx. 1,1 billion USD (Rs. 795 Crore).

Table 8 Government incentives for EVs in India provided according to Fame Phase I scheme – implemented in 1st April 2015 till 31st March 2019

Demand creation focus area	Output
Upfront purchase price reduction (by the dealer)	- From inception till 6th December 2018 government incentives were given to about 261,507 electric/hybrid vehicles – 119 models from 27 OEMs got registered under FAME-India scheme for availing demand incentives
Support to procurement of fully electric buses for public transport (from Department of Heavy Industries)	- Sanctioned 455 E-buses for 9 cities in a pilot scheme launched 31st October 2017 - Got interest from 44 cities seeking a total of 3144 E-buses
Manufacturing of E-Buses received no proposal	- 100% foreign direct investment by automatic route is permitted in the automobile sector
Automobile sector is in the deregulated sector	- Private and public sector are free to carry out investment in the automobile sector, including for manufacturing of E-cars and E-Buses

Source: Author's own depiction. Data retrieved from GOI (2015)

FAME II

Financial input of approx. 1.4 billion USD (Rs. 10,000 crores) from 2019-20 to 2021-22.

The scheme is addressing the issue of environmental pollution and fuel security.

It is aimed to impact upfront purchase incentives and establishing charging infrastructure for EVs.

Table 9 Government incentives for EVs and E-buses and charging infrastructure in India provided according to Fame Phase II scheme – implemented in 1st April 2019 till 2021

Demand creation focus area	Output

Electrification of public transportation including shared transport	- Demand incentives on operational expenditure mode for E-buses will be delivered through state/city transport corporation (STUs). - Electric engine vehicles incentives applicable mainly for vehicles used for public transport or registered for commercial purposes (only E-3wheelers and E-cars) - It is planned to support 55,000 E-cars and 7000 E-Buses - The government sanctioned 5595 E-buses in 64 cities for intra city and intercity operations, in August 2019 (News 18, 2019).
Establishment of charging infrastructure	- 2700 charging stations to be established in metros (all EVs including E-bus) - In cities with a population over one million - In smart cities - In cities of Hilly states - Aiming for an availability of at least one charging station in a grid of 3km x 3km. - In major highways connecting city clusters with charging stations and to be installed at 25km from each other

Source: Author's own depiction. Data retrieved from GOI (2018)

Private vehicles are not addressed in the scheme due to a desire to optimally allocate funds and due to considering private vehicles unviable even with the subsidy unless they operate for 200km/day or 40000km/year. The scheme is targeting only the public transport (Madhavan, 2019).

India is planning to reduce the VAT for electric vehicles from 12 to 5% and for charging stations from 18 to 12%. It is also noted that currently in India conventionally powered cars are being taxed at 28%. Plans are being made to exempt from VAT the public transport tickets, awaiting future approval (Electrive, 2019a).

India leapfrogged from 0.6 million car sales (both E-cars and conventional vehicles) in 2000 to 3.3 million car sales in 2018 (Chhibber & Dhawan, 2019). VAT in India is found at 29-50% GST in India, approx. 49% fuel taxes, and lower interest rates at 5%, resulting in an overall vehicle ownership cost per capita income of 450%, making vehicles relatively "unaffordable" (Chhibber & Dhawan, 2019).

Charging infrastructure and policy

The public charging infrastructure in India has only 222 publicly accessible chargers for E-cars in India in 2017 (Bunsen et al., 2018; Agrawal, 2018) and 650 charging stations for E-cars in 2018 according to BNEF, compared with 456,000 charging points for E-cars in China for 2018 (Bloomberg, 2019). A supportive framework to employ private enterprise is needed to enable the charging eco-system in India (Agrawal, 2018).

Public charging facilities are increasing installation rate. This is done through the Electricity Act, 2003, converting the meaning of electric vehicles to a 'service', where all users can have access to charging points with dynamic pricing, tariffs being crafted for specific time of the day (Agrawal, 2018). Infrastructure development is one of the major requirements for India next to the government policies and incentives for EVs including E-cars (Agrawal, 2018).

Availability of a proper charging infrastructure is one of the principal requirements to speed up the adoption of electric vehicles in India. An enabling framework it is proposed to support this for EVs (including E-2wheelers, E-3wheelers, E-cars, E-buses) (GOI, 2018).

Objectives set by the Government of India, Ministry of Power (GOI, 2018) are:

- To enable faster adoption of EVs in India by ensuring safe, reliable, accessible, and affordable Charging Infrastructure and eco-system

- To promote affordable tariff chargeable from EV owners and Charging Station Operators/Owners

- To generate employment/income opportunities for small entrepreneurs

- To proactively support creation of EV Charging Infrastructure in the initial phase and eventually create a market for EV Charging business

- To encourage preparedness of Electrical Distribution System to adopt EV Charging Infrastructure

Decisions that have been made in accordance with the previous objectives are:

a) Private charging at residence/ office shall be permitted

b) Setting up of Public Charging Stations shall be a de-licensed activity and any individual/entity is free to set up public charging stations, provided that, such stations meet the technical as well as performance standards and protocols laid down in GOI (2018) as well as any further norms/standards/specifications laid down by Ministry of Power and Central Electricity Authority from time to time

Implementation mechanism for rollout is done by the designated Central Nodal Agency. States need to choose their own Nodal Agency for establishing the charging infrastructure. The state DISCOM is usually the Nodal Agency for this purpose. The State Government is independently choosing what Nodal Agency to have. This is made of a Central/State Public Sector Undertaking together with Urban Local Bodies, Urban/Area Development Authorities etc. (Mandela, 2018).

In January 2019, the Ministry of Housing and Urban Affairs made new guidelines for directing the residential and commercial buildings to share about 20% of their parking space for electric vehicle charging infrastructure (Gnguly, 2019). Thus, individuals can open public EV charging stations without applying for license. The ministry of Power is setting a cap on the price charged (Singh, 2018a).

Standards

Government of India is looking to support both public and private transport system however charging infrastructure is fundamental to support a mass adoption of EVs (UITP, 2018). On the 14 December 2018 the government of India released a document to outline guidelines and standards for charging infrastructure for electric vehicles (UITP, 2018) the Public Charging Infrastructure notification (Shah, 2019). The policy is aiming to enable faster adoption of electric vehicles, promote affordable tariff, build city-wide charging infrastructure, create market for electric vehicle charging business, and to encourage preparedness of Electrical Distribution System (UITP, 2018).

The policy outline is:

1. Private charging at residences / offices shall be permitted

2. Setting up of Public Charging System shall be a de-licensed activity

3. Power Distribution Company should facilitate power connectivity to any person

4. Chain of charging stations may also obtain electricity from any generation company

The government has followed the existing current international standards like CCS, CHadeMO etc. that are prevalent and used by most vehicle manufacturers internationally (GOI, 2019). The standards for fast and slow charging stations are given below:

Table 10 The standards for fast and slow charging stations in India as per 2018

Charger Type	Charger Connectors	Rated Voltage (V)	No. of Charging Points/No. of Connector guns (CG)
Fast	CCS (min 50kW)	200-1000	1/1 CG
	CHAdeMO (min 50kW)	200-1000	1/1 CG
	Type-2 AV (min 22 kW)	380-480	1/1 CG
Slow/Moderate	Bharat DC-001 (15 kW)	72-200	1/1 CG
	Bharat AC-001 (10 kW)	230	3/3 CG of 3.3 kW each

Table Source: GOI (2019), Guidelines and Standards

Any individual entity interested to set a public charging station for E-cars, will need to have the minimum charging infrastructure requirements described in the Public Charging Infrastructure government notification (Shah, 2019). Every charging station must include three fast chargers that are a CCS, a CHAdeMo and a Type-2 AC. The former too are required to operate on 50kW/200-1000V, the Type-2 on 22kW/380-480V. Two more slow charge points need to be installed on the charging station, a Bharat DC- 001 (15 kW/72 – 200V) and a Bharat AC – 001)10 kW/230V) (Shah, 2019).

The Department of Heavy Industries Committee, in 2017 deliver the Bharat charger specifications for AD and DC chargers: Bharat EV Charger AC001 & DC001, that are slow E-car chargers having under 120 Vats DC (Shah, 2019). These standards were kept due to current E-cars on the market made for this kind of charging standards in India, while new E-cars are deployed these will be removed, being replaced with DC output for 400-500V or higher (Shah, 2019). All standards, CCS-2, CHAdeMO and the Bharat chargers (Shah, 2019) are set to co-exist in India.

Present types of electric cars in India have different battery sizes that require fast charging, such as 11kWh (Mahindra e20) to 40kWh (Nissan Leaf) going up to 90kWh (Tesla Model S) (Shah, 2019). In India the only manufacturers that produced electric cars are Mahindra Electric and Tata Motors. The time of E-car charging might be slow for these vehicles due to the batteries used, that cannot use charging above 1C rate (Shah, 2019).

A clearance certificate stated that all public charging stations shall be operational only after inspection and clearance. The certificate was constituted by electrical inspectors/technical personnel designated specifically by the respective distribution company (UITP, 2018).

According to the 2018 guidelines minimum requirements for public charging stations of long-distance E-cars and/or heavy-duty electric vehicles (buses, trucks etc.) shall be:

a) At least two chargers of minimum 100 kW (with 200-1000 V) each of different specification (CCS and CHadeMO) and with single connector gun each in addition to the minimum charging requirements.

b) Appropriate Liquid Cooling Cables for high-speed charging facility for onboard charging of Fluid Cooled Batteries.

c) Fast Charging Stations (FCS) for long distance EVs and/or Heavy Duty EVs may also have the option of swapping facilities for batteries for meeting the charging requirement.

The battery manufacturers are to impose charging standards for E-buses that have battery sizes bigger than 100kWh. The cost of these batteries is around several million rupees (1million rupees =14,500 USD) and charging from any public Charging Station is not recommended. The charging stations are to be supplied or advised by bus producers and installed by bus operators (Shah, 2019).

All stakeholders of the EV (E-car, E-bus, E-truck etc.) industry express that one of the major obstacles of adopting clean technologies on road is the lack of a proper charging infrastructure. Decisions around what standards to choose for charging infrastructure hinders the widespread of EV adoption (Shanti, 2019). Leading car manufacturers in India have been lobbying for choosing their standards option, since they invested heavily in various technologies (Shanti, 2019).

Building charging stations in India at the present is expensive. A major cause of this is that companies in India must buy licenses from Japan, China, or other countries (Shanti, 2019). Thus, efforts are made to standardize the charging points that can reduce the cost of building such infrastructure. This is being realised by the Department of Science and Technology (DST) and Bureau of Indian Standards (BIS) (Shanti, 2019). India wants to develop its own charging stations that will minimize costs and accelerate the use of electric vehicles (Smiti, 2019).

Fleet procurement

The initial E-cars appearance in the country is driven by taxi fleet operators, various public sector segments, government departments and biggest corporations (Shah, 2019).

Through Energy efficiency Service Ltd (EESL), a joint venture to facilitate the implementation of energy efficiency projects, the government made a tender to procure 10,000 E-cars to be used by government departments, which was won by Tata Motors Ltd and Mahindra and Mahindra in August 2017 tender. However, the procurement of E-cars was slowed down due to the lack of charging stations (Ghosh, 2018). TATA and Mahindra were supposed to release the order by June 2018 but was firstly extended until March 2019 because of the insufficient charging stations for E-cars (Saluja, 2019). Due to states still working at their EV policies, and because only 1000 were delivered, EESL for a second time moved the distribution date by September 2019 (Saluja, 2019).

According to operational guidelines for providing the demand incentives under FAME II notified by the heavy industry ministry, the dealer must make sure that the demand incentives are utilized only by public purpose. A valid permit it is required from the government agency mentioning that the vehicle will be used only for public transport purpose to avail incentives under the 1.5 billion USD (Rs 10 000 crore) (Economic Times, 2019).

Moreover, firms such as BYD Auto Co. Ltd from China have launched products such as E-buses in India. BYD also plans to provide E-buses to some state transport firms (Ghosh, 2018). As an example, in the city of Bangalore was introduced an E-bus built by BYD for a trial run of three months (Adheesh et al., 2016). An economic analysis was made after data on operation and maintenance was examined, comparing this with the already diesel buses on road in the same route. This concluded that E-buses as public transport would bring benefits both environmentally and financially (Adheesh et al., 2016).

Maharashtra state – EV Policy 2018

Next to national targets and electric vehicle policies, many local Indian states have emerged their own policy support for electric vehicle growth.

The Electric Vehicles Policy adopted in Maharashtra accounts for all three segments of EV sector – manufacturing, creation of infrastructure, and consumers (EAI, 2018). The Policy envisions to create a proper environment that accommodated 500,000 EVs within the next 5 years (EAI, 2018). The policy was used also for attracting investors in Maharashtra for EVs, introducing promotional strategies, next to creating a proper scene for investors, competitive and sustainable (Poojary, 2019). EV include industrial fork-lift trucks, electric carts, electric scooters, electric motorcycles, electric three wheelers, full-size electric cars, trucks, vans, buses, and other electric vehicles (EV Policy 2018, Government of Maharashtra).

Table 11 Electric Vehicle Policy 2018 Maharashtra state (valid 5 years) – demand measures

Policy targets	• Increase the number of EV registered in Maharashtra to 5 lacs (100,000) • Generate an investment of Rs. 25,000 crores (3 billion 625 million USD) in EV, EV manufacturing and component manufacturing, battery manufacturing/assembly enterprises and charging infrastructure equipment manufacturing in the state. • Create jobs for 100,000 persons
Strategic drivers of the policy	• Promotion of adoption of EV technology: Increase the viability of EV by way of providing fiscal and non-fiscal incentives • Promotion of creation of dedicated infrastructure for charging of EVs: through subsidization of investment
Incentives and provisions for EV buyers	• Incentives for only Battery Electric Vehicles • Initially promote EV in public transport in six cities: Mumbai, Pune, Aurangabad, Thane, Nagpur and Nashik • The first 1000 EV private/public passenger bus buyer whose vehicles are registered in the state will be eligible for user subsidy over the 5-year policy period • 10% subsidy for passenger E-buses registered in the State to private/public E-bus transport buyer, on the base price (maximum Rs. 20 lacs (around 29,000 USD) per vehicles) being eligible to buyers. It will be transferred to a buyer's accounts within three months of purchase date. • The first 10,000 all categories E-cars registered in the state, private transporter and individual buyer is eligible to get end user subsidy over the 5-year policy period • 15% subsidy (maximum limit of Rs 1 lac (1450 USD) for E-cars) per vehicle to private transport and individual buyer for EVs registered in the State, on the base price will be paid to buyer. The subsidy will be transferred to buyer's bank account within 3 months of purchase date • Exemption from road tax and registration fees for EVs
Incentives & assistance for EV Charging	• Common charging points in residential areas, societies, bus depots, Public Parking areas, railway stations and fuel pumps etc. will be allowed. After the receipt of application for setting up a charging point is received, the concerned planning

	authority & electricity supplying agency shall grant permission within 15 days. If permission is not received within 15 days, it will be deemed to be permitted • Development Control Rules of all local self-Government & Special Planning Authorities will be suitably modified to allow for setting up of common public charging facilities in parking areas of malls, residential properties & parking areas etc. • Petrol pumps will be allowed to setup charging station freely subject to charging station areas, qualifying fire & safety standard norms of relevant authorities under relevant acts/rules • Commercial public EV charging stations for E- 2 wheelers, E-3 wheelers, E-cars and E-buses will be eligible for 25% capital subsidy on equipment/machinery (limited up to Rs. 10 lacs (14,500 USD) per station) for first 250 commercial public EV charging stations.
EV charging infrastructure	• Domestic user facility (individual) • Public charging facility (government facility, bus depots, railway stations, 2 fuel stations etc.) • Common charging facility (malls, residential building, educational institutions etc.) • Commercial charging facility (roadside, fuel stations etc.)

Source: Table adapted after Electric Vehicle Policy 2018, Government of Maharashtra

Present E-car manufacturing arena in Maharashtra

The Maharashtra chief minister Devendra Fadnavis announced the plan to invest 3.4 billion USD (INR 25,000 Cr) in the manufacturing of E-cars, their components and charging equipment (Ganguly, 2018). He stated that in his department are going to use such vehicles to encourage the use of E-cars in Maharashtra. As well the Ministry of Power declared that the state would acquire 1000 E-cars within the next year for government use (Ganguly, 2018).

Opinions of foreign manufacturing firms are expressing the state of the E-car conjuncture in India. For instance, German car manufacturer Mercedes Benz said that "it doesn't yet see a viable business case to launch electric vehicles in India due to lack of a clear EV policy framework, and incentives to sell such vehicles". This was said by the Mercedes-Bens India Vice President, Sales and Marketing, Michael Jopp with regards to the present situation (Ganguly ,2018). The company has also required that government should reduce the import duty on battery-operated electric vehicles and stated that this will make E-cars available in the country (Ganguly, 2018).

A reduction in import taxes was made for 10-15% according to the Central Board of Indirect Taxes and Customs from a level of 15% to 30% added import duties for components of electric vehicles (Ganguly, 2019). The purpose of this reduction is to encourage manufacturers to produce electric vehicles in India (Ganguly, 2019).

A Memoranda of Understanding (MoU) has been established in between the government of Maharashtra and Mahindra & Mahindra and Tata Motors. Under the two MoUs Maharashtra government plans to work closely with various stakeholders to help deploy 1000 E-cars over the next year (Banerji, 2018; Business Line, 2018). The E-cars will be deployed part of the contract signed in between Tata Motors and M&M with EESL, this way bringing no projects for wither of the companies (Business Line, 2018). This will be done by EESL purchasing E-cars from these manufacturers, that are the only ones producing electric, that after will lease these E-cars, offering e-vehicles on rent. This will be effectuated in Maharashtra as well (Business Line, 2018).

Tata Motors

Under the aegis of the MoU, Tata Motors next to the E-cars deployment, said to be facilitating setting up charging stations in the state supported by the group firm TATA Power (Banerji, 2018). Tata Motors has partnered with Tata Power to support Maharashtra towards E-car transition and to establish E-car charging stations for public use (CarAndBike, 2018). Maharshtra is on plan to have 100 E-car charging stations installed by Tata Power (CarAndBike, 2018).

'As part of our tender with EESL, we have already completed the production of 250 cars (E-cars) and initiated the execution of phase 2 orders. Today's delivery of 5 Tigor EVs (E-cars) by EESL to the Maharashtra government has effectively paved the way for connecting our aspirations in the e-mobility space with the government's vision. With Tigor EV (E-car), we have begun our journey in boosting e-mobility and will offer a full range of electric vehicles to the Indian customers. We continue to work in a collaborative manner to facilitate faster adoption of electric vehicles and to build a sustainable future for India,' said Guenter Butschek, CEO & MD, Tata Motors (Business Line, 2018).

The MoU states about other similar collaboration between private firms and state governments across the country to support electrification of transport (Banerji, 2018).

Mahindra & Mahindra

Automakers have been positively receiving the FAME II scheme, that brought confidence for large investments in electric mobility. Pawan Goenka, managing director at Mahindra and Mahindra Ltd., said that FAME 2 brings a strong support on local manufacturing and charging infrastructure, through a 1.5 billion USD offered for 3 years, bringing this way the required support to for the development of E-cars in India (Ghosh, 2019). 'It addresses key issues, including national energy security, mitigation of the adverse impact of vehicles on the environment and growth of domestic technology and manufacturing capabilities. The revised FAME II removes all the uncertainty and will put E-cars in the fast lane,' he said (Ghosh, 2019).

The largest manufacturer of E-cars in India is Mahindra & Mahindra that has established a production point of E-cars in Bengaluru and has a target to produce 60,000 E-cars per year starting from 2020 (Ghosh, 2018). Moreover, Mahindra considers building a lithium-ion production point in Maharashtra partnering with the South Korean company LG Chem (Ghosh, 2019).

Mahindra & Mahindra Ltd signed two memoranda of understanding (MoUs) with the Government of Maharashtra with the aim to move for the next stages in developing E-cars and becoming entirely electric. This was done under the Governments goals to achieve fast EV adoption for private and public sectors (Mahindra, 2018).

Mahindra & Mahindra, part of the first MoU plans to turn fully electric investing more (approx. 7.75 million USD, that is Rs 500 crore) in the Chakan production facility for E-cars, e-motor, battery pack and other automobile components (Mahindra, 2018). The second MoU sets alliances to help Mahindra deploy E-cars in specific cities in Maharashtra. These are in between the government and the company and different fleet partners, taxi aggregators, logistics companies. This work is aimed to bring 1000 E-cars on road over the upcoming year from which 25 Mahindra E2oPlus vehicles ported on the Zoom car platform are planned to be the first E-cars in Mumbai (Mahindra, 2018). Applications for the use of these E-cars comprise transport of employees between offices and home for corporations, ride sharing, self-drive etc.

(Mahindra, 2018). The government of Maharashtra has named this expansion as "Pioneer Mega Project".

E-cars in Mumbai

With a population higher than 4 million residents, Mumbai is one of the cities where the E-cars will firstly be rolled out as set by GOI, FAME II scheme (Dhabhar, 2018). This means public electric charging stations will become reality rather than just a plan on paper. Moreover, special green number plates are mentioned to be part of the E-car package (Dhabhar, 2018).

Under the Energy Efficiency Services Ltd (EESL) initiative to provide 1000 E-cars in phases on rent in the Maharashtra state, two charging stations are said to be set in Mantralaya, Mumbai (and Nagpur) (Economic Times, 2018). Fadnavis said that this initiative is set to encourage government departments to use E-cars and protect the environment (Economic Times, 2018).

The first charging points for E-cars set by Tata power are deployed in Mumbai (Tata Power, 2019). Following this Mumbai launched the first nine E-car charging stations placed in significant locations (Tata Power, 2019). As of 2020, Tata has set up already 30 charging stations in Mumbai that are expected to increase to 200 by 2021 (Economic Times, 2020). It is also planned an upgrade from the standard 15 kW stations as the demand increases with installation of charging stations of 30-50 kW (Economic Times, 2020).

4.1.4 Explaining the comparability established variables between the cases selected

It is important to mention the unique character of China as a socialist market economy, having a centralized system with state-owned companies and public ownership where public policies are enforced by central government and local governments using actions through their networks and power interests. Such an approach has weak institutional framework and policy experiences and may not have the potential to sustain growth in innovation or productivity levels in developing market economy systems such as India (Roolaht, 2010), it may create short term interests for isolated parties that louse power when the policy is phased out (Roolaht, 2010). Therefore, using the case of China in a comparison may require specific conditions and due to this it is used keeping in mind the context limitations in recommendations for innovation creation in the Indian case. Even if the findings expose more data details, to map a comparability of existing policies between cases (see also Table 12), the case recommendations focus more on a specific geography within China and mechanisms. Only the public fleet of E-buses, E-taxi and both infrastructure creation can be used more fairly in the comparison with India, as a public measure supported in Shenzhen. This is being formed as a driving mechanism for E-bus and E-car development in the city. It is being heavily subsidized to support fleet targets being realized with command-and-control economy.

Such issues are not present in the UK thus the degree of comparability can be established for any variable selected. As both being parliamentary democracies India and the UK have perhaps similar political systems determining an easier to compare measures and policies, barriers to adoption and benefits.

Table 12 The summarizing cross case comparison of policies implemented towards an E-car market.

	United Kingdom	China	India	Intended aim

Financial policies	- Subsidy to consumer for E-car purchase – targeting market uptake of the vehicles	- Subsidy for E-car purchase – targeting market uptake of the vehicles	- Subsidy to consumer for E-car purchase – targeting market uptake of the vehicles	- Reduce the financial barrier to deciding to purchase an E-car
	- Favourable fiscal treatment of leased cars – targeting market uptake of the vehicle			- Reduce the financial barrier to deciding to purchase an E-car
	- Discount on or exemption of congestion charge – targeting market uptake of the vehicles	- Discount on/or exemption of congestion charge – targeting market uptake of the vehicles		- Encourage adoption of E-cars
	- Free parking places for E-cars – targeting market uptake of the vehicles	- Free parking places for E-cars – targeting market uptake of the vehicles		- Encourage adoption of E-cars
	- Subsidies to economic actors for the installation of charging stations – targeting charging point availability –	- Subsidies for the installation of charging stations – targeting charging point availability - Government subsidies supporting E-car charging stations	- Subsidies for establishing a charging infrastructure - Establishment of charging stations are also proposed on major highways connecting major city clusters	- Helping to improve function of whole system + reducing range anxiety barriers of customers
	- Subsidies for R&D (E-car manufacturers and research institutes) – targeting to improve technology, reduce cost – improve technology and reduce cost of production	- Subsidies for R&D and research (for technological development and innovation) - Direct subsidies to manufacturers	- To encourage advanced technologies, the benefits of incentives, will be extended to only those vehicles which are fitted with advanced battery as Lithium-Ion battery and other new technology batteries	- Reduce the financial barrier to deciding to purchase an E-car - Reduce consumer range anxiety and encourage adoption of E-cars
	- CO_2 and cars regulation: super credits, counting E-cars as zero emissions cars – targeting supply vehicles (EU regulation)			- Reduce the financial barrier to deciding to purchase an E-car - Encourage manufacturers to produce low CO_2 cars
Non-financial policies	- Standardization of charging systems – increase consumer trust for E-car use and purchase	- Standardization of charging points – increase consumer trust for E-car use and purchase		- Reduce consumer range anxiety and encourage

				adoption of E-cars
	- Government procurement – targeting market uptake and supply of the vehicles (UK)	- Mandate government procurement	- Demand Incentives on operational expenditure mode for electric buses will be delivered through STUs - E-car and E-bus segment incentives will be applicable mainly to vehicles used for public transport or registered for commercial purposes.	- Help raise awareness of E-cars and establish a local manufacturing production
	Planned dedicated bays for E-cars in London			- Reduce consumer range anxiety and encourage adoption of E-cars

Source: Author's own depiction

4.2 Analysis

4.2.1 Assessing the functionality of the TIS in India

In the formative stage and its emergence phase five functions are identified as being associated with it: *knowledge creation, entrepreneurial experimentation, influence on the direction of search, market formation and resource mobilization* (Hekkert & Negro, 2009). Therefore, the analysis will comprise these functionalities except the entrepreneurial experimentation evolving around the actors of the TIS in focus (see Appendix A). The function is excluded from this study due to resource constraints such as data availability limitations, time, length, and space of such studies when attempting to cover the entire segments of the TIS. Moreover, due to the EV policies in India comprising all EVs, and a low level of development of E-cars, the analysis will include the EV policy from where it can be induced more information that also applies to E-cars. Appendix C and D comprise the TIS analysis for China and UK, for a clearer comparison between the TISs. The Indian TIS is presented and analysed bellow following its functionalities.

Knowledge development and diffusion through networks

It is identified that discussions at ministerial level are continuously held where different stakeholders are consulted such as the economic policy think tank National Council of Applied Economics Research, car manufacturers and auto parts companies. There is an ongoing flow of information exchanged in between these actors, with new directions set during meetings that tend to equilibrate decisions and targets set, as for instance the move of government target from electrification of all new vehicles back to 30%.

Even more India is learning from international parties and is devoted to keep up with the EV global progress by taking part in international dialogues. India is doing this by joining the

Electric Vehicles Initiative (EVI, supports all EVs: E-2wheeler, E-3wheeler, E-car, E-bus, E-truck including battery-electric, plug-in hybrid, and fuel cell vehicle types) a high-level dialogue among energy Ministries from major economies in the world. Under this initiative, different programs are organized to facilitate cooperation and communication between countries and cities (IEA, 2019). For instance, the 2017 EV campaign under EVI holding a goal to drive all EVI members to push their EV vehicle sales to 30% of all vehicle sales.

Assessment projects were conducted with Phase I of the FAME launched in 2015, aimed for a period of two years but subsequently extended until 2019. This was considered a pilot project for testing and determining the consumer reaction to EVs in different major agglomerations including the greater Mumbai area. It is observed the need to extend the scheme due to delays in finalizing the Phase II. Phase II was developed in 2019 bringing additional developments. It is noted that the phases of development are gradual, and that the learning process is continuous allowing for the technology to establish new learning curves and expand its network and activities. The knowledge unfolds at various levels, between government officials and industries to consumer. A consumer ground level survey identified that low demand in India of EVs, including E-cars is also due to a low awareness (Gulati, 2012). However, the prolonging dates that occurred three times, every six months, for FAME I (prolonged till March 2019, the original date being March 2017) also due to the scheme not providing the desired results, can be interpreted in a lack of resources, clear direction and flexibility of the authorities that were not focusing entirely and targeting all the barriers in this phase. This determined them to go back and forth in their decision-making process. The new emerged solutions came only in 2019, with the launch of FAME II, that brought a big improvement over the earlier policy. Such flows in policy decisions bring uncertainty for all actors engaging to set new actions for EVs and subsequently drive E-car development.

A network activity is found between the EESL, that implements the NEMMP, and the government and its agencies aiming to replace the old vehicles used and provide E-cars fleet. EESL collaborates with a service provider agency to ensure end to end fleet management of the procured vehicles. All actors involved in this process benefit from knowledge exchange and information development for providing customers with E-cars and optimum services. By 2018 two companies delivered E-cars to the government as part of EESL 2017 procurement plan, Mahindra, and Tata. These initiatives contribute to other companies to introduce E-cars in their portfolio, doing tests and announcing launching dates in the country of their models, some by 2020 (Jadhav & Shah, 2019).

India's ambitious plans are labelled as positive events however the modifications in the targets set, for instance the governments change from 100 to 30% E-cars target within a short period of time send messages of instability. Such fluctuating information are discouraging rapid progress, investments, new entrants, and lower trust in the development targets of the market. Institutional alignment it is affected likewise. Among other issues, all actors need to at least feel that they are making changes towards a viable path that offers a secure direction rather than risking investing time energy and resources to be wasted.

At the local level, in Maharashtra state there are various announcements to further support E-cars development such as investments in manufacturing, components and charging equipment, as well the procurement of E-cars for the use of Maharashtra government, in the chief minister's department Devendra Fadnavis (Ganguly, 2018). The minister aligned its goals with the national initiatives being inspired by the central government's actions and is subsequently showing leadership practices in Maharashtra state to promote E-cars. However, it is noticed that other government departments are not yet fully aligned to introduce similar practices, thus knowledge exchange might be hindered by weak collaboration and low network activities between units in the government. There was no information found stating that all governmental departments are prone to implement the same actions. Thus, we may deduct that there could be internal disinterests and lack of communication and knowledge exchange between such actors.

The Maharashtra state by signing the MoU partners with two local largest vehicle manufacturers and the only E-car producers at this time, Mahindra & Mahindra and Tata Motors. With this agreement the Maharashtra state expands its influence network and engage various stakeholders and help reaching the target to deploy 1000 E-cars (passenger and commercial) in 2019 (Banerji, 2018; Business Line, 2018). Under this Mumbai adopts the EV Policy 2018.

Barriers identified for E-cars:

- Lack of expertise, knowledge, and coordination to reach the desired targets in a timely manner or to make better estimations of when such measures can be achieved (due to prolonging of FAME I three times, with the FAME II arriving only in 2019). No measures for private E-cars have been adopted. <u>Effects:</u> dragging behind new policy plans and postponing, as it happened with the FAME II launch dates; giving uncertainty to all stakeholders of the industry to set new actions for EVs and E-car development.
- Unstable targets (huge difference in the modification of targets, from 100 to 30% E-car market penetration target within a short period of time). <u>Effects:</u> discouraging rapid progress, investments, new entrants and decrease trust in targets set for development.
- In Maharashtra government departments are not yet fully aligned with national initiatives, even though the goals set by the ministers were in tandem with the national ones. There might be disinterests internally and/or lack of initiatives happening possibly due to lack of proper communication, collaboration, and knowledge exchange in between government actors. <u>Effects:</u> knowledge exchange might be hindered by weak communication, collaboration, and lower network activities between units in the government.

<u>*Recommendations from the case of UK*</u>

In the UK the government makes a commitment to work in partnerships with industry, local governments, and consumers. Such collaboration could be forged by the Indian government to develop partnerships agreements and better build actions on such relationships. This way it can better deliver on short and long-term targets.

<u>*Recommendations from the case of China*</u>

In the case of China, next to the political motivations we find the environmental and economic incentives for supporting E-cars. It is known that promoting technologies such as E-cars help improve the urban environment but also boost the urban economy by developing local enterprises like BYD (Li et al., 2016). However, to realize this in India there is a need to reach consensus between the department responsible for each sector involved from the municipality. In Shenzhen we find proposals for collaborations pointing at the main responsible department of E-car implementation, the Shenzhen Development and Reform Commission (Shenzhen DRC) (Huang & Li, 2019), the TCSM, the department responsible for the management of urban public transportation, and the Urban Planning, Shenzhen UPLRC responsible for the charging infrastructure that together would better realize objectives (Huang & Li, 2019). Such network collaborations could be initiated in Maharashtra, Mumbai. Achieving the successful implementation of charging stations and increasing E-cars number is dependable of many sectors, and departments. Institutional alignment is fundamental to proceed with the implementation of the project and achieve beneficial results.

For instance, space for building such infrastructure is also emphasized in the case of Shenzhen and is important to be developed. To have access to such space, some constraints at institutional level need to be overcome. The land use for the construction of charging points it is not included in urban land use planning making it difficult to amend land use plans that have been approved by national and provincial governments (Huang & Li, 2019). The challenge was even more complicated for E-bus charging stations that require larger tracts of land and government coordination. Additionally, issues are encountered also when facing social stakeholders. This is exemplified by a case in a residential area in Shenzhen, where locals manifested disapproval of such stations to be built in their neighbourhood stating safety potential issues (Huang & Li, 2019). Here might be a similar possible challenge in which Maharashtra need to investigate and take in consideration all stakeholders involved when charging points are planned to be built and take measures and actions accordingly to eliminate such issues in advance.

Influence on the direction of search

In the present TIS there are a complexity of actions that support and hinder this function. India has a high potential to become one of the main EV including E-car technology drivers (Dhar et al., 2017) due to its context facilitating the technology to diffuse. It allows higher innovation capabilities to develop however there are also some issues encountered in realizing these.

It is observed that the political context in India is a decentralized system, with liberal markets, where cities choose independently their economic goals and even compete with one another. This system is providing a foundation of support for innovation systems, allowing the economy to develop more naturally the emergence of new E-car technologies and foster innovation.

There are different underlying reasons for India to electrify its automobile sector. Looking from the perspective of the assessment of the present and future technology opportunities and appropriability conditions, the environmental reasons are used mainly to support decrease their oil dependence on foreign imports. This is done while developing the local gas industry firstly. Environmental reasons such as benefiting cities by reducing CO_2 emissions and improve air quality are only considered secondary to economic growth. In this sense India follows a similar path with China that strived to introduce electric mobility to reduce oil dependency. However, India is lagging far behind, with poor measures and policy programmes of subsidies and incentives that provide no clear policy guidance (Agrawal, 2018). Due to its economic priorities and the existence of mass gas resources in India, it is expected that India will continue to catalyse additional efforts in developing gas fuelled cars that might receive greater attention compared to E-cars. The development of the gas distribution infrastructure has been developed in several cities (Dhar et la., 2017; Dhar & Shukla, 2010). Thus, the major political direction of search in India for developing an E-car industry in the country is its protectionism reasons and far less preoccupied with environmentalism.

The regulations and policies in India are catalysed by international and national moves. The landscape of international policies such as climate change targets, is considered and used as a strategy by India in reaching its economic goals. For instance, India is part of the Electric Vehicles Initiative (EVI) coordinated by the International Energy Agency and comprising the leading countries in the field. Even more India launched its NEMMP 2020, under which FAME was built to support EVs, with Phase I, testing consumers reactions to EVs, leading from its experience to the inbuilt of Phase II. Phase I can be said to be a preparatory state of mind and awareness for developing further also the E-car industry that is not receiving support in this policy. Phase II is bringing additional identified necessary interventions such as addressing public transport measures, as shared transport, and the establishment of the charging infrastructure. In accordance with this, at the local level some states announced their own policy complementing the national policy including actions for tackling specific state needs (GNCTD, 2018).

Despite these measures, the demand for E-cars in India stays low. Reasons identified for demand articulation are high upfront costs, low number of public charging stations, lack of products comparing to ICEs, low investments in manufacturing (GNCTD, 2018) and low awareness (Gulati, 2012). A high latent demand for E-cars is identified with 25-30% of surveyed consumers preferring E-cars to ICE -cars if price is met (Gulati, 2012). Even more, some technical bottlenecks are defined by consumers as charging time, driving range, battery replacement costs, top speed and acceleration being key barriers to buy E-cars. Some studies expose that the battery would be the main source of these barriers (Painuly, 2001; Boldt et al., 2012) and it is recognized that further battery technology developments would be fundamental in helping to minimize acquisition costs of E-cars compared to conventional vehicles and increase E-car diffusion. Even more, the cost of ownership of an E-car is identified to be lower than a conventional vehicle when excluding the battery cost. Thus, presently overall costs and functionality are playing an equal major role. Consumers consider high costs of batteries and the lack of infrastructure development the main criteria for not buying an E-car (Mukherjee & Varadhan, 2019). This is also exemplified in the NEMMP 2020, after a study survey, that identified consumers being highly sensitive to price and range of E-cars (Gulati, 2012).

Even more, it is observed that waivers pay a higher role for consumer choices than tax exemptions and tax rebates do (Edler, 2013). Consumers prefer to purchase a cheaper E-car than the conventional vehicles and to spend less money now than future allowances being considered secondarily (Research and Markets, 2019; Edler, 2013). The same reference is found in the NEMMP where cash incentives/tax subsidies are found to be most preferred by consumers (58% of respondents) to increase demand for E-cars adoption (Gulati, 2012). The subsidies for batteries were found on the second most preferred mean but almost at an equal level comprising 56% of respondents (Gulati, 2012). This is also translated from the customers' preference of the battery leasing scheme that offers a lower initial acquisition cost and free quick charging points in all petrol stations (Research and Markets, 2019). Such strategy is offsetting the battery price while making the vehicles' cost equal or lower than the combustion engine cars, budgeting the battery cost that runs under the operating costs (Electrive, 2019).

Moreover, waivers are not fully used in India, leaving aside major opportunities to push forward the E-car industry development. The Indian government says VAT reductions for E-cars purchase and charging stations are being planned and public transport tickets for E-buses are to be exempted from VAT in the near future (Electrive, 2019). These actions are not presently used concomitantly with FAME I and II. Not considering such measures due to prioritizing steps than concomitantly actioning it is only delaying targets achievements that may result in higher investments that would be the case if all necessary measures would be implemented, especially since waivers proved to bring the highest response in consumers choices. It is observable that subsidies in India lack continuity and fluctuate or are missing proving problematic in such economies where learning costs are high also due to its inflationary trends (Pani, 2013). Therefore, the subsidy needs to be adjusted and adopted on a permanent nature (Cantono and Silverberg, 2009) to enable local production and realize the latent demand for E-cars. Even more high-performance E-cars should receive the highest number of incentives. The main consumer issues are correlated with the level of performance such as pick up and top speed of the vehicle thus setting better parameters of performance is required (Gulati, 2012).

The Maharashtra state is using solely an EV Policy through which envisions to become a leader in E-car manufacturing (Government of Maharashtra, 2018). The policy does not include air pollution, CO_2 emissions mechanisms to drive their targets in creating demand for EVs including E-cars. It also lacks some waivers to better aid consumers. These driving elements are lacking even if Maharashtra state recognizes to have the highest number of vehicles in India with Mumbai having the highest car registration and being one of the most polluted cities in India (Madhukar Varshney, 2018). The Policy follows the national framework and includes incentives for manufacturing and aims to benefit consumers. For lowering the price of retailers E-cars get exempted from road tax and registration fees (Swapnil Rawal, 2018). A 15% incentive is introduced on the registered E-cars' original cost. The policy also supports the charging stations offering 25% capital subsidy for the first 250 charging stations including E-cars and E-bus, with a limit of around 15,549 USD/charging station (Swapnil Rawal, 2018; Prateek, 2018).

The innovation is radical and occurs in niches to disrupt the current regime car mobility that is locked into combustion engine. This is due to the consumers being adapted and used to the technology's characteristics such as expected speed and power, knowledge and maintenance networks, regulations, cultural acceptance etc. A disruptive model is represented by the replacement of the existent public buses with E-buses, or the governments car fleet replacement with E-cars being examples of niches emerging through demand creation. The measure is positive and seen to encourage innovation on a long-term frame (Edler, 2013). In this respect, EESL implements NEMMP facilitating demand creation by promoting public procurement and aims at creating a market for E-cars using a business model of aggregation of demand and bulk procurement. For instance, it procures 10,000 E-cars in 2017 and another 10,000 tenders to procure for 2018 under FAME (Power Technology, 2018). A coordination failure is noticed between the central government decisions, for instance to procure E-cars, implemented by EESL, to be used by governments and the lack of infrastructure, delaying the manufacturing of E-car production twice until 2018 then 2019.

It is therefore noticed that market-based instruments (taxes, subsidies, fees, waivers) are used predominantly with less command-and-control regulations (standards for charging stations, E-car battery performance). The TIS in India is in its early stage of development and government policy and market-based instruments are used to support the formation of the E-car industry but must be persevered to give space for innovation. It has been proved primordial and recognized to maintain in this sense consistency of terms of the targets set, with continuous long-term subsidy programs to better encourage and sustain manufacturers and consumers to switch to E-cars. The tendency of the technology use is in its major part driven by governments decisions and the feedback causality between economic growth and the type of energy consumption. For instance, the choice of building a gas industry instead of catalysing efforts towards electrifying the system, the efforts are made for economic growth and enhancing the national energy security. However, it is observed that India wishes to diversify its energy use for urban transport and promote different transport means and sharing transportation system (Edler, 2013).

FAME II, unlike the earlier version, sets a target for the number of vehicles to be subsidized, at 35,000 E-cars and 7,090 E-buses. Considering the dynamics of the sector the implementation has been made simpler. The work will be reviewed every three months by the Project Implementation and Sanctioning Committee and tweak the policy, if need be, for reaching the objectives set. Moreover, FAME II provides additional complementary incentives to FAME I, as noted in the policy but it keeps private vehicles out. The resources used by the government were purposed only for electrifying the public transport and commercial use. There is an underlying conception that all private vehicles will remain unviable unless they operate for 200Km/day or 40,000 km/year. However, without the private vehicle development of E-cars, that provide a critical mass for the industry development and environment, the volume will be delayed. It is noticeable that the Indian government tends to think decisions through a fund's limitation perspective, has an inability to better forecast and lacks experience to foster demand innovation policies, leading to postponing decisions. The approach is based on a step-by-step instead of using concomitant actions. This is limiting their investment potential and experimentations with all sets of mechanisms that are needed to diffuse E-cars faster and innovate better actions. It goes in contrast to India's fast-ambitious targets set, to develop E-cars, be less dependent on foreign imports (the country imports advanced engines and other technologies) (Madhavan, 2019) and become leaders in the industry. Nevertheless, to reach this goal, actions are not yet fully aligned and missing.

Various partnerships are developed between the Maharashtra municipality and car manufacturers such as Mahindra & Mahindra and Tata Motors under MoU I and MoU II. Under the MoU I Mahindra & Mahindra mentions about investing further in its plants to manufacture E-cars, E-motors, controllers, battery pack and other vehicle components to become fully electric (Mahindra, 2018). Under the second MoU a strategic alliance is envisaged to enable deployment of E-cars in key cities in Maharashtra by partnering with various fleet partners, taxi aggregators, logistics companies to roll out 1000 E-cars. These partnerships are important, providing a solid ground for reinforcing the E-car development agenda and extending to a faster longer-term support.

Barriers identified for E-cars:

- Environmental reasons are used as secondary basis to support decreasing oil dependence on imports. Effects: decreased policy influence on reducing CO_2 emissions.
- High upfront costs, low number of public charging stations, low investments in manufacturing (GNCTD, 2018) and low awareness (Gulati, 2012). Consumers identify charging time, driving range, battery replacement costs, top speed and acceleration being key barriers to buy E-cars. High cost of battery and the lack of infrastructure are identified as main criteria for consumers not choosing E-cars (Mukherjee & Varadhan, 2019) with high sensitivity of price and range (Gulati, 2012). Effects: low consumer demand of E-cars.
- Waivers are not fully used in India (VAT reductions for E-cars purchase and charging stations, tickets VAT exempted for public E-bus use are in plans (Electrive, 2019)). Effects: low consumer demand of E-cars.
- Coordination failure between the central government to procure E-cars for local governments and the existent charging infrastructure. Effects: delayed production of E-cars (happened twice).
- Exclusion of measures for private vehicles in FAME II (possible underlying reasons could be funds limitations but also a lack of proper forecasting of the E-car market development potential). Effects: the industry volume will be delayed.

Recommendations from the case of UK

The government of India would benefit from considering the environmental direction when framing its policies (e.g. Particulate matter emission standards, fleet emission norms, safety requirements) to accelerate the development of E-cars and enterprise profitability together with minimizing environmental issues. Environmental benefits could be monetized and offered in appropriate subsidies. Such environmental measures could produce a win favour for manufacturers of EV encouraging the inclusion of environmental based decisions.

It may also be ideal to give consumers a view based on their usage requirements and TCO and create commercial sense, especially because E-cars in India are not showing a high market increase (for instance since the year 2000 as seen in Table 7) with a low preference from consumers. Some E-car subsidization is needed because users do not factor in the societal costs fully while considering TCO based decisions.

There might be a need for India to include environmental drivers in policy designs for each electric vehicle for instance E-buses. Some studies compared E-buses built by BYD with diesel buses operating on the same route. These studies show that E-buses are more economical and as well environmentally friendly, however the policies in India and Maharashtra still do not include such environmental targets embedded in their actions.

The UK has such non-financial CO_2 and cars regulation with super credits and including E-cars as zero emissions cars for instance. India could learn from the UK to adopt such measure to recognize E-cars as one of most beneficial car technologies to switch to.

After such measures are implemented, may be beneficial to leave the market forces dominate and decide between internal combustion engine vehicles and hybrids or E-cars.

Recommendations from the case of China

What is interesting, in terms of policy support for E-cars, and what India could learn is that China has adopted a structured approach with concomitant action addressing all areas that need action, a five-policy tool support for E-cars for reducing taxes, give direct subsidies to manufacturers, consumer subsidies, mandate government procurement, and the industrial policy MIC2025 (NBR, 2017). The last policy driver supports indigenous technology development. China has economic and environmental reasons with environmental policies used when shifting to EVs and E-cars however, India does not use environmental policies to drive such change. Thus, there might be a need to adopt environmental policies and look also at China's model for inspiration in this case.

In terms of procurement, the government in China puts a major emphasis. China required that the central government, some cities, and public organizations, should have a minimum of 30% of their vehicle fleet comprised of E-cars by 2016. After this, in 2016 the goal was increased to 50% more. Such national targets imposed to local regions would help to create the "critical mass in the marketplace" (Jieyi, 2018) that India could follow and adapt especially for "agglomerated regions".

Market formation

The already existence of the automobile industry provides hopes into future developments and thus better supporting the development of similar but new technologies such as E-cars. However, the car industry in India is at an early stage of development (Heidrich, 2017), with non-motorized and public transport covering most of the trips. There is a low ownership per capita, with 22 out of 1000 people owning a vehicle (Abbas, 2018). These provide difficulties for E-cars to increase their share in the market, since most of the consumers presently are demanding more other forms of transportations, that are cheaper. Thus, most users are not seeing a real practical need of such technology to invest more money in. At the same time such conjuncture provides opportunities as well. For instance, to better manage air pollution and CO_2 emissions in cities which majorly come from the use of combustion engine vehicles and then to better persuade customers to choose an E-car instead of a combustion engine car. In the case of already owning an ICE-car could prove more difficult to convince to switch in a short time to E-cars in the present conditions and system.

India shows openness to cooperate with foreign companies, such as BYD from China that has already established a large manufacturing of E-buses and is willing to expand its E-buses in India. China is the largest producer of E-buses in the world, therefore can reduce costs when producing large quantities of commercial orders (McKinsey & Company, 2012). India received the initiative of BYD to launch in Bangalore an E-bus for a trial period of three months. This project had a positive result from where India could better observe the benefits but also the barriers to such technologies and seek to better integrate them within the cities' dynamics. From an operation and maintenance point of view the E-bus demonstrated that has a higher efficiency both economically and environmentally in comparison with a diesel bus. Moreover, it may be useful to adopt a battery leasing scheme and free quick charging points in all petrol stations that would sustain such cost benefits. However, importing buses from other countries is known to create additional costs such as for transporting the vehicles and adding taxes on top of the production cost, not to mention about the environmental costs involved. Thus, it would be useful to make a cost comparison between having a local production and importing E-buses allowing to consider the most benefiting choice.

Such tests are also undertaken by manufacturers in India, demonstrating that the manufacturing industry is willing to launch their E-car and E-bus products. It is signalling that the market is having a good potential for development if the policy subsidies are to be maintained on a long term. Even more, due to the consumer perceptions, it is found that OEMs started to standardize fast chargers for every E-car model and put attention into vehicles with longer range, offering competitive prices compared with ICE-cars.

It is noticed a correlation between the market share of E-cars, new E-car sales and the number of publicly accessible chargers depicted from the difference between the year 2016 and 2017 (see Table 7 - Electric cars yearly situation in India). Recent years show that India started to increase the number of public charging infrastructure that is highly correlated with the number of E-cars uptake. Under the framework set by GOI to enable charging infrastructure, different stakeholders are set to take initiative and any individual/entity is freely allowed to set charging stations without any license needed, from where it can derive a profit with a cap on the tariff. There are specific standards set that need to be respected when installing such charging stations. Even so, the number of charging stations are not enough, and the government of India is continuing discussions of whether to created adequate charging infrastructure for promoting sales or to wait until there are enough E-cars on the roads to start building it (Kotoky, 2019).

In Maharashtra, the adopted Electric Vehicle Policy 2018 is targeting demand by offering different value subsidies, fiscal and non-fiscal. An E-car fleet procurement is announced for the use in the chief minister's department, and minister of power declared an acquisition of 1000 E-cars within 2019 for government use. The Maharashtra government is partnering with manufacturing companies to help deploy E-cars for the course of 2019. There are only two manufacturing firms identified in the state to sell E-cars that is Tata Motors and Mahindra & Mahindra. Mumbai having the largest population in the state will be one of cities where E-cars will be firstly deployed and setting charging stations.

Nish markets emerging in India are government procurement E-car fleets, and public E-taxi fleet (Shah, 2019). Due to the lack of infrastructure (Ghosh, 2018), since the proposal in 2017, only 1000 E-cars from 10,000, were delivered by EESL to be used by government departments until 2019 (Saluja, 2019). Tata Motors Ltd and Mahindra and Mahindra the manufacturers that won the tender consequently were put on hold in producing and commercializing E-cars and expanding their business in the E-car segment (Shah, 2019).

Since we are dealing with a formative E-car market stage, many institutions have not yet been aligned to support the national direction to build an E-car industry in India. From the data collected we observe that the Competition Law in India is formulated around its traditional market and does not support in any way the current innovation trends. New technologies rely heavily on government support especially at such stages and adapting the Competition Law to this direction according to its context could contribute leveraging such interests to reach the set targets for E-cars.

Barriers identified for E-cars:

- Low ownership per capita of cars, 22 out of 1000 people owning a vehicle. This is a barrier for E-cars to increase their share in the market. Effects: low market uptake.
- The number of charging stations are not enough, and the government lacks directions for decisions of whether to created adequate charging infrastructure for promoting sales or to wait until there are enough E-cars on the roads to develop it (Kotoky, 2019). Effects: reduced market uptake (since the proposal in 2017, only 1000 E-cars from 10 000, were delivered by EESL to be used by government departments until 2019 (Saluja, 2019)); manufacturers put on hold production and commercialization of EVs.
- Lack of specific standards of charging infrastructure. Effects: confusion of which standards to use by manufacturers; decreased market uptake.
- Competition law does not support current technology innovations. Effects: lower support for E-cars development; lower market uptake.

Recommendations from the case of UK

India could think of implementing measures to support reducing environmental impact and rolling out of E-cars through its Competition Act. Such initiatives have been found in the UK that for instance, had allowed vehicle manufacturers to pool together and act jointly to meet emission targets, resulting in a chance for manufacturers of vehicles to sell CO_2 credits to the pool (Bird & Bird LLP, 2018). At the same time, it is important to note that in the UK the Competition Law is respected and companies limit their information shared to emissions of CO_2, emission targets and total number of vehicles registered. These examples can continue, with the Competition Law allowing more flexibility for businesses to collaborate and work for the societal good such as to reduce the environmental impacts arising from the transport sector and tackle climate change effects.

Even more, the UK supports local governments through funding (£40 million available immediately) for feasibility studies to build local plans for tackling pollution. This was added next to the £100 million in funding that was declared for the retrofit and purchase of new low emission E-buses (van Dorn, 2017). Next to the investments targeting EVs, India is lacking such budget push, where pollution reduction is targeted in case specific plans. This distinction may have the potential to aggregate more action in the market and have a clear distinctive environmental action direction.

The upfront cost of E-cars stays high in the UK compared to ICE-cars, however other factors are found to play an important role in consumer choice such as range anxiety, the reduced variety and limited choice of car models. Therefore, a take-away for India is to look into the consumer preferences and could put emphasis on the non-financial incentives that may be the most effective means to push E-cars uptake.

In this sense charging infrastructure plays a fundamental role in encouraging market uptake. We observe that in Sunderland under the Plugged in Places – a government funded program – a high number of charging stations have been installed. The program includes standards development, evaluation of technologies, harmonization of local incentives, understanding of users' behaviour and its impact on infrastructure, elements that can be included in the case of Maharashtra, Mumbai. The adoption of such a program, properly used can help India for instance to better decide on how many charging points to build in relation to the existent number of E-cars on roads. Even more, city centers are seen as easy access locations that can allow E-cars to charge faster than at home with stations built only for E-car use. Such strategies could be considered by the Maharashtra, Mumbai and finding strategic points for chargers to better serve users of E-cars.

Due to the high costs of E-cars, Nissan in Sunderland has introduced pricing business models, with leased battery sold E-cars that has the potential to reduce consistently the purchase price of E-cars. Even more, the manufacturer is planning to change its employees' conventional car use to using only E-cars acquired from Nissan. These are all measures that may inspire Maharashtra state to adopt sound business models that can reduce EV costs for consumers.

Recommendations from the case of China, Shenzhen city

China plans to ban the production and sales of conventional vehicles and uses economic but also environmental policy that target the creation of an innovation lead economy (NBR,2017). However, China enforces such policies when a low environmental preference exists, that is lower willingness to pay of consumers for E-cars than conventional vehicles, with environmental reasons not being present when consumers are making their choices. Even more, foreign manufacturers of E-cars are at risk of not being able to stay or enter in such critical market due to mandates for technology transfer, risking intellectual property or reducing the price of E-cars below the market competitiveness (NBR, 2017). Thus, considering India's context, would be unbeneficial to learn in this respect from China, that adopts a strategy that is tied to its unique political context and pushes decisions without requiring local governments and consumers preference. Thus, in India adopting such a model could be followed with limitations. India could learn from China's tendencies of protectionism and outcomes that are found in certain degrees as well in India and adopt measures to refrain from such protectionism that at certain extent are proved to result in unproductive outcomes.

China shows that government incentives and subsidies for public fleet have been more effective than private purchase for stimulating the sector. A subsidy from the central government has been in place in China since 2009 and helped to reach 0.3% of new sales in the E-bus market in 2011. This was ten times larger than the market uptake in the passenger E-car sector (McKinsey & Company, 2012). Therefore, a good strategy that India could follow is to catalyse efforts towards its public fleet procurement, supporting it with adequate government subsidies and local measures. These measures increasing E-bus and/or E-taxi fleets, rely heavily on government subsidies, being the initial catalyser of an E-car market creation where E-buses prepare consumers mind for EVs and E-taxis increase the existing public charging stations. This also supports consumer adoption of E-cars. Next to increasing the number of E-cars uptake, the sales increase in the commercial market would help reach critical mass manufacturing scale and increase capabilities. These will influence costs to decrease and improve performance and promote expansion of the charging infrastructure (McKinsey & Company, 2012) and subsequently evolve into a stage of market competition and less or not dependable on government incentives.

Shenzhen city in China, stands as a pioneer city in EV development. After benefiting from the government subsidies part of the demonstration cities project set in 2017 it moved on the second place from 13 cities that benefited from this program and emerged as the world leader in E-buses, E-taxi, and electric logistic vehicles (Huang & Li, 2019). All its bus fleets became 100% electric at the end of 2017 (Dmitry & Pontes, 2018). Therefore, India and Maharashtra state, could learn some good practices from this case specifically for building an E-bus fleet. For supporting the acceleration of E-car development, Shenzhen focused its efforts towards building a charging infrastructure with 173 charging points being installed and 36,550 charging piles deployed in 2017. An important factor for developing such niche and industry is the presence of the vehicle manufacturer BYD, being the largest E-car producer in China (Huang & Li, 2019). E-cars have highly contributed to the development of the economy in Shenzhen with an annual growth rate of the E-car industry going over 100% compared with its level in 2009. Therefore, having a look at Maharashtra, Mumbai we can see terms of comparability. In Maharashtra there are some large car manufacturing companies, thus having the potential to develop E-cars in the state faster and even become a leader among cities. Under a proper government program Maharashtra and Mumbai could start forging such actions and focus to engine the industry by building a proper E-bus fleet and E-taxi following the example of Shenzhen city.

An important part for the configuration of E-cars is the charging infrastructure, being a barrier for scaling up the private market if not developed properly. As well a small market gives low incentives to manufacturers to invest in building charging points (Huang & Li, 2019). The municipalities intervened in China to build charging points. Similarly, in India municipalities could begin actions in building such charging stations.

In Shenzhen, due to higher prices of E-cars compared to conventional vehicles, specific business measures have been adopted for the public transport. A business model strategy used consists in a financial leasing of the battery, being this way separated from the vehicle, combined with a charging and maintenance model that has been reported to be highly successful (Huang & Li, 2019). This approach could help Maharashtra to better tackle its barriers of costs and infrastructure development. Maharashtra, Mumbai could implement a same business strategy for supporting its E-bus and E-cars fleet development.

Resource mobilization

FAME Phase I scheme comes with a total investment of approx. 1,2 billion USD and allows several financial capital mobilizations. From its inception until December 2018, incentives were provided for a limited number of E-cars, 261,507. The procurement investment sanctioned 455 E-buses for 9 cities. However, the number of cities requesting E-buses were 44 seeking a total of 3144 E-buses, a discrepantly high figure with what was offered. Therefore, we can conclude that there is an economic miscommunication between the central government and the municipal level, a mismatch between government supply and local demand.

In manufacturing 100% foreign direct investments are permitted in the automobile sector while the private and public sector are free to carry out investments in the automobile sector, including manufacturing of E-cars and E-buses. However, such investments of foreign entries as well local are not happening due to the instability and volatility of the market. This is caused by the incipient nature of the market, continuous policy changes and discrepant short-term change of targets. Such changes happen even during the same political mandates, making it tougher to predict on how the market will fluctuate and in which direction will develop, if a stability would be manifested at some point.

FAME Phase II scheme brings a financial input of 1,4 billion USD from 2019 to 2021 for upfront purchases and infrastructure establishment. For the electrification of the public transport, including shared transport demand incentives on operational expenditure mode for E-buses will be provided through STUs. The incentives will be available only for public transport or commercial purposes. 55,000 E-cars and 7000 E-buses are planned to benefit from the scheme. The charging infrastructure establishment will aim at 2700 charging points to be established in metros, comprising cities with a population of over 1 million, smart cities and cities of hilly states. Until August 2019, 5595 E-buses distributed in 64 cities were sanctioned by the government. It is therefore noticed a stabilization of the relation between local demand and the supply offered by government, allowing space for more E-buses to be deployed. The charging points are to be set part of the grid of 3 x 3km. In major highways that connect city clusters, charging points are set to be installed at 25km distance from each other. Infrastructure is seen as a principal point to speed up E-car and E-bus in India. As observed private vehicles are not included in the scheme being considered unviable to be supported directly at this stage. This exclusion brings again uncertainty and may block certain investments in manufacturing allowing lower space for the industry to develop. The E-car market is being pushed forward based on public transport enablement, funds allocated for infrastructure. However, since the private vehicles do not receive any direct financial incentives, it may be concluded that the strategy to increase E-cars on the roads is incomplete with limited perspective for manufacturers and support for buyers of private E-cars. The existent latent demand is not entirely used.

Barriers identified for E-cars:

- Discrepancy between national supply and local demand (The procurement investment sanctioned 455 E-buses for 9 cities. However, the number of cities requesting E-buses were 44 seeking a total of 3144 E-buses). Effects: reduced market development of E-buses; delayed consumer awareness for E-cars.
- Instability and volatility of the market caused by the incipient nature of the E-car market, continuous policy changes and discrepant short-term change of targets, happening even during the same political mandates. Effects: tougher to predict the market fluctuations and if/when a stability will be set; investments are reduced. (This barrier has a functionality overlapping nature. It was put in this function due to argumentation of its effects on investments).
- Private vehicles are not included yet for subsidies in policy schemes. Effects: blocking certain investments in manufacturing; not making entirely use of the existent latent demand.

Recommendations from the case of UK

Fiscal incentives could create positive outcomes when directed at specific barriers, impediments, or synergies to promote the development of the demand. Such as in India in the UK the upfront cost of E-cars is higher than the ICE-cars, but the fiscal incentives in UK does not have a clear share in the E-car market with other non-financial factors playing a significant complementary role. Thus, India could learn from this case and balance its fiscal interventions with non-financial instruments, such as waivers. Road waivers have been included in India so far, but these are not enough (Saluja, 2019). Since waivers in India are seen to play a primordial factor in consumers choices such instruments could generate better results if included also in the initial purchase price and better managed along the financial options. For instance, in UK the annual ownership tax of 600 euros is waived for cars with emissions of up to 100 g/km, or the first-year tax ownership which is higher, is reduced for low carbon vehicles. Even more, taxes are seen beneficial if are applied similarly to commercial vehicles. In the UK, for private use of company cars, the taxable income ranged from 5% of the cars price for vehicles emitting below 50 g/km to 37% being applied to cars releasing high CO_2 emissions (Tietge, 2016).

Even more, since in India there are no measures to support private E-cars, the UK may offer a viable scheme that India could adopt and adapt to its context and support E-car adoption. In this sense we identify three financial incentive policies representative through their names: Plug-in Car Grant, CO_2 -based annual ownership taxes, and reduced taxes on the private use of company cars with low CO_2 emissions (Tietge, 2016). Here we observe that the UK includes environmental policies applied on the competing technologies ICE-cars thus aiming directly at reducing CO_2 emissions element that could also be considered by the Indian government. Including taxes on cars that exceed a certain level of CO_2 emissions with taxes applied for the different CO_2 values accordingly might persuade consumers to switch to cleaner technologies and E-cars. There is a recommendation found by the House of Commons when the UK government announced to cut substantially the grants to the Plug-in Grant Scheme, that may be kept in mind for Indian government actions as well. This was to maintain levels of support until the cost of E-cars reaches parity with ICE-cars. The policies may be constructed to reach every consumer. Even more, the targets set to be reached may be accompanied by adequate incentives, that need to be maintained continuously to better promote E-cars.

Charging points are currently few in India, only 222 publicly accessible chargers as for 2017 (Global Outlook, 2018). In its FAME II India started to put a strong emphasis on charging infrastructure through which it employs private enterprises to enable the charging eco-system. Through this scheme it enlarges the permission of setting public charging stations by different actors and in different locations. It allows private charging at residence and office, and any individual/entity to set up a charging station, without requiring a license. The individual/entity must respect the technical requirements standards and any other specifications set by the Ministry of Power. Although the scheme brings important changes, there is no subsidy support identified for such private chargers in India. The UK through the Electric Vehicle Home Charge Scheme is offering a subsidy support of 75% of the total installation cost for the private chargers that could be adopted and adapted in India. In the UK the private users must own an E-car, this detail is not included in India however may be considered in a later stage after seeing the results of the current actions and/or when E-cars start to increase in numbers. India could also consider a program of investments to match private investments and public funds, as the Plugged-in Places program activating until 2013 for instance in the UK that brought an additional support to the subsidy of home chargers offering funds for public and semi-public charging infrastructure. From 2015-2020 the UK is allocating funds for different directions with the largest sum canalized towards home-charging schemes, then to public infrastructure and other infrastructure investments.

It is found that the UK has a poor provision of charging infrastructure, being in deficit of size and geographic coverage, where national authorities despite their decisions leaves the initiative more to local authorities. This brings discrepancies and the government should take responsibility to coordinate a shared approach for national charging. Such take away lessons could serve the Indian government future actions to maintain a proper coordination, support, and shared vision with the local municipalities. Whatsoever, compared with many other countries, in the UK the E-car industry has gained larger experience and results since its inception, thus India could be inspired and learn from such a model for its future decisions.

Even more, India could try to involve OEMs to move down the value chain to ensure that their E-cars are sold providing their own installation services and/or offering hardware discounts (PwC, 2018). Even if subsides are provided or when subsidies end, not all consumers in India afford home chargers or E-cars or will be willing to pay a full price. In tackling such differences OEMs could share their part in offering specific provisions to increase sales of E-cars. It is seen that in this sense Tata Motors in Maharashtra state, under the MoU said to build up charging stations in the state together with the group firm Tata Power (Banerji, 2018). Tata Power is planning to install 100 E-cars charging stations in Maharashtra (CarAndBike, 2018).

Standardization plays an important role and information to motorists on the location, capacity, availability, and pricing of charge points are needed. Other such decisions that would help users to trust the infrastructure service and have better access to charging points (House of Commons, 2018). These are important provisions for the UK and to be considered potentially from earlier stages of development in India. The government needs better regulations and to continuously improve consumer experience (House of Commons, 2018).

The Maharashtra state and Mumbai could learn good practices from Sunderland case in the UK on how to manage the cluster manufacturing, local government and national government information and resource flow. This could be realised together with associated actions for building a better infrastructure and reduce E-car costs. Sunderland is considered the best place in the UK for E-car charging stations. The region benefited from the Plugged in Places government programme that made available funds for building charging points and reduce E-cars purchase costs (Hübner, 2013). An interesting feature of the program that could be beneficial if considered in Mumbai, would be the aim of the program to feedback the experience gained by practice, while creating and operating charging infrastructure, into future policy decisions regionally and nationally (Hübner, 2013). This included standards development, technology evaluation, harmonization of local incentives, understanding of user's behaviour and its impact upon the infrastructure (Hübner, 2013). It is found that even if Sunderland has a high number of charging stations, many of them are staying empty with no vehicles to be charged. E-cars have not increased their number in the market concomitant with the provision of the charging points due to the lower purchase cost of ICE-cars (Sunderland Echo, 2013). This determined Sunderland to change the pricing model and use instead leased battery sold E-cars resulting in a £15-6000 price reduction, but it was still not enough to obtain a cheaper price than ICE-cars (Sunderland Echo, 2013). This could be the same case for Maharashtra, learning from the Sunderland case could consider such difficulties and take measures in advance that can secure in time and faster the potential to reduce E-cars price below the petrol and diesel vehicles.

From such learnings, and if stabilizing its policy ecosystem to support the development of E-cars, the Maharashtra state could attract high investments in the area considering its existent automobile manufacturing centres, that could develop a massive production of E-cars by pursuing better the demand. Presently India is making reductions in import taxes of components of EVs including E-cars, reduced in January 2019 at 10-15% from 15-30% according to the Central Boarding of Indirect Taxes and Customs (Ganguly, 2019). However, instead of importing E-cars develop the local production, where parts of cars especially batteries, could be produced in the region. This could propel India in an even better position with increasing local economic productivity and helping decrease costs of such vehicles. We observe that the Sunderland Plant has invested in its own development and received massive funds from the local and national government but also from European institutions – European Investment Bank (2011). In this sense the European fund is also supporting the construction of a plant for production of lithium-ion electric battery cells at Sunderland Plant. Locating battery production close to E-car production can support the reduction of working capital, shortening the cross-border supply chain, and lowering carbon emissions caused by transport (Faraday Insights, 2019). Lithium batteries are in the category of miscellaneous dangerous goods implying a careful handling of such products and with the increase of volume this can become more costly and challenging for the industry to handle (Faraday Insights, 2019). It is noted that if the UK would have not developed such strategy to build a manufacturing of E-car battery industry in its proximity its production of E-cars might have been decreased. Mahindra & Mahindra, the largest manufacturer of E-cars in India has already said to establish a lithium-ion battery manufacturing plant in Maharashtra together with the South Korean company LG Chem (Ghosh, 2019). To realize this, there is a conglomerate of funding that the local municipalities and regions in Maharashtra, Mumbai could attract from different stakeholders. To realize this, policies, political decisions, and strategies should be better aligned and build trust through consistent behaviour and actions. They could benefit from building a market that indicates continuous potential for such business investments to find profit.

Recommendations from the case of China

The same as the other cases, in China the limited battery capacity and travel range are a major barrier for E-cars to diffuse. For this reason, local governments in China could receive around 13 million USD, for building charging stations. This funds however, come with certain conditions to be met, as for instance the cities must reach a certain amount of E-cars purchase. This kind of conditions could be considered in Maharashtra, Mumbai to avoid creating a discordance between the number of charging stations and running E-cars, as we have seen in the case of Sunderland.

Learning from the protectionism cases of infrastructure standards in China we can deduce a benefit if doing the opposite. Standards for charging stations need to be aligned with all municipalities and regions, building a national standard set for all electric chargers and allow manufacturers to collaborate if needed for such purpose. Having different charging standards from one region to another can hinder innovation. When setting protectionism to allow only the charging of E-cars used in the respective region, it limits the market expansion and competitiveness.

4.2.2 One of the key reasons for chasing E-cars: environmental drivers in India

Pure environmental drivers are found not to be the biggest thing in India. Economic growth reduced foreign oil dependency and increased energy security are the main drivers of desiring a switch to E-cars. These can be translated from the discrepancies found between such desires and the key features of environmental problems which are complex and have long time frames (Mickwitz, 2003). The complexity behind such environmental issues finds India unprepared to act and comprehend entirely such reasons. India would require building a greater capacity and system interactions at every level to better handle an environmental transition to E-cars.

In connection with the above, environmental problems have very unequal distributions of impacts on different groups in society and have been formulated mainly by scientists. Being in an early-stage E-car market formation and considering its political and consumer preferences, India has not been assessing yet such environmental impacts, or better said did not have yet the right resources to properly evaluate benefits to create a clear policy based on environmental drivers. Environmental drivers involve huge uncertainties and involve stakeholders with conflicting objectives and different beliefs systems (Mickwitz, 2003). These features resonate with the current situation in India, where clear environmental goals are not yet defined, with large changes in target set happening in a short time, with stakeholders having different perspectives.

Framing policies to reach environmental targets would be significantly important for India and EVs are recognized for their potential to decreasing such impacts. Embedding the criteria found in the framework for the evaluation of environmental policy instruments (see Appendix B) that is the general criteria for the evaluation of environmental policy instruments, the economic criteria, and the democracy related criteria in the assessment of the electric vehicle policies, would reveal specific environmental weaknesses of policies and strengthen the environmental perspective of benefits that E-cars can bring. For instance, research has revealed that the characteristics of regulatory instruments and their flexibility in being implemented are important for increasing economic welfare (Majumdar and Marcus, 2001; Blind et al., 2013). The criteria are evaluated according to Maharashtra policy that is adopted in Mumbai as well (Table 13, Table 14 and Table 15).

Table 13 General Criteria for the Evaluation of Environmental Policy Instruments: assessing the EV Policy 2018 in Mumbai, Maharashtra through the demand measures perspective

Criteria	Related questions
Relevance	The goals and targets of the policy do not include direct targets in reducing environmental problems. The targets aim at increasing the number of E-cars on road and state such number targets to be achieved and secondary supporting measures, to support such target, such as the investment target required for E-cars and manufacturing and infrastructure. Another indirect target, to create jobs, aims more at economic growth through the sector though being as well a supportive side for E-cars and implicit environmental impact reduction.
Impact	No environmental impacts due to the policy instrument can be identified yet.
Effectiveness	The policy envisions promising achievements in terms of supporting E-car deployment, no specific data can be found now regarding the policy specific contribution to achieving the targets.
Persistence	It can be inferred that increasing the number of E-cars as the policy is supporting and the continuous maintained support that is provided will sustain adjacent improvements in the state of environment.
Flexibility	The policy seems to be accommodating flexibility for changing conditions from outside (national level) or inside (new measures that are needed due to local context requirements). It is found that the policy is in tune with the national policy plan for E-cars.
Predictability	The pre actions materialized during the national policies FAME I and FAME II, the political support for transitioning to E-cars, the existence of the manufacturing sector in Maharashtra that is found to be willing to turn electric if the conditions of the market turn favourable, all these make the output predictable in practice.

Source: Table adapted after Mickwitz (2003)

Table 14 Economic Criteria for the Evaluation of Environmental Policy Instruments: assessing the EV Policy 2018 in Mumbai, Maharashtra through the demand measures perspective

Criteria	Related questions
Efficiency (cost–benefit)	Difficult to determine precisely in this study and due to the conceptual and practical problems involved by the economic criteria.
Efficiency (cost-effectiveness)	India can learn from other successful cases, such as exposed in the present analyses, from China and the UK. Doing so and with the right means can better plan and strategize its actions and build policies that support faster implementation without lousing time and resources in experiments that turn out to be unviable. India should maintain its policy support on a long-term basis. If learning economies are too low (meaning costs of learning are high), a subsidy requires a permanent setting, and would not contribute to a self-dynamic process (Edler, 2013 p 23).

Source: Table adapted after Mickwitz (2003)

Table 15 Democracy-related Criteria for the Evaluation of Environmental Policy Instruments: assessing the EV Policy 2018 in Mumbai, Maharashtra through the demand measures perspective

Criteria	Related questions
Legitimacy	Not included
Transparency	The process conduct is transparent. Decisions and opinions are published and stated openly, and policy documents are discussed in different instances and made involving a large category of stakeholders. Nevertheless, due to the low awareness found can be concluded that consumers are not much included in the decision-making process.
Equity	The policy seems to be agreed and implemented by a varied number of actors. The outcomes and costs of the environmental policy instrument are generally evenly distributed, however omitting to target private consumers directly in the formation stage. Presently private vehicles are considered unviable, even if the subsidy would be in place.

Source: Table adapted after Mickwitz (2003)

This section can constitute the starting point of future research that could comprise such fundamental issues where a proper environmental evaluation of the system in India could reveal, support, and complement future transitions towards E-cars development.

5 Discussion

5.1 Discussing findings against the literature review

5.1.1 Comparative analysis of findings with the current knowledge related to EVs in India

This section looks at comparing the findings from the literature review section with the analysis results after using the analytical framework. The discussion flows from the literature review to the analysis. This way it is allowed a clearer identification as well of what was found in the functionality and the literature review falling in its category. The discussion does not include the recommendations made in the analysis.

The NEMMP 2020 expressed hopes for innovation development, alternative technologies and energy efficiency while reducing oil imports, depleting of local traditional energy resources and the negative impact on the environment. However, these points were not reached as planned. The points are in accordance with the analysed indicators in the influence on the direction of search function where also some obstacles next to drivers are identified for realizing this. Drivers identified are the decentralized system, with liberal markets, where cities compete between each other, spurring the creation of innovation and supporting E-cars. Local gas industry may serve to a certain extent as a driver/supporting allied to switch from the use of oil-based gasoline to E-cars and on the other half as a barrier if E-cars are used just as a motivation to switch to more gas engine vehicles. A complementary approach may serve as a driver.

Two most important barriers are shown in the NEMMP 2020, that must be improved in an earlier and existing E-car demand incentive scheme, which are lack of continuity of the incentive policy/scheme and simple and effective incentives delivery mechanism for an easier more efficient reach of facilities (Gulati, 2012). The *influence on the direction of search function* finds that India has poor measures and policy programs of subsidies and incentives (Agrawal, 2018) being in accordance with the NEMMP 2020 stated requirements. The function analysis also exposes the lack of continuity of the subsidies in India, that fluctuation of subsidies or totally missing affecting effectiveness. Important missing mechanisms are for instance those addressing directly environmental issues. As mentioned in the previous chapter in the Evaluation of Environmental Policy framework, the criteria of in Table 13 and 14 are structurally highlighting issues found from this matter.

A study conducted by the Indian government using consumer surveys revealed that OEMs, research institutes and component suppliers indicated that the low demand for E-cars in India is a consequence of high price, low performance, lack of infrastructure and low awareness (Gulati, 2012) and indicated a high latent existent demand for E-cars especially if the prices are met (Gulati, 2012). Main barriers for E-car adoption according to NEMMP 2020 are poor pick up, low top speed and issues relating to battery replacement. Demand side incentives are identified as being critical for local production and demand creation and realize the latent demand. In case of E-cars a sensitivity analysis demonstrated that consumers are highly influenced by price and range of E-cars (Gulati, 2012). In the *influence of the direction of search* analysis the same barriers are mentioned, with some studies identifying battery being the main source of many of these barriers. Consumers see high costs of batteries and lack of infrastructure the main criteria for not buying E-cars (Mukherjee & Varadhan, 2019).

An increase in latent demand is identified based on the projections on TCO analysis for E-cars if the right incentives are provided. The most preferred incentive for E-cars was found to be cash/tax subsidies (in 58% of respondents) with subsides for batteries on the second preferred option (56% of respondents). Free parking is found to be third on the preference rank (Gulati, 2012).

The demand incentive scheme according to NEMMP 2020 strategy, suggests comprising a quantum of incentive, the parameters for deciding their distribution between the vehicle's segments and technologies, the minimum qualifying criterion/boundary parameters that need to be insisted, and the supplementing demand assurance measures for some of the vehicle segments (Gulati, 2012). The E-cars and E-buses are required a demand assurance through government fleet procurement mandate (Gulati, 2012). We identified in the findings and analysis of the *resource mobilization function*, that FAME I and FAME II are not falling completely in the NEMMP 2020 recommendations. FAME I and FAME II have been developed chronologically separately, complementarily, with one built on the learnings of the other. However, for E-cars there are still some supporting measures missing such as measures for the private vehicles, being considered unviable at this point. In the *resource mobilization function,* it is concluded that this can slow down development of E-cars and market diffusion, adding to uncertainty anxieties and not taking advantage of the existent latent demand.

The E-cars and E-buses are seen to be considered for the highest incentive due to larger battery size as compared with hybrid E-cars and hybrid E-buses. Higher performance E-cars would be recommended to receive the higher number of incentives, performance being set according to consumers identified needs, such as pick up and top speed (Gulati, 2012). However, additional performance parameters are mentioned to be developed (Gulati, 2012). These incentives are not found to be rolled out yet for private E-cars, as mentioned previously in India, these are not being subsidised yet. Private vehicles are seen not to be viable unless they operate for 200 km/day, or 40,000 km/year as specified in FAME II.

At the local level, in Maharashtra and Mumbai we find different announcements from the government to support E-cars development (Government of Maharashtra, 2018; Swapnil Rawal, 2018). This is comprised in the *knowledge development and diffusion through networks function*. The function reveals that the institutions in Maharashtra and are not yet collaborating smoothly in between each other and with national departments, networks showing missing activity between units in the government. Important established partnerships in Maharashtra are with local vehicle manufacturers, Mahindra & Mahindra, and Tata Motors, through signing the MoU (Banerji, 2018; Business Line, 2018). These are analysed in the *influence on the direction of search function*. We could argue that the process is held democratically, with transparency in the process and involvement of different stakeholders to a certain extent however with limitations and with obvious place for extending collaboration. In the Evaluation of Environmental Policy framework Table 15, the democracy criteria identifies such transparency and also equity questions in Maharashtra, Mumbai. Looking from the *market formation* perspective functionality, it is found that nish markets in India such as government procurement E-car fleet and public E-taxi fleet were held behind due to the lack of infrastructure. Consequently, EV manufacturers Tata Motors Ltd and Mahindra and Mahindra, the tender winners, were hold behind (Ghosh, 2018). Moreover, the Electric Vehicle Policy is adopted in Maharashtra offering various subsidies that advantage manufacturers and consumers to pursue their desire to develop and adopt E-cars.

5.1.2 Assessment of contribution to theory

Demand in innovation theory is described in chapter 2 and used in this study. As identified as well in the analysis the policy instruments targeting demand in the transport segment are crafted for helping innovation to occur, with regulations, standards, and public procurement as engines for innovation creation (Edler, 2013; Izsak & Edler, 2011). These instruments are sometimes confused with regular policy instruments, as traditionally categorized, however in India demand policies are used with the purpose to support innovation as mentioned also in the NEMMP 2020. Demand incentives are shaped by the potential buyer, that expresses a need and can co-produce the innovation with the suppliers (Edler, 2013). Consumer subsides are considered extremely important demand instruments especially on early commercialization phase (Sierzchula et al., 2014). Fast growing demand is seen as the most important incentive for investments and a main support of technology diffusion (Horbach et al., 2012; Newell, 2010).

TIS structural components and functions

It is specified that in TISs that are newly emerging there are uncertainties having the structural components not easy to identify and to utilize with networks for such technologies not being formed yet. For instance, as identified in the resource mobilization function analysis, the local demand of E-buses came from 44 cities with a total of 3144 E-buses compared with incentives provided by the FAME I that supported 455 E-buses for only 9 cities. This concludes the lack of proper network formation, between local and national levels, posing uncertainty and difficulty of E-bus market creation and subsequently E-car. In India the phase of development of the TIS is at a formative stage with non-motorized and public transport forming most of the trips (Agrawal, 2018). During this phase are being set up the constituent elements of the innovation system and the functions of the emerging innovation system are influencing the technology development. For instance, charging infrastructure functionality in India needs greater development, with the government pushing presently in its FAME II the development of public fleets, but lacking behind on charging stations in relation to the number of E-buses planed for deployment (Saluja, 2019).

In such formative phases the theory specifies that it is found natural that the TIS is characterized by new entry of firms and other organizations, formation of networks and institutional alignment with high uncertainty of entrepreneurial actors, investors and policy makers, markets, and regulations (Bergek et al., 2008 a). These are identified in India and exemplified in each functionality analysed and found in an interdependent relationship and influencing one another. This explains the functions as well overlapping nature construct mentioned in the TIS theory as well (see Bergek et al., 2008a, Bergek et al., 2008b) with repetition occurring but from the different functionality perspectives. The interdependence and overlap can be understood in this case as well from an economic perspective and market fluctuation according to supply and demand rule. Manufacturers and investors need assurance that their investment will provide returns and depend on such certainty that is provided by the other dimensions: policy makers, markets, and regulations. Policy makers, need to develop the right investments mechanisms, regulate markets in such a way to support the new technology and increase consumers' demand.

Moreover, for the TIS to be formed it can take even decades, a long time to be formed. This process requires many small cumulative changes (Bergek et al., 2008 a), found in detailed levels that after being set in a proper place can cause the transformation towards the growth phase, and scale up at a more considerable size the electric vehicles. Such characteristics are obviously revealed in India, with policies starting small, testing initially as in FAME I that was extended until FAME II was released with new actions to complement each other, however not entirely in such dimension to realize the targets proposed and the NEMMP 2020 target expectations. With changes occurring in the system, such as institutional change or new entrants, will influence the system to develop in relation to the change and its direction, that in turn generates actions and reactions (Bergek et al., 2008 a). These are observed when the BYD E-bus test was implemented, or when the government started subsidizing charging stations for EVs, positive reactions were produced with such nish markets driving way through the existent incumbent. In Bergek et al., 2008 a, it is mentioned that the role of policy is to support the formation of new TISs that then can develop further in a "self-reinforcing growth system". For this to be realized entrepreneurs and policy makers need to be aware and put their efforts in contributing to build the new system. These are points recognized in India, where policy makers and manufacturers are working together towards such achievements.

In the Indian emerging TIS the present study has focused on the main functions, building blocks in such stage. These were identified as *knowledge development and diffusion through networks*, *influence on the direction of search*, *market formation and resource mobilization*. As illustrated in the theory as well, suggests that developments normally begin having a limited number of functions called "motor of change" that encourage other system functionalities (Hekkert et al., 2007), and bring the destruction within the incumbent system. The literature here suggests that for this reason it is important to look at how such building process take place, that in return could help observe insights that guide the innovation direction in other nations and sectors (Hekkert et al., 2007). These are identified in the cases selected for this study, bringing the advantage of more experience, and developed E-car systems, from where such functions are being analysed, India can learn and start implementing actions without lousing time with some experiments and may consider less postponing of some actions due to specific insecurities of realization and accelerate the technology growth. The functions in the TIS help identify system strength and weaknesses (Bergek et al., 2008 a) after which policy makers and entrepreneurial firms may choose which blocking areas need attention for being improved (Bergek et al., 2008 a). Such weakness and strengths have been identified in all the cases selected for this study, while focusing on the Indian system. The UK and China were used as learning cases with an emphasis on strengths however some weaknesses have also been included, so that India could possibly avoid such conducing actions towards producing similar system weaknesses and massively learn from their strengths, resulting in possible solutions for India. Here it might have been indicated as well to complement such comparisons with a chronological assessment of events in each system, the UK and China. Such analysis could reveal more specific details of system building activities and for the specific stages of development that then can be better mapped with other systems, such as India. This may contribute as well to better delineate the stage formations of the TIS that may be categorized with additional levels or sublevels. Since India is learning from other systems that have already experimented largely and diffused high numbers of new technologies in the market, it might be useful to consider the restructuring of the stages/substages of the TIS, and adapting them, that in such learning cases may overlap more, reduce considerably the time of a phase and/or eliminate a specific phase or/and subphase. Such theory can create a map that helps learning systems to reduce learning time that was used in already more developed market technologies and skip stages/substages by already adopting all elements required by the system to help the new technology develop faster. These imply the utilization of additional functions earlier compared with systems that already experimented, however always considering context specificities. The stage of formation of the present analysed innovation system, might be considered slightly above a formative stage, but a formative and strengthening design stage, a single stage that includes elements from both categories, thus leading to the idea of the necessity to build a specific merged category for such learning economies. This could influence a faster adoption of the new technology and make such observation clearer if India implements faster and less gradual what was already learned and what could be learned. The policies adopted in India as seen in FAME I and FAME II are gradually building the system however, the questions arise whether these are too gradual or slow and might need at some stages more supporting actions to benefit the TIS formation. Since already India can learn from other systems experiences, these could be easier to implement if there is enough political will.

Process approaches method

A sequence approach or process approach is suggested in the literature (Poole et al., 2000; Abbot & Tsay, 2000; Wu, 2000). It is also mentioned that when using statistical models, the qualitative aspects of processes and the multitude of knowledge created around these are usually disregarded (Hekkert et al., 2007). The process approach adds a different dimension, by telling a story about how function X is influencing the technology development whereas the variance approach, with a function X can explain in a limited way how a new technology is developing (Hekkert et al., 2007). As for instance looking at the sales figures of EVs in India for a period, without a thorough understanding of how these figures changed and emerged with 'event' descriptions there would be insufficient evidence to support other systems in developing new technologies. In such cases of mapping the events in a specific TIS, requires not a thorough look at all system agents but a broader overview of events happening at system level (Hekkert et al., 2007). As the theory suggest and applied in the present study, these are collected "preferably" from newspapers articles and professional journals and then allocated to the specific functions (Hekkert et al., 2007). Additionally, in the present study data has been collected also from government documents. If there are many events not able to allocate, it translates in having functions that are not complete or with no meaning (Hekkert et al., 2007) or if there are too few events in a function it might make the function irrelevant (Hekkert et al., 2007). This could stand as a secondary reason, after the space limitations of such present studies, confining its investigation to the functions found fundamental and more active in a formative phase TIS as found in India, Maharashtra, Mumbai case thus for this reason excluding legitimation/counteract resistance to change. Such events are found to be positive or negative to the specific function they are contributing to (Hekkert et al., 2007). Such events are mapped in all the functions analysed, with precise statement and actions found in the specific function for India, Maharashtra state.

These events if can be all allocated to functions can be after visualized in figures that can show more precisely patterns over time (Hekkert et al., 2007). These drawing figures could be a needed tool for the present study, to better clarify certain directions and complement it. As identified just some lines before, such storyline analysis would serve if plotted over time, revealing details about how the changes occurred contributing to the development of the technology system (Hekkert et al., 2007). These would reveal specific causes of the function's dynamics that can determine their performance level. Analysis between cases can be performed after this to test if the specific patterns identified are bound to a sole case or can have more general characteristics (Hekkert et al., 2007). These as well motivate the use of more case studies in the present research, where the comparability identified similar patterns, that can be adopted in the context of India but as well identify context specific patterns and eventually map ideas on how these can be tackled. The final role of these patterns is serving policy makers recommendations for the governance of the specific TIS (Hekkert et al., 2007).

Driving forces and blocking mechanisms

Differentiation between internal and external factors of the TIS are important to see the influences coming from these directions. In the functions of the TIS such dimensions are not visible but present (Bergek et al., 2018 a). Such differentiations are better characterized by Geels (2002), in niches that are part and forming regimes, and regimes are part of a larger segment called landscape. From these the landscape is an external factor and obviously are more difficult to change than regimes seen as incremental innovation and radical disruptive changes appears in niches (Geels, 2002). In the influence on the direction of search niches are identified in India, as disrupting actions of the combustion engine regime. In the formative phase it is seen that in India niches need to multiply and cumulate forces continuously to reach an incremental stage.

The landscape here is represented by international reports on climate change, such as pe IPCC requiring a reduction of 50% in GHG emissions from 1990 by 2050, aims to reduce the current import oil dependency in India, targets to reduce pollution in cities. Moreover, the work of manufacturers of electric vehicles, world-wide are pushing the industry globally. Targets set by all big car manufacturers around the world to electrify their vehicles production, such as Volvo in Sweden to phase out production of vehicles that run on gasoline or diesel fuels by 2020 (Mitchel, 2019), BYD in China expecting increased revenue from e-buses (Cox, 2018), new model released by Nissan Leaf with 85% less running costs than an average petrol or diesel family car (Ward, 2018) are important constituents of the landscape. Even more, India is part of the Electric Vehicle Initiative coordinated by the IEA where many countries are active at the moment (Tata Power, 2019). These are all external driving forces supporting the electrification of the transport system in India.

The definition of a technology system's borders is realized by the analysis of blocking and promoting factors of the system. As seen above, these factors can be technology specific (internal) or general, having an influence on other systems (external) as well, with "units of analysis such as technology, industry, nation" (Johnson & Jacobsson, 2001, p. 93). The blocking mechanisms identified in the Indian TIS, reveal the specific needs of interventions that policy makers need to make. Moreover, identified blocking mechanisms in advanced EV system such as UK and China, can help India and Maharashtra state, Mumbai city to avoid doing the same, gain time and better results faster.

5.2 Reflections on the results of the study

Methodological, theoretical, and analytical choices

A case based oriented research (COR) design is used for this study. COR uses multiple cases, in moderate number to compare between cases the selected variables that have been chosen (Ragin 1994; 6 & Bellamy, 2012). The present study used COR characteristics, and analysed in depth variables particularities and behaviours, taking in account the context where they are found to allow comparability. The selected cases are UK, China around a central case study, India. Therefore, UK and China were selected to match the case comparability with India in accordingly specific selected areas. By following such characteristics, the comparability could be made, and the results could be obtained more accurately. Qualitative methods were found fundamental for this kind of research, allowing research instruments and analytical frameworks to be improved (Ragin, 1994). Using such methods, the events in the cases could explain how the electric vehicle market in India is starting to take shape and how it moves from a specific point A to B, such as from having no policy measures to support the development of a charging infrastructure to measures incorporating such subsidies. How specific niches contributed to raise demand, such as the creation of an electric fleet, and what were the missing dots that blocked their deployment, as we have observed the mismatch between the number of e-buses the government could dispatch and the number demanded in the cities, were not coordinated. Looking into the benchmark cases barriers identified in India are raising opportunities for finding key learnings from these cases that can support better measures in India and Maharashtra, Mumbai.

Coding data explains the systematically important variables behaviours and results. As we can see in table 16, the category of policies and their intended aim in each of the countries analysed were mapped, revealing patterns, clearly missing policies and other existent differences or similarities between cases. In this case, as well as mentioned in the COR theory, the missing elements are of most interest, that lead to search for explanations that cause such differences to exist and explain the course of events in each case to establish transfer of good practices if the case comparability is appropriate.

The method of agreement is found to be one of the ways to have valid comparisons for creating meaningful inferences (6 & Bellamy, 2012). It comprises the choice of one or two cases with similar outcomes or dependent variables (DV), where the independent variable is analysed as outcomes they produce. These are clearly embedded in the RQ and tasks of this study. E-cars diffusion is seen as dependent variables whereas subsidies, fleet procurement and infrastructure can be seen as the independent variables (IV). It is important to choose most similar cases or cross-national research, with countries having similar contexts (6 & Bellamy, 2012), meaning the IV respect a major similarity. By doing this then the study can better focus on the relation between E-cars and few important IVs. For this reason, the study looks at specific IV from each case selected that can best replace barriers found in India as driving forces. Due to limitations in the method of agreement, the indirect method of difference was adopted. The method helps identifying the absence of an outcome, allows for subdividing the cases that then permit asking specific questions of why countries are put in specific categories, such as in our case the TIS in India, can be categorized as being in a formative phase. The method can identify barriers of technology adoption, by the means of comparison. In such case the joint method of agreement and difference is to be used where the complementary approaches share stronger explanations and results.

The TIS framework helped to structure the findings in such a way to allow a better system analysis with the aim of identifying hindering and supportive mechanisms used by policy makers for the development of an electric vehicle car industry. The use of the TIS theory has such predicting theory embedded in its construct where the use of A leads to B. The method of agreement and the indirect method of difference are approaches complementary to the TIS, that can help better establish the degree of comparability between cases.

The analysis of the TIS excludes any weighing measures. Even if qualitative methods are found most suitable for such COR designs, quantitative data measures would have helped to determine more accurately the value of different criteria selected or to be selected and to better assess the degree implications of different aspects. A statistical model could complement the present study offering a numerical side of the coin and then allow comparison between the results offered, that could allow higher accuracy. The study could have used as well, the framework for evaluation of environmental policy instruments (see Appendix B). The framework would have looked closer at policy environmental measures success in meeting their targets as for instance in the UK and then set best practices recommendations for India.

The analysis is based on a synthesis of texts that may present limitations requiring interviewing actors related to the study in India thus leaving space for further investigation for reinforcing present studies, conduct robustness tests and verifying such conclusions. For instance, the study aims to build a more comprehensive idea of the situation in Mumbai, however details are/might be missing that could not be found in online sources and could have been probably gathered by interviewing various stakeholders in the industry. This could as well clarify the language barrier, culture and the availability of the data exposed in English. For this data limitations reason, the study looks at the larger system from a top-down approach towards the Maharashtra state and Mumbai city.

Legitimacy

The RQ was legitimate, with the tasks leading to answers that are providing logical argumentations to answering the RQ. The RQ has been answered however, even if desired, it could not focus the analysis and discussion more on the case of Mumbai city, Maharashtra state. This was due to the lack of data found in online source and the TIS in Mumbai being in its emerging, strengthening formative phase (Bento & Wilson, 2016). Further research would be needed to complement the present study and answer fully the RQ.

Generalizability

The conclusions are specific to the analysed case, due to the differences in contexts – no two countries or cities can be alike. Therefore, the conclusions cannot be relevant for a different context but only if adjusted accordingly after a proper analysis of the specific case. This way it could be that selecting accordingly to specificities of the case from the recommendations could be considered as applicable but not the conclusions set in their entirety.

6 Conclusion

6.1 Identified barriers and recommendations for India

The aim of this study is to identify demand supporting policy measures to scale up E-cars in India, Maharashtra state, Mumbai. It firstly identifies barriers in India and then it looks at deriving good practices identified in the UK, Sunderland city and China, Shenzhen city that are subsequently used as recommendations for India, Maharashtra, Mumbai. The recommendations on barriers identified may be used as an action plan for India that currently is missing.

This study answers the following RQ:

How can Mumbai city implement policy pull-strategies that drive the scale up of E-cars?

Task 1: Look for barriers (blocking mechanisms) in India, Maharashtra state, Mumbai city affecting E-car scale up with a focus on E-cars demand measures, public E-bus procurement, charging infrastructure and regulatory standards for charging stations.

Barriers for E-cars were identified in various instances.

In the *knowledge development and diffusion through networks function* barriers identified are:

- Lack of expertise, knowledge, and coordination to reach the desired targets in a timely manner or to make better estimations of when such measures can be achieved (due to prolonging of FAME I three times, with the FAME II arriving only in 2019). No measures for private E-cars have been adopted.
- Unstable targets (huge difference in the modification of targets, from 100 to 30% E-car market penetration target within a short period of time).
- In Maharashtra government departments are not yet fully aligned with national initiatives, even though the goals set by the ministers were in tandem with the national ones. There might be disinterests internally and/or lack of initiatives happening possibly due to lack of proper communication, collaboration, and knowledge exchange in between government actors.

In the *influence on the direction of search function* barriers identified are:

- Environmental reasons are used as secondary basis to support decreasing oil dependence on imports.

- High upfront costs, low number of public charging stations, low investments in manufacturing (GNCTD, 2018) and low awareness (Gulati, 2012). Consumers identify charging time, driving range, battery replacement costs, top speed and acceleration being key barriers to buy E-cars. High cost of battery and the lack of infrastructure are identified as main criteria for consumers not choosing E-cars (Mukherjee & Varadhan, 2019) with high sensitivity of price and range (Gulati, 2012).
- Waivers are not fully used in India (VAT reductions for E-cars purchase and charging stations, tickets VAT exempted for public E-bus use are in plans (Electrive, 2019)).
- Coordination failure between the central government to procure E-cars for local governments and the existent charging infrastructure.
- Exclusion of measures for private vehicles in FAME II (possible underlying reasons could be funds limitations but also a lack of proper forecasting of the E-car market development potential).

In the *market formation function* barriers identified are:

- Low ownership per capita of cars, 22 out of 1000 people owning a vehicle. This is a barrier for E-cars to increase their share in the market.
- The number of charging stations are not enough, and the government lacks directions for decisions of whether to created adequate charging infrastructure for promoting sales or to wait until there are enough E-cars on the roads to develop it (Kotoky, 2019).
- Lack of specific standards of charging infrastructure.
- Competition law does not support current technology innovations.

In the *resource mobilization function* barriers identified are:

- Discrepancy between national supply and local demand (The procurement investment sanctioned 455 E-buses for 9 cities. However, the number of cities requesting E-buses were 44 seeking a total of 3144 E-buses).
- Instability and volatility of the market caused by the incipient nature of the E-car market, continuous policy changes and discrepant short-term change of targets, happening even during the same political mandates.
- Private vehicles are not included yet for subsidies in policy schemes.

Task 2: Find possible policy actions that India and Maharashtra state, Mumbai city could learn from the case of UK, Sunderland especially, to support E-car purchase and manufacturing and building charging infrastructure.

Recommendations from the case of UK: Knowledge development and diffusion through networks function

- Work collaboratively and develop partnerships agreements - the Indian government could expand its collaborations and better build relations to better deliver on short- and long-term targets.

Recommendations from the case of UK: Influence on the direction of search function

- The GOI should consider adopt policies that directly target the environmental issues such particulate matter emission standards, fleet emission norms, safety requirements.
- Environmental benefits should be monetized and offered in appropriate subsidies.
- Include policy environmental drivers for all vehicles such as ICE, E-buses, and E-cars, with environmental targets embedded for each type of vehicle

- The GOI could consider non-financial CO_2 and car regulation with super credits and include E-cars as zero emissions cars
- Give consumers more information for instance about their usage requirements and TCO
- Could be beneficial to offer E-car subsidies while TCO based decisions are made to help users fully factor in societal costs
- After such measures are implemented could be beneficial to leave the market forces dominate and decide between ICE and EVs

Recommendations from the case of UK: Market formation function

- India could make use of its Competition Act to implement measures for reducing the environmental impact and rolling out of E-cars such as allowing manufacturers to pool together and sell CO_2 emissions to the pool and leave businesses collaborate for the societal good.
- India could allocate its budget more clearly targeted in case specific plans for instance in feasibility studies to build local plans for reducing pollution that can allow subsequently more accurate actions and budget plans.
- Consider consumer preferences in policy measures and non-financial measures that could be the most effective means to push E-cars uptake.
- Adopt a sound infrastructure program that may include standards development, evaluation of technologies, harmonization of local incentives, understanding user's behaviour and its impact on infrastructure. These can help for instance on how many charging points to build and the placement of charging stations in strategic locations, such as the city centres
- Encourage manufacturers to consider pricing business models to reduce the cost of the technology such as leased battery sold E-cars and equip employees with E-cars instead of conventional ones

Recommendations from the case of UK: Resource mobilization function

- Balance fiscal interventions with non-financial instruments such as waivers. For instance, include waivers in initial purchase price and properly manage their integration with financial options such as waive the ownership tax for cars with lower CO_2 emissions, waive or reduce taxable income for low emission vehicles and increase the tax for the ICE.
- India may include policy measure support for E-cars such as the UK's Plug-in Car Grant, CO_2 based annual ownership taxes, and reduced taxes on the private use of low CO_2 emissions company cars.
- Maintain targets set and incentives on a long term to better promote E-cars. Maintain the required support until the cost of E-cars reaches parity with the ICE-cars.
- Offer subsidy support for charging stations, for instance UK gives 75% of total installation cost subsidy support for private chargers.
- Set preferably at a later stage conditions of E-car ownership for private users that wish to install electric chargers.
- Consider a program of investments to match private investments and public funds that can bring additional support for instance to home chargers' subsidy, then to public and semi-public infrastructure.
- Maintain coordination, collaboration, support, and a shared vision from national to local levels and vice versa.
- Encourage OEMs to move down the value chain to ensure their cars are sold providing their own installation services and/or hardware discounts.

- Provide information to motorists on the location, capacity, availability, and pricing of charge points and other such decisions that support better user access to chargers. Continuously improve consumer experience.
- Carefully manage the cluster manufacturing, local government and national government information and resource flow for instance to reduce the E-car price below the ICE-car price and coordinate E-car numbers with charging points availability
- Maharashtra, Mumbai could focus to attract high investments considering E-car supporting measures and its existent automobile manufacturing
- Canalize efforts in developing the local production of E-cars to increase economic productivity and decrease costs of E-cars
- Support attracting investments for building the battery manufacturing in Maharashtra, a plan currently built by Mahindra & Mahindra and the LG Chem South Korean company

Task 3: Find possible policy actions that Maharashtra state, Mumbai city could learn from the case of China, Shenzhen city especially for building an E-car fleet and infrastructure.

Recommendations from the case of China: Knowledge development and diffusion through networks function

- Collaborate and reach consensus between each department involved from the Maharashtra, Mumbai municipality for supporting successful implementation of charging stations and increase E-car numbers
- Consider all stakeholders involved, including consumers in the decision-making process

Recommendations from the case of China: Influence on the direction of search function

- Develop a structural policy approach with concomitant action comprising all areas that need support with tools for reducing taxes, direct subsidies to manufacturers, consumer subsidies, mandate government procurement, and support for indigenous technology development
- Introduce environmental policy specific actions to drive EVs and E-car development
- Impose specific targets for governments, cities and public organizations with minimum targets for their fleet to be electrified and increase gradually to create the "critical mass in the marketplace"

Recommendations from the case of China, Shenzhen city: Market formation function

- Limit protectionism tendencies that prove to result in unproductive outcomes
- Target government incentives and subsidies for the development of public fleet procurement, such as E-bus to prepare consumers' minds for EVs and/or E-taxi fleets to increase public charging stations for E-cars, reach critical mass manufacturing scale and increase capabilities
- Focus efforts on building a charging infrastructure in Maharashtra, Mumbai with municipality directly investing in such charging points but also supporting local manufacturers
- Adopt appropriate business models for E-bus and E-car development such as separate lease of the E-car battery, combined with a charging and maintenance model

Recommendations from the case of China: Resource mobilization function

- Allocate additional funds considering specific targets were reached, such as reaching a certain number of E-cars purchase for funds allocated to building charging stations
- Aligning standards with all municipalities and regions and allowing manufacturers to collaborate if needed for developing charging points to support market expansion, competitiveness, and innovation development

6.2 Recommendations for future research

The environmental evaluation framework (Mickwitz, 2003) was mentioned in section four of the analysis and was used to highlight important environmental policy issues in India that need further attention. Such research would be required to support the creation of policies in India that include sound environmental reasons in their strategies.

This study excludes specific functions from its analysis, which are not relevant to study at this stage but also due to space and time limitations of the current study. Additional research could be undertaken in these specific areas for India.

Even more, a thorough look at the events happening under each function with a subsequent mapping to identify precise patterns would provide more accurate conclusions with specific explanations. This could be done for all countries benchmarked with, spread during the time frame of the formation of the new technology demand, then the patterns could be better compared and set more accurate lessons learned. Nevertheless, such work could be built on the present study to better support policy making and improve the TIS framework.

Further research could also look at better categorizing the phases of the TIS in India, emphasizing and demonstrating when each phase ended with their underlying reasons, exposing the timeline for each of such phases. This could be done in all the other cases used for comparison and better practices.

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Appendix

Appendix A - Overview of identified structural components of the TIS in India, Maharashtra, Mumbai city

The structural components identified can provide a better visual and informative note on the number and kind of actors involved in building the electric vehicle system in India, Maharashtra state, Mumbai. It can serve the reader to better comprehend the system of specific interactions, and as well could serve comparisons with other electric vehicle country systems, in studies that have a more specific focus on such actors, their interactions and institutions and explain missing actors for instance in some system and such consequences, or the impact on institutions etc. The table is included in the Appendix section because this is not central to the requirements of the analysis.

Components	Findings
Major Actors	Political and policy: National level - Government of India (NEMMP) - Ministry of Heavy Industry and Public Sector Enterprises (launched FAME I and II scheme India) - Ministry of Power, Coal, New and Renewable Energy – Energy Efficiency Service Limited (procure EVs in bulk) - Central Electricity Authority (advices the gov on policy. - charging infrastructure) - Ministry of Housing and Urban Affairs (support urban regional development for EVs to expand the charging infrastructure) - Ministry of Consumer Affairs, Food & Public Distribution - The Bureau of Indian Standards (BIS) working towards standardization - Ministry of Science and Technology - Department of Science and Technology working towards standardization - Mumbai Metropolitan Regional Development Authority (MMRDA) State level (Maharashtra) - Maharashtra government (EV Policy 2018) - Public sector utilities - Central Nodal Agency for charging stations Companies (B2B; B2C): - Main local electric car manufacturers Maharashtra: Tata Motors, Mahindra and Mahindra - Infrastructure companies: Tata Power, Mahindra and Mahindra Consumers: government use, states, cities, end-users
Networks	Formal networks: - Ministry of Heavy Industry to achieve the FAME goals scheme collaborates with the Ministry of Power (charging infrastructure development), Ministry of Housing and Urban Development (charging infrastructure) - The Minister of Power administers the charging infrastructure program and will be implemented in the country by the Energy Efficiency Service Limited (EESL). - The Bureau of Indian Standards and the Department of Science and Technology are working towards standardizing charging infrastructure - Maharashtra Government invest 3.5 billion USD to support manufacturers to roll out E-cars

	- Maharashtra government signed MoUs with Mahindra & Mahindra and Tata Motors to promote E-cars in the state - Under MoU Maharashtra government plans to work closely with various fleet partners, taxi aggregators, logistics companies etc. - Maharashtra state under the EV Policy 2018 plans to promote E-cars in public transport in six cities: Mumbai, Pune, Aurangabad, Thane, Nagpur, and Nashik. - 16 May 2018 Fadnavis handed over 25 hybrid E-buses from Tata Motors to MMRDA. This marked the commencement of E-buses being used for public transport to the city of Mumbai.
Institutions (hard, soft)	Formal structure: - Government of India - NEMMP - Ministry of Heavy Industry and Public Sector Enterprises - FAME scheme - Ministry of Power – Charging Infrastructure - Government of Maharashtra – EV Policy 2018 - Mumbai city Government – EV Policy 2018 Some informal institutions: - Best practices: effective implementation of EV and E-car policy actions is comprised of: initiation of the policy development process from the chief minister's office; clearly delegated authority to agencies; and properly designed policies for smooth implementation and enforcement. - Expected outcomes: while specific targets are set to be reached, expected outcomes from specific interventions are uncertain

Source: Author's own depiction

Appendix B - Determining the fundamental environmental issues – A Framework for the evaluation of environmental policy instruments

Context

Since the transition is motivated by and has at base pressing environmental issues there is an increase in voicing of environmental policy evaluation. More often, policy makers and administrators are requesting it (Mickwitz, 2003). For instance, this task is formulated in the 6th Environmental Action Program for the European Union (1600/2002/EC), adopted in June 2002. In article 10 it is suggested an ex-ante evaluation of the possible impacts of new policies and ex post evaluation of the effectiveness of existing measures in meeting their environmental objectives (Mickwitz, 2003).

Key features of environmental problems are identified as:

- they are complex;
- they have long time frames;
- they concern geographically remote regions;
- they have very unequal distributions of impacts on different groups in society;
- they have been formulated as problems largely by scientists;
- they involve huge uncertainties; and
- they involve stakeholders with conflicting objectives and different belief systems.

Some value criteria for evaluation of environmental policy instruments

Evaluation is inherently normative thus related criteria is used as a base for the normative judgements. Mickwitz (2003) discusses three groups of criteria: general criteria, economics criteria and criteria linked to the functioning of democracy.

Table B1 General Criteria for the Evaluation of Environmental Policy Instruments

Criteria	Related questions
Relevance	Do the goals of the instruments cover key environmental problems? On a general level this criterion is trivial, but specific norms or rules can be questioned using this criterion.
Impact	Is it possible to identify impacts that are clearly due to the policy instruments and their implementation? All impacts may be considered in the light of this criterion, irrespective of their occurrence inside or outside the target area.
Effectiveness	To what degree do the achieved outcomes correspond to the intended goals of the policy instrument? Similarly, the effectiveness of reaching other public goals can also be assessed if these are first identified.
Persistence	Are the effects persistent in such a way that they have a lasting effect on the state of the environment? The effects outside the target area and the unintended effects that may create new problems can also be considered via this criterion.
Flexibility	Can the policy instrument cope with changing conditions?
Predictability	Is it possible to foresee the administration, outputs, and outcomes of the policy instrument? Is it thus possible for those regulated, as well as others, to prepare and consider the policy instrument and its implications?

Source: Mickwitz (2003)

Not all effects are relevant for the criteria mentioned above:

- The *relevance* criterion is relevant for the anticipated effects in the target area versus knowledge of key issues in hindsight.
- The *impact* criterion is useful for all effects
- *Effectiveness* is a criterion that can be limited to the anticipated effects in the target area in relation to the stated objectives.
- *Persistence* can be used as a criterion for all effects, but with particular emphasis on effects that may jeopardize the intended beneficial effects.
- *Flexibility* is an important feature due to the complexity of many environmental problems; many external factors affect the outcomes and are often constantly changing.
- *Predictability* is sometimes in conflict with *flexibility*.

Table B2 Economic Criteria for the Evaluation of Environmental Policy Instruments

Criteria	Related questions
Efficiency (cost–benefit)	Are the benefits worth the costs? Both benefits and costs are valued in monetary terms
Efficiency (cost-effectiveness)	Do the results justify the resources used? This is a cost-results criterion in which benefits are not valued in monetary terms. Another possibility in considering costs is to use the cost-effectiveness criterion: could the results have been achieved with fewer resources?

Source: Mickwitz (2003)

The economic criteria for evaluation of environmental policy instruments is almost always problematic. Problems can be conceptual and practical. The conceptual problems are related to valuation and the practical to data availability. Using these criteria require considerable resources for evaluation and it is noted that efficiency in a cost-effectiveness sense is in practice often an easier and more usable criterion than efficiency in a cost-benefit sense (Mickwitz, 2002).

Table 3 Democracy-related Criteria for the Evaluation of Environmental Policy Instruments

Criteria	**Related questions**
Legitimacy	To what degree do individuals and organizations, such as non-governmental organizations (NGOs), interest organizations and firms accept the environmental policy instrument?
Transparency	To what degree are the outputs, outcomes of the environmental policy instrument, as well as the processes used in the implementation observable for outsiders?
Equity	How are the outcomes and costs of the environmental policy instrument distributed? Do all participants have equal opportunities to take part in and influence the processes used by the administration?

Source: Mickwitz (2003)

Environmental problems are found to impose specific problems to democracy. Subsequently a particular role is created for the evaluation of the processes involved and the use of criteria such as legitimacy and transparency (Mickwitz, 2002).

- *Legitimacy* involves the type of instrument for instance the right of the government to tax incomes or create private property rights to pollute (Mickwitz, 2002). However, when accounting legitimacy a look at the specific institutions involved, the implementation procedure used, and the outputs and outcomes generated.

- *Transparency* deals with the assessment of the degree of transparency of the administration, the output, and the outcomes. Some aspects can be very transparent others not. It has been stated (Fung and O'Rourke, 2000) that much of the impacts of some environmental policy instruments is because information is made public that has not been available before (Mickwitz, 2002). From this we conclude that transparency relates to other criteria such as impact or effectiveness (Mickwitz, 2002).

- *Equity* is important with respect to outputs, outcomes, and costs and with respect to the process on how they are agreed and implemented. Many times, equity discussions concern only outputs and outcomes. Equality of the process is suggested not to be missed (equal participation and equal access to information) mainly when the stakeholders' capabilities are considerable different. Time scale of many environmental problems encourage to look not only at the present distribution of the effects and costs but also at the distribution over time such as intergenerational equity.

Appendix C – China's TIS

Knowledge development and diffusion through networks function	• Ministry of Environment Protection and Ministry of Industry and Information Technology work on building policies to cut vehicles emission such as: vehicles emissions standards, a cap-and-trade system, and the overall promotion of E-cars • In 2008 China's Ministry of Finance and the Taxation Services General Office declared that E-cars will benefit consumers from an *exemption of standard consumption tax that consumers pay on new automobiles* • *the China's 2012 "Energy-Saving and New Energy Vehicle Industry Development Plan (2012–2020)" plan.* The draft defined the industry structure and by 2020 aimed for the development of larger companies specialized in different components of the industry value chain as vehicle, battery, raw materials also motor and automatic gearing production

	• At national level the government formed state alliances allowing for the large enterprises to cooperate along the electric vehicle value chain and get access to financial support. Through these alliances another purpose is to better realise future electric vehicle standards • Shenzhen in 2009 was selected as one of the 13 national EV (including E-car and E-bus) demonstration cities, where most of them have a strong industrial automotive sector. • The private sector has important transitioning capacities and enterprises are actively getting involved in urban transitions when strong economic incentives are provided • Promotion of technologies as E-cars and E-buses can improve the urban environment but as well boost the urban economy by developing local enterprises such as BYD. For this achievement consensus must be reached between different departments within the municipality. • - For the land use issues in Shenzhen, the central government put pressure and discussions between departments in the municipal government were held. However, issues were encountered when facing social stakeholders. Issues encountered for ex when a bus charging station in a residential neighbourhood, faced opposition by the residents that worried about safety potential issues
Influence on the direction of search function	• Reaffirmed commitment to the UN Paris Climate agreement • Transportation is seen as an important element for reducing and meet carbon emissions goals • China strives to make its indigenous E-cars market stronger and strive for the international competitiveness automobile market • Anti-Monopoly Law used to favour domestic companies to foreign companies • E-cars policies targeted to reduce emissions and impact foreign manufacturers of E-cars • Working at a plan to ban conventional manufacturing and sales • The government prioritizes E-car manufacturing, using environmental and economic reasons • No single policy addressing only electric mobility in China • Five key policy support tools for E-cars includes advantages of reduced taxes, direct subsidies to manufacturers, consumer subsidies, mandate government procurement, and the industrial policy *Made in China 2025* • In 2008 China's Ministry of Finance and the Taxation Services General Office declared that E-cars will benefit consumers from an exemption of standard consumption tax that consumers pay on new automobiles • Second policy tool, *manufacturers subsidies for promoting EV* (E-car) development. China has invested many years billions of dollars in direct subsidies to manufacture as for instance: BYD received a subsidy totalling $435 million between 2010 and 2015, being the largest subsidised company in China for electric and hybrid vehicles • The China's 2012 "Energy-Saving and New Energy Vehicle Industry Development Plan (2012–2020" • The government began a *consumer subsidy program* in 2010, that allocated 60,000 Chinese Yuan (approx. $8,700) and 50,000 Chinese Yuan (approx. $7,250) per battery E-cars and plug in hybrid cars, cutting 40%-60% of the vehicle purchase price • Local governments also launched their own subsidy program offering additional discounts for EVs purchase through cash subsidies, free parking and/or free license plates • The fourth government action policy for E-cars is to *increase demand through government procurement arrangements* that mandate governments to include a specific proportion of E-cars. In 2014 the government urged a minimum of 30% of its vehicle purchase to be E-cars by 2016. The figure was increased to 50% in 2016. • The last driver policy for E-cars is the MIC2025 (made in China) industrial policy, that supports the indigenous technology. MIC2025 was adopted in 2015 to support the development of ten key local strategic industries, accounting also for energy saving and E-cars. • An older but important policy in the development of the automotive industry in China is the "Auto Industry Restructuring and Revitalization Plan" introduced in March 2009. The policy aimed also at increasing E-cars targeting 500,000 E-cars to be produced by 2012

	• In between 2014 and 2017 there were no purchase taxes for E-cars, and this was extended until 2020 • A consumer subsidy program was initiated by the central government. The subsidy is updated, decreasing the amount offered after every two or three years and increasing the eligibility threshold • Beijing and Shenzhen governments that initiated a program having the same number of subsidies as the central government. Due to cheaters attracted by the generous subsidies (manufacturers declared different sales numbers and registered ineligible vehicles for getting more subsidies), the local government reduced the number of subsidies provided by the central government with 50% • Policy tools used for installing charging infrastructure include subsidies via tax credits, grants and low-cost loans-as well as mandated and standards • Central Government of China has released a series of policies to develop the national charging network, considered the largest deployment program in the world. For this China launched the Guideline for Accelerating the Plug-in Electric Vehicle Charging Infrastructure Deployment (Guidelines) in October 2015 for enabling an adequate charging network. Aims at reducing the range anxiety of plug in E-cars users, encourage potential plug in E-car adoption, and increase the electric miles driven by plug in E-cars. • With the New Energy Vehicles policy China intends to build E-cars being an initiative part of the electric vehicle (E-car) standardization project (Voelker, 2018). To become a global leader in E-car manufacturing China plans to standardize electric car technology nationally. National E-car charging plug standards in China is comprised of both slow and fast charging • Shenzhen being the centre of the largest EV manufacturer in China, Build Your Dreams (BYD). • - All bus fleet of around 16,000 units in Shenzhen became all electric at the end of 2017 being the first city to electrify 100% of its public buses
Market formation function	• The potential of the market to produce battery technology, especially lithium-ion batteries found in the electronics industry, which contributes to cost lowering as the industry scales up for mass production of batteries for electric vehicles • Some other barriers such as limited charging stations, low charging time, and a limited travel range disadvantage the attractiveness of E-cars • Price of purchase of E-cars (plug in and battery electric cars) is the most important for consumers, and the purchase cost of an E-car compared with conventional vehicles is much higher • In between 2014 and 2017 there were no purchase taxes for E-cars, and this was extended until 2020 • Beijing and Shenzhen governments that initiated a program having the same number of subsidies as the central government. Due to cheaters attracted by the generous subsidies (manufacturers declared different sales numbers and registered ineligible vehicles for getting more subsidies), the local government reduced the number of subsidies provided by the central government with 50% • In some provinces in China, E-cars are not restricted by traffic control measures (such as policies that restrict the number of cars on the road during a prescribed period), are allowed to drive on bus lanes, and benefit from free parking • For E-cars in some Chinese provinces and cities, the plates are exempted from the typical fees and more quickly than conventional vehicles. For instance, in Shanghai the driver's license plate fee was waived, which is around 15,900 USD (RMB 100 thousand). • The main enablers of the car market (both E-cars and conventional vehicles) in China were to keep the costs of production and indirect taxation low • The VAT in China is now 13% (reduced in early 2019 from 16%), with 40% fuel taxes and lower real interest rates (2%) resulting in a vehicles ownership cost per capita income of 97% in China • China leapfrogged from 0.7 million car sales per year in 2000 to 23million car sales in 2018 • The limited battery capacity and travel range are still a major obstacle for E-car market uptake. • By 2014 31,000 distributed chargers and 780 centralized charging and battery swapping stations were deployed. As of 2017 China has in place 213,903 charging stations and sets a target for 12,000 charging stations and more than 4,800,000 new

	chargers, integrating slow/fast charging and private/public charging options to be in place by 2020 accommodating a 5 million E-cars. • The Chinese provinces and cities expressed their willingness to support charging stations via subsidies. The biggest subsidy could arrive at a 30% from the total investment • The government must support the creation of a standardized version of charging infrastructure for creating an environment conducive to sale of E-cars and discourage local protectionism. • Public fleets, especially bus fleets, may represent the first leading wave of electric vehicle adoption in China • A central government subsidy program for public transport has been in place since 2009 and helped to reach a 0.3 percent of new sales in the bus market in 2011. In 2017 the Chinse market sold approximately 89,546 buses which had a decrease of 23% from 2016 mainly due to changes in electric bus subsidies. • Next to the political motivations, there are as well environmental and economic incentives to trigger EV development. EV technologies can improve the urban environment but as well boost the urban economy by developing local enterprises such as BYD • Shenzhen municipal government has also limited ICE-cars ownership by license plate control ownership. From January 2015, the number of vehicle license plates issued each year has been diminished to 100,000 of which 20,000 are exclusively allocated to EVs • - For reducing costs of EVs a business model used is the financial leasing separating vehicle and battery and combining charging and maintenance model for E-cars and E-buses.
Resource mobilization function	• China has invested many years billions of dollars in direct subsidies to manufacture as for instance: BYD received a subsidy totaling $435 million between 2010 and 2015, being the largest subsidized company in China for electric and hybrid vehicles • Under the China's 2012 "Energy-Saving and New Energy Vehicle Industry Development Plan (2012–2020)" $15 billions were allocated for supporting the development of energy-efficient vehicles and E-cars, pilot car projects (create local experiments) and E-car infrastructure • The government began a *consumer subsidy program* in 2010, that allocated 60,000 Chinese Yuan (approx. $8,700) and 50,000 Chinese Yuan (approx. $7,250) per battery E-cars and plug in hybrid cars, cutting 40%-60% of the vehicle purchase price • In Shanghai, E-cars get cash subsidies, and the license plate fee is waived and with the license plates able to action at around $14,000 (approx. 100,000 Chinese Yuan) it accounts for a large incentive. • The matching program in Beijing, initiated in 2014 through which the government offers incentives that are equal to those of the central government, discounting the cost of vehicle up to 60% of its cost • In 2010 a subsidy of 9530 USD (60,000 Chinese Yuan) was offered for battery E-cars, amounting 40 to 60 percent of the E-cars cost. In 2012 the subsidy programme expired, and the government renewed it in six months • In 2013 subsidies for EVs were adjusted to 5200 USD (35,000 Chinese Yuan) to around 8800 USD (60,000 Chinese Yuan) based on the vehicle's driving range (Jieyi, 2018). The subsidies decreased by 5% in 2014 and by 10% in 2015 as from 2013. In 2016 the subsidy was changed to approx. 8200 USD (55,000 Chinese Yuan) for each E-car. In 2017 and 2018 is decreasing by 20% as of 2016's values, and by 40% in 2019 and 2020 based on 2016 values. The plan China has is to have no subsidy dependence for E-cars by 2020 • Local governments could get around 13,190,000 USD (90 million Chinese Yuan) for setting the charging station infrastructure after some conditions are met, such as having a certain number of E-car purchases. • - Shenzhen was one of the cities selected as one of the five pilot cities for the provision of subsidies for privately purchased E-cars, both national and local subsidies. The purchase price for EVs has been reduced by government with about 17,640 USD (120,000 RMB) for every vehicle. The price for a E-car produced by BYD, for instance was almost halved from about 24,961 USD (169,000 RMB) to about 13,201 USD (9,900 RMB), making the E-car more affordable for buyers

Source: Author's own depiction

Appendix D – UK's TIS

Knowledge development and diffusion through networks function	• The UK government supports the transition to electric vehicles, seen as an important measure for reducing GHG emissions, air pollution and access a new economic opportunity. • Road to zero strategy is released in July 2018 and helps cut exposure to sir pollutants, lower GHG emissions and improve energy security. • The government is working in partnerships with multiple national actors such as industry, local governments, and consumers with the aim to work on delivering the long-term targets set. The government also works with the international community playing an active leadership role and accelerate the greener transport transition.
Influence on the direction of search function	• Fiscal incentives are considered but not as an important driver in the UK. It is used next to other factors such as range anxiety due to lack of sufficient charging stations and limited choice of the vehicle model, thus combining financial and non-financial mechanisms. • Some financial incentives found in the UK are Plug-in Car Grant, CO_2 -based annual ownership taxes, and reduced taxes on the private use of company cars with low CO_2 emissions. • The government states that EVs need to be promoted by preferential `vehicle Excise Duty rates and other incentives, and preferential rates on the company car tax for EVs. • The Competition Act supports collaborations between companies to lower carbon emissions.
Market formation function	• The Automated and Electric Vehicle Bill supports EV development with various important measures such as to improve consumer experience of charging points, ensure provision at key strategic locations, require that smart points have smart capability; and assure that specific charge points data can be transmitted to specific persons.
Resource mobilization function	• The UK sets to end sales of conventional vehicles by 2040 and also provides £255 million to local governments for feasibility studies and conceiving of local plans to reduce pollution. This is next to the £100 million funding declared for low emission buses. • Electric Vehicle Home Charger Scheme supports the private chargers with a subsidy of 75% or 700 pounds of the installation cost for EV owners and primary user of a private EV car. This grant was available until the end of 2016 and until the scheme budget was used. • The Plugged-in Places helped installed 5500 charging points with 65% available publicly. • The government grants 32 million pounds for charging infrastructure from 2015 to 2020. 15 million pounds from these are allocated to the Electric Vehicle Home Charge scheme, 8 million pounds going to public charging infrastructure and 9 million to other investments in infrastructure. • House of Commons recommends coordinating a shared approach for planning national charging infrastructure. • House of Commons recommends supporting local authorities with strategies for accessing needed funds for EV development. OEMs could have a role in building the needed charger infrastructure for supporting EV purchase. • Sunderland used the Plugged in Places government funded programme. The scheme offered funds to 8 areas within the UK for installing EV charging stations. • European Investment Bank agreed to support the Nissan's first electric car and the production of lithium-ion batteries for electric vehicles. • The Road to zero strategy is seen to provide useful guidance to reach the 2040 goal to have all new cars purchased having ultra-low emissions.

Source: Author's own depiction. Information retrieved from Arseni (2018).