U.S. Governmental incentives and policies for investment in electric vehicles and infrastructure

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Upphovsrätt

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Abstract

The purpose of study is to research the development of electric vehicle technology in the United States. This study describes the United States public policies towards electric vehicle technology and system of innovation approaches. The government roles with the help of national system of innovation have been also covered in this study.

The point of departure was the study of available literature and U.S energy policy acts which illustrates that the break-through in electric vehicles still not only depended on better battery technology and infrastructure for charging stations but also on social, economic and political factors. The important actors involved in the process are both at local and international level are private firms, governmental departments, research and development (R&D) institutes, non-government organizations (NGO’s) and environmental organizations etc. The arguments which are put forward in the background of development of such technologies are to reduce dependence on foreign oil and to reduce emissions of harmful gasses.

Key words

Transportation, system of innovation, national system of innovation, electric vehicles, plug-in hybrid electric vehicles, renewable fuels, research and battery development, lithium-ion battery, environment and sustainability, The American Recovery and Reinvestment Act of 2009.
Acknowledgement

The idea of writing this paper was conceived in my mind a few years ago. This was due to the fact that I grew up in an environment and culture (Pakistan) where car plays a pivotal role for transportation. It is considered by many as a symbol of status and freedom. Nowadays, great deal of research is going on in this area of mobility and technologies associated with it especially in United States. Recently electric and hybrid vehicles technology is getting fame again. However we ignore the history and negative aspects related with these technologies. So it is valuable to review those factors and expectations associated with them.

I would like to thank my teachers, friends, family and fellow students who always believed in me. Without their support and prayers I would not able to finish this study. Special thanks to Linköping University for giving me a chance to study and to write this thesis.

My most sincere gratitude goes to Vasilis Galis, Associate Professor and program director Teresia Svensson. Especially, my Supervisor, Simon Haikola and special thanks to examiner Anders Hansson, Assistant Professor who guided this work with patience and kindness. Thanks to all at TEMA – The Department of Thematic Studies, Linköping University that have been of great help to me during my studies.

At last I would like to thank Swedish government for allowing me a chance to study in this beautiful part of World.
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1. Introduction

1.1 Electric vehicles and policy institutes

Simon and Walls (2008:01) in their study *The U.S. National Innovation System* "identified four cornerstones of United States success at innovation that helps to establish conditions allowing innovation to flourish on its own such as i) incentives ii) government support iii) mix of entrepreneurial and large firm capitalism iv) societal institutions". However, in this study role of government and incentives has been elaborated. This study addresses the regulatory challenges and incentives created for the development and integration of electric vehicles (EVs) in the United States of America (U.S.). These regulatory challenges involve various problems to the speed at which EVs are introduced at national level in U.S. Thus making it important for the regulatory institutions to responds effectively by providing incentives and making national policies to deal with complicated issues such as risks involved and pave the way for their penetrations into current fleet of vehicles. Also, improvement in battery technology challenges the regulation policies at national and international level. Similarly, knowledge and policies based on earlier EV technology need to be reviewed as currently lot of improvement in battery technology has occurred.

This paper examines and discusses about U.S. government policies to see how they help to facilitate the EV technology and did it affect the EVs market share at national level. It has been found out in the study that U.S. government identifies several barriers, just to mention few - production capacity, technology, vehicle cost and infrastructure that have to be overcome in order to achieve large-scale market penetration of EVs. As identified earlier, the national government can play a significant role to facilitate the successful implementation of EVs in the U.S. Therefore, I will make the use of concepts and ideas from the systems of innovation (SI) approach focusing national system of innovation (NSI) about the technology in question.
1.2 Aim of the study

The aim of this research is to understand how the legislatives Acts during the time period 1992 to 2009 emerges within the U.S. for EVs deployment with a particular focus on directives in *American Recovery and Reinvestment Act of 2009* (ARRA 2009).

The concept of risk involved such as uncertainty about this technology and their acceptance in society and market are the conceptual focus of this investigation because of the fact that these concepts have been at the forefront of the EVs regulations debate for many decades. This investigation will show that the regulations have been altered in different time periods during 1992 to 2009.

1.3 Research questions

The study will answer the following research questions:

- How can U.S. governments facilitate to the successful implementation of technology such as EVs in this study?
- How can we understand policy aimed at electric vehicles in terms of US national innovation system?
- Does policy help to overcome the barriers that exist to the successful deployment of EVs in US and how?

1.4 Structure of the thesis

The thesis starts with the presentation of the topic and introduces the reader with the underlying aim of the study. This chapter also describes different barriers in the development of EVs in U.S. that provide the background knowledge of study that has been one of the reasons why the EVs was introduced in U.S. With the help of scientific literature the author has presented and discussed the existing barriers in the development of the EVs technology as well as identified which barriers hindering the development of EVs technology in U.S. most.
The chapter 2 of this study is dedicated to explain the methodology of this study. The approaches used during this study and how the data for the study have been collected are explained. The credibility of the findings and limitations has been discussed in this chapter.

The chapter 3 describes the theoretical framework of the study and how the national system of innovation approach can to understand and identify the important actor’s in a system. Particular space is dedicated to explain the government role in the innovation diffusion process.

The results of the thesis are revealed in the chapter 4. The author starts with presenting the relevant political acts and sections that are relevant to the study. Author also discusses how government through time and with the help of political tools has created national system of innovation. And how the relevant conditions and environment for the successful implementation of EVs has been slowly build up. Author also analysis the government attempts to address the existing barriers.

Chapter 5 concludes the thesis with a general discussion. In this chapter, many problems associated with this technology have been discussed and throws light upon various shortcomings with this technology.

1.5 Barriers in the development of electric vehicle technology in the USA

In this part, an analysis of various types of barriers facing EVs development is introduced. The aim of this analysis is to find out what factors are important for acceptance and development of EVs on a large scale. The most important obstacle with alternative technologies is that their introduction and use simply does not adjust into the current transportation system. According to Romm (2005:2610) there are six concerns regarding alternative fuel vehicles:

1. High first cost for vehicle;
2. On-board fuel storage issues (i.e. limited range);
3. Safety and liability concerns;
4. High fueling cost (compared to gasoline);
5. Limited fuel stations: chicken and egg problem;
6. Improvements in the competition (better, cleaner gasoline vehicles).
In present, it seems difficult to switch to alternative vehicle technologies and fuels as we are locked-in the dominant gasoline car technology. Nevertheless, that escape could be possible as mentioned by Cowan and Hulten (1996:61) “crisis in existing technologies, regulations, technological breakthroughs, changes in taste, emergence of niche markets, and new scientific result.” However, this dream has not fulfilled yet on large scale because of many technological, economic, political and social factors as explained below.

1.5.1 Technical barriers

Battery technology is considered a key to the future of electric, hybrid and plug-in hybrid electric vehicles. Canis (2011:5) put forward this “the major hurdle in providing a large national fleet of hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and fully electric vehicles (EVs) is the size, cost, weight, durability, and safety of the batteries that would power them.” Likewise, Kushnir and Sandén (2011:1406) mentioned “success of EVs depends on their technical performance, cost and safety of battery system.” And Rand et al., (1998:54) notes “success of EVs in public still relies on improvement in battery technology”. Consequently, the improvement in battery technology is crucial for the development of such vehicles types. In order to achieve this goal, development of appropriate battery type seems to become biggest challenge for researchers and scientists.

There are various types of batteries that are currently being used - or being developed for the use in EVs such as lithium ion, nickel cadmium and nickel metal hydride that is also mentioned by Kiehne, (2003). The author assumes that the battery of the future will likely be the lithium-ion battery. Similarly, Sierzchula et al., (2012:49) state that “in present the variety of battery types used in EVs has expanded, largely through lithium-ion chemistries.” And this is the reason that due to advancement in battery technology, large firms and startup firms start targeting different consumer markets with their EVs models. These authors also mentioned that startup firms developed EVs for
niche market - sports cars and low speed vehicle, while large firms are generally developing EVs as per customer demands.

In present, lithium ion batteries are considered as a promising battery technology. According to IEA (2010:9) “the most prominent major new battery technology is based on lithium which is naturally occurring, light weight, reusable, can be extracted from depleted batteries and recycle for use in new batteries.” This is an important characteristic from the environmental prospective and due to its light weight feature it can be easily fabricated into small and large battery packs that can be used in electric and PHEVs types. Rand et al., (1998:423) states “success of primary lithium cells in 1970s becomes the source of involvement for large companies such as Exxon and Bell Telephone in the USA to investigate rechargeable alternative in that area.” According to Liu et al., (2011:1) “rechargeable lithium-ion batteries have made great advances in the past 20 years and are extensively used for consumer electronic devices due to their high energy density and long cycle life.” These consumer product ranges from laptops, mobile phones, MP3 players and small EVs etc. Similarly, Marom et al., (2011:9939) note “among the available battery technologies to date; only Li-ion batteries may possess the power and energy densities necessary for EV applications.” It can be said that in forth-coming future, rechargeable lithium-ion batteries can be considered as a viable battery technology for EVs.

![Figure 1 Picture showing how Lithium ion battery looks like (Source: Chambers, 2009).](image)

Furthermore, nanomaterial may be used in future lithium-ion batteries which are mentioned by Kushnir and Sanden (2011:1405-1406) that “variety of nanomaterials is under investigation to
replace the active material in lithium-ion batteries to overcome various performance limitations.”

These authors also called lithium-ion battery ‘a front runner technology’ for energy storage in proposed electric vehicles. Besides authors focused on the development and understanding of nanomaterial in lithium-ion batteries and there is a possibility that nanotechnology may bring a breakthrough in battery technology (Bruce et al., 2008; Kushnir and Sanden, 2011).

Bandhauer et al., (2011:01) state that “lithium-ion batteries are well-suited for fully electric and hybrid electric vehicles due to their high specific energy and energy density relative to other rechargeable cell chemistries.” Likewise Valøen and Shoesmith (2007:01) analysis show that the performance of lithium ion batteries is better than NiMH and NiCD batteries. Due to above mentioned features the sale of lithium-ion batteries are increasing worldwide. According to statistics from battery association of Japan, there is a significant increase in the sale of lithium ion batteries from 29,722 to 1,218,342 between 1995 and 2011 (Ministry of Economy, Trade and Industry, November 2012).

Nevertheless, lithium-ion batteries also have shortcomings that are pointed out by Bruce et al., (2008). Safety is a serious issue in lithium-ion battery technology. Similarly, Goodenough and Kim (2010:6668) points out that “the principal remaining challenge is to develop safe, rechargeable batteries for larger plug-in hybrid and all-electric vehicles (PHEVs and EVs) of larger driving range, faster charging rates, and lower cost as well as for EES for the grid”. The author mentioned in their study that on commercial scale the lithium-ion batteries are currently being used in small EVs. Thus the major drawbacks with lithium-ion battery packs seems to be short life cycle, safety, weight, range, poor low temperature performance and costs. However, lithium-ion batteries can be regarded as batteries of future as they are making great progress in modern electrochemistry. These batteries have to go long way to establish public trust and attention of the researchers and scientists.
According to the findings it can be said that EVs have been manufactured since the mid of 1800s and early 1900s. Development of battery by Volta in 1800 paved the way for Davenport revolutionary electric motor in 1830’s. However this battery was not useful for EVs due to voltage storage problem. Nevertheless Plante developed lead-acid storage battery that further helps in the development of EVs as these batteries were capable of being recharged that was a compulsory condition for such vehicle types. Thus 1890-1910 was considered significant period in the history of EVs as battery technology improved significantly. Due to battery rechargeable capacity and technology development the EVs were encouraged to be used as taxis in the U.S. and one such example was Pope Manufacturing Company that had 500 electric cabs at the end of 1898. One other example that could be found in the history is electric Carriage and Wagon Company that operated EVs as taxis in New York City. These taxis were considered as symbol of luxury and comfort.

EV technology is not a new technology. Still there are many problems associated with EV technology as described in the academic literature. Holzman (1997:584) asserts:

“Most of the major manufacturers are experimenting with battery power in cars... there is a need for a breakthrough in battery power in EVs. The reason is simple: existing gasoline cars have a range of about 380 miles and it is difficult for EVs to gain that power and mileage range. Even battery advocates concede their limitations.”

In other words, the competition between ICV and EV in general are still about mileage and range. Though most of the companies are showing great interest in the development of EVs/PHEVs and they are doing extensive research in this field of technology. One such example is BMW i3 and i8 concept cars.

1.5.2 Economic barriers

There are always expectations related with alternative fuel types of technologies. Especially, the expectations rise when there is a shortage of fuel or increase in the petroleum prices. Everyone starts looking into alternative mode of transportation that runs on electricity or consumes less petroleum. However, every innovation requires significant investments. Government funding and
grants as well as ability to boost their public image could be a strong motivator for the private automobile companies to invest in uncertain technologies and niche markets.

According to the International Energy Agency (IEA, 2011), the primary issue that has challenged the adoption of EVs in the 1990s, and that continues to be the greatest barrier, is the trade-off between battery performance (top speed and driving range) and vehicle cost. Kurani et al., (1996) estimated that “there is a small market share for electric vehicles (EVs) because of their high price, low range and slow recharging” (in Ewing & Sarigöllüb, 1998:429). It can be said that EVs have not been able to offer an alternative reasonable price so far, therefore EVs are “sold mostly in the niche markets as low speed vehicles or as prototypes exhibiting technological advances” (Sierzchula et al., 2012).

Other economic factors such as manufacturing and maintenance costs, maximum distance and recharge time can affect the use of EVs. Ewing & Sarigöllüb (1998:437) mentioned that “battery-powered EVs have the high cost for manufacturing and battery replacement but their energy costs would be much less than a conventional vehicles”. They also suggest that there is a need for policies such as electronic road pricing or carbon taxes for non-EV that might help to improve the image of the EV's relative operating costs. The authors in their study give the example of EVs use in Montreal showing the potential of EVs, but only if they overcome the performance and cost barriers.

Despite the fact that EVs exist for centuries, it is still expensive to buy and maintain. However, nowadays battery size and weight problem is solved to some extent but still long lasting battery charge is the obstacle in their development. And in present it seems impossible for common people to buy EVs due to their high costs and lack of charging facilities. EVs are not expected to make any progress until battery and infrastructure issues related with them will be solved first. It seems that debate about what should be in place first - technology or infrastructure, only prolongs the process.

At present the innovative vehicles that could match the range and refueling time of conventional vehicles
vehicles are consider only the hybrid EVs and the fuel-cell powered EVs. Motavalli (2001) also suggests that hybrid vehicles could solve not only costs and range of battery but also reduce air pollution. And some people are also willing to pay an extra CAN$1000 for such vehicle types (Ewing & Sarigöllü, 1998).

1.5.3 Environmental and social barriers

According to Gjøen and Hård (2002:268) “politically, the EV is first and foremost regarded as an environmentally benign solution to urban pollution problems”. Concern over urban air quality in recent years has propelled the electric vehicle (EV) to the forefront of debate concerning technologies and strategies to reduce the environmental and health impacts of urban transport, among the largest contributors to urban air pollution as well as to anthropogenic greenhouse gas emissions (see US Dept. of Energy, 1996; Walsh, 1995 in Funk and Rabl, 1999). Similarly Kempton and Kubo (2000) show strong connection between increasing concerns about air pollution and resource depletion and public acceptance of EVs.

However, Funk and Rabl (1999:409) in their case study compared electric and conventional vehicles in France showed that “the cost of air pollution is not enough to give the EV a clear advantage against all conventional cars”. Besides we need to consider the resources for electricity generation and the amount of emission produced by for EVs to be able to determine the actual environmental and social outcome. According to Funk and Rabl (1999:398) “most agree that there are emissions trade-offs, and that the net reduction due to the use of electric vehicles depends on the source of fuel for electricity generation.”

Glover and Brzezinski (1989) claim that “generating electricity for recharging batteries for EVs can cause considerable environmental harm”. Similarly, Lave et al., (1995:993) focused on environmental consequences of producing and reproducing large quantities of batteries to power electric cars. According to them "lead-acid batteries experienced peak production in late 1997", therefore, it can be assumed that their smelting and recycling will cause great environmental and
Recycling of batteries is considered a big problem from an environmental and human health perspective. According to U.S. Environmental Protection Agency (2012) “batteries contain heavy metals such as mercury, lead, cadmium, and nickel, which can contaminate the environment when batteries are improperly disposed. When incinerated, certain metals might be released into the air or can concentrate in the ash produced by the combustion process.” Similarly, Fujita et al., (1992) mentions some of the negative effects of lead which are reduced cognitive function and behavioral problems, even at low levels in the blood. Moreover, such battery elements as nickel and cadmium can be dangerous to humans and the environment as they are considered to be highly toxic (Lave et al., 1995). There are growing concerns about environment, air pollution and health. However, these problems may overcome by the help of extensive research and development efforts in the field of batteries, fuel cells and alternative energy storage devices. As it has been showed earlier, battery manufacturing, handling and disposing has to be done more safely and with much care to avoid contamination of nature.

Besides, environmental obstacles of EVs there are also social and cultural barriers. Lave et al., (1995) explains the human need and desire to experience high speed and long range when using personal vehicles. But as Calvert et al., (1993) points out EVs cannot compete with gasoline cars for speed and distance due to limited battery features.

Experiences and knowledge are important factors for public acceptance of EVs. Motavalli (2001:107) points out the difference between USA and Europe when it comes to EV development “U.S. events are mostly about technology while European one are more about infrastructure, building an EV friendly base through local initiatives and public participation.” Some European countries by renting EVs try to raise public participation and to develop their interest in these vehicles. This put emphasis on user-product interaction as elaborated by Andersen and Lundvall (1998:11) “successful innovation is to a large degree dependent on close and persistent user-producer contacts.”
Thus user’s point of view is important in this process as it can put limitation on product
development or provide vital information that is not seen by the car producer. Furthermore,
Freeman & Lundvall (2008:12) states “learning-by-interacting between parties linked together and
is dependent on time and space”. This aspect of learning-by-interaction can be useful for the
acceptance and development of EVs in society. The public should be given an opportunity to try
these vehicles types by the automobiles companies. And companies should take primary
responsibility to inform public about the positive and negative aspects related to them.

1.5.4 Political barriers

Many projections about penetration of the electric vehicle in automobile market were made already
in 1970 and further on. With introduction of the California Zero Emission (ZEV) Mandate in the
1990s interest about EVs increased, but not to expected range. One positive outcome of the ZEV
was continuing investments and research of hybrid-electric vehicles (HEV) and low-emission
vehicle technology (Sierzchula et al., 2012). The strict restrictions and laws from California Air
resource board helped to stir interest in EVs and PHEVs. Sperling and Gordon (2009:24) states
“due to California zero emission rule, the number of EVs reached 3,000 in the year 2000 that bind
automakers to manufacture zero emission vehicles.” Following the California initiative, in 1996
General Motors Corporation introduced EV1 which was driven on lead acid battery. However, it
turned out to have significant issues with not only battery durability and weight but also safe
recycling (Lave et al., 1995).

When it comes to implementation and popularization of EVs government support is pivotal. Hall
and Kerr (2003) show the importance of policy development, subsidies or tax exemptions and need
for infrastructure to influence the public acceptance of innovation. However, these are not the only
factors that influence the implementation of new technologies. Calef & Goble (2007:1) analyzed the
government failure of implementing EVs in California and France and came to conclusion that apart
from political support, people behavior and attitude was among decisive factors.
When it comes to political barriers, Banister (2005) in his work about sustainable transportation makes distinction among legal or regulatory barriers, policy failures or unintended outcomes, and institutional and administrative barriers.

Regulatory or legal barriers can be related to a lack of relevant government regulation and incentives. There may be unreliable or weak policy signals, which hold back investor willingness to invest and consumer readiness to purchase. Inadequate incentives and policy signals can lead to market failures, which hinder the distribution of cleaner technologies (Banister, 2005; Browne et.al, 2012).

According to Banister (2005) policies might fail, might be abandoned or modified as a result of unplanned events, for example, economic crisis, changed political priorities or unexpected public/media reaction. Browne et.al, (2012) argue that government subsidies and excise relief schemes do not always achieve planned outcome as they aim at the acquisition of EV rather than use. Therefore, such programs might be misused in order to obtain tax exemption and does not imply behaviour change in long term. Similarly, authors doubt the usefulness of demonstration projects. Even if government claims that such projects would enhance the deployment of the necessary technological innovation, often government-funded demonstration projects are about public relations and political objectives.

According to Browne et.al, (2012) the institutional and administrative barriers can be seen from ‘chicken and egg’ perspective. Government are reluctant to develop infrastructure, which affects demand for EV and low demand makes vehicle manufacturers unenthusiastic to invest in new technology. It is like circle of activities dependent on each other.

Melaina and Bremson (2008:3233-3241) analyzing the refueling availability for alternative fuel vehicle markets came to conclusion that the enormous investment in conventional energy assets are slowing down the development of alternative fuel markets. There is lock-in by existing technologies and institutional infrastructure.
Despite the above mentioned barriers, concerns are growing about finite oil resources and air pollution caused by the ICEVs. Rand et al., (1998: vii) states, “a renaissance of interest in road EVs began in the 1970s as a result of the world ‘oil crises’ of 1973 and 1979.” Because of oil crises the people and government started to realize that oil supplies will end sooner or later and it would be hard to compete with ever growing demands of worlds growing population and transportation. Number of factors has contributed to fact that policy makers are seeking to reduce greenhouse gas emissions and air pollution as well as develop greener economy and reduce the U.S. dependency on fossil fuels.
2. **Methodology**

The aim of this chapter is to provide information about the method used in this study and discuss the reasons for choosing them. The methodology illustrates how the necessary data is collected and the usage of gathered data to answer the research questions.

2.1 **Research approach**

According to Denzin & Lincoln (2000) “there are two main approaches to investigate any research study i.e. qualitative and quantitative methods”. Qualitative methods are natural towards human interpretations with more details and quantitative methods are more often used for quantifiable results. The qualitative method helps us to develop casual relationships for underlying events particularly from secondary sources (books, articles and journals). This approach helps to build the theoretical framework of the study and helps to answer the research questions. As far as this study is concerned, it is qualitative in nature and it also covers document analysis of political regulations surrounding the EV technology in U.S. The document analysis provides the empirical material of this study and fulfill the aim of study.

Political document and law is usually created as a response to some identified problem and aims to provide solutions. At this point background study is important to understand and analyze the policy documents. The studies of policy and policy-making is changing its nature and policy is no longer made by the elected politicians, more and more various actors, for example, industry and non-governmental organizations are involved in the process (Buse et al., 2005). Keeping in mind these changes and fact that various approaches to policy analysis exist, I have chosen to highlight a context and relations of certain political documents, identified problems and suggested solutions. I will also pay particular attention to identify and describe how political documents lay grounds to embrace the collaboration with private sector. Further, I will use the concepts and ideas of national system of innovations to scrutinize existing policies.

According to Denscombe (2007:35) “case studies focus on one instance of particular phenomena
with a view to providing an in-depth account of event, relationships, experiences or processes occurring in that particular instance.” Based on this it is possible to say that the thesis also has some aspects of a case study of EV technology in U.S., however, I do not claim that it is a pure case study.

2.2 Research method

This study is built upon document analysis of American political manuscript such as Energy policy acts from 1992, 2005 and 2007 and the Recovery and Reinvestment Act of 2009, focusing EVs technology. This way of data collection is chosen for two important reasons; first previous studies in this area are often fragmented and focuses on separate aspects such as environmental, technological, economic or political problems. Second, there is no particular data showing government support and funding for the development of EVs technology in an easy and comparable way.

2.2.1 Document analysis

Institutional documents serve as a purpose of qualitative research for many years. In recent years, there has been tremendous amount of increase in the number of journals and research reports that mention document analysis as an important part of the methodology. This type of methodology helps to describe the nature and type of documents to be in use. The document analysis also helps to increase the understanding and knowledge about the subject in study.

2.2.2 What is document analysis and how it serves as a part of research study?

According to Glenn A. Bowen (2009:28) “document analysis is a systematic procedure for reviewing or evaluating documents - both printed and electronic (computer-based and Internet-transmitted) material and like other analytical methods in qualitative research, document analysis requires that data be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge”. The documents that are being used in study can be of different forms. They can include government policies, regulations, laws, conferences reports, background
papers, books and journals, press release documents, institutional reports and agendas. This method also helps to study and identify the language, content, meaning and structure of the document. And it supports to identify the interrelationship between different documents and their significance to each other. Content analysis of document can also help to organize information into categories related to the central aim and questions of the research.

Glenn A. Bowen (2009:34) further points out that “document analysis is a process of evaluating documents in such a way that empirical knowledge is produced and understanding is developed.” Document analysis process involves finding documents/information regarding required study purpose, selecting and evaluating them. The document analysis helps to define the type of documents and needs related to study. Merriam (1988:118) pointed out, “documents of all types can help the researcher uncover meaning, develop understanding, and discover insights relevant to the research problem.” It is important part to understand how the document can serve as a part of research study. For that reason documents can provide the facts and background information about the study topic.

This sort of background and historical information can help the researcher to identify what has been done in the past in regard to specific issue and what condition were favorable at that time. This helps the researcher to get hold of past as well as the present. Thus document analysis can provide a source to track development and changes in different time period. And it can help the researcher to compare various available documents such as American legislative acts from 1992 to 2009 to track and identify the changes. This can also help in a way to validate the document and its effectiveness to the policy implementation. Thus the knowledge gain from documents analysis can be valuable for present and for future research study.

2.2.3 Use of language in documents

The recognition of language use is important when doing document analysis. Atkinson and Coffey (2004:59) state that “a document reconstruction of social reality depends upon particular uses of
language.” One can often recognize what sort of document one is looking for and what information it contained that is simply possible by the through recognition of its distinctive use of language. At a common-sense level we can recognize that official documents and reports are often embedded in language that differs from everyday language use.

We can regard language as one of the tool that can help us to understand the construction of certain documents and its discrepancy from other documents. In this regard, it is important to pay attention to the question of how documents constructed and is the flow of text. Moreover, documents may form a certain kind of predictability about future development. And, document reality depends upon logical relationships between documents. Hence, analysis of documents must take justification of such relationships to see if they can be related to each other or not.

### 2.2.4 Relationship between documents

According to Atkinson and Coffey (2004:66) “documents do not stand alone and they do not construct systems or domains of documentary reality as individual and separate activities.” The documents refer to other documents or realities. Therefore, the analysis of documentary reality must look beyond separate texts and one should ask how they are interrelated. This feature of document analysis is important as it helps to identify the background and purpose of the document. Moreover, Atkinson and Coffey (2004:68) points out that document analysis can help to “explore the inter textual relationships and examine how conventional formats are shared between texts, and thus how they construct a uniform, bureaucratic style.” In this, way we can note how they are linked as series or sequence of documents.

### 2.2.5 Advantages/strength of document analysis

Document analysis can be regarded as an efficient and cost effective method. It is less time consuming as compared to other qualitative research methods, because it does not require for example, planning and holding interviews and then transcribing them. In this case, the researchers
need to identify and select the data instead of collecting data; however it does not mean that it is an easy task. Even though various types of documents are available online, one must make sure that the documents of interest are selected. Thus researcher might be required to visit several websites and browse hundreds of archive pages. One must bear in mind that in order to identify appropriate documents, one must get acquainted with the organizational structure of the subject in focus. On other hand such official government/political reports that does not require author’s permission and is most often available on the public domain and accessible to the public. Besides, it can be considered as cost effective method as compared to other research methods.

2.3 Selection of the documents

I have found out in my search that documents like 2005 Energy Policy Act (EPAct 2005) and the 2007 Energy Independence and Security Act (EISA) are used as a reference/data source for the earlier mentioned American Recovery and Reinvestment Act of 2009. Therefore, it was important for me to examine those previous documents and not only focus on one single document. For that reason, I have performed cross-sectional comparison between new and old documents. It helped me to understand the quality of those documents and the evidence they contain that help to satisfy aim of the study. I could say that I used snowball method to recognize the significant documents for my study and the American Recovery and Reinvestment Act of 2009 served as the point of departure.

I ended up selecting four political documents:

- The Energy Policy Act of 2005
- The Energy Independence and Security Act of 2007
- The American Recovery and Reinvestment Act of 2009

In my qualitative analysis of the content in the selected documents I have focused on themes I have found in the literature. First, I searched for all paragraphs and sections that spoke about electric and
plug-in electric vehicles or alternative fuel vehicles. All relevant information, which can be found in the policy documents are described and presented further in this work.

Thereafter, I started to work with the grouping and content analysis of the texts. In order to remain objective and systematic, I used earlier knowledge in the literature and theory recognised and described themes: environmental, technological, political, economic and social. For my own convenience, I drafted several questions, for example:

- Is the document easy to understand and implement?
- Is the document still valid?
- Who is the target audience of the concrete section of the document?
- What concerns lies under the proposition?
- What issue does it aims to solve?
- Why was the document written and when?

Finally, I looked closer at content and tried to see how can it been explained in terms or national innovation theory.

### 2.4 Limitations

Documents come into existence in order to confirm reality other than just to satisfy research purpose that makes it harder to get directly sufficient answer to the research question. And it could be possible that access to some classified documents can be hidden from the public access. For this study, four government policy acts (1992, 2005, 2007, 2009) related to aim have been analyzed. These documents show government perspective in relation to EV technology development by providing incentives and infrastructures at national level. Here, negative point is a risk that NSI can be misinterpreted as only promoting just government perspective and EV technology as a success ignoring other negative aspects/factors related to it. It is because other actors such as car industry/firms, universities R & D programs, market perspective (public views) which are also
considered as main components of NSI as mentioned in the figure.2 in theoretical part of this study has been omitted. It was due to the fact that author wanted to focus on these four government legislative acts and to present government role/result in a simple and comprehensive way.

There are many studies already present showing detailed role of those missing NSI components. Hence, it can be said that one limitation of NSI approach is its broadness as it cannot be easily integrated into one theoretical perspective. This may create confusion and analysis from same actors (government) can be regarded as a weakness of study/theory.

Besides that, some other possible methodological limitations of study are as follow:

**2.4.1 Sample size**

In total four numbers of political/legislative documents issued during the time period (1992, 2005, 2007, and 2009) have been chosen as an empirical material for study. This small size of data may restricts/limits document analysis to minimum as there are so many other U.S. political documents available that could be added to the study such as mentioned below:


• February 12, 2010: Statutory Pay-As-You-Go Act, as Title I of Pub.L. 111–139

• March 4, 2010: Travel Promotion Act of 2009, as Section 9 of Pub.L. 111–145


• March 23, 2010: Patient Protection and Affordable Care Act, Pub.L. 111–148

• March 30, 2010: Health Care and Education Reconciliation Act of 2010, including the Student Aid and Fiscal Responsibility Act, Pub.L. 111–152


• July 29, 2010: Tribal Law and Order Act of 2010


• August 10, 2010: SPEECH Act, Pub.L. 111–223


The above mentioned Acts from January 29, 2009 until January 4, 2011 are shown here as an example to demonstrate that large number of Acts exists and issued each year which is aimed to address known issues in the country. And one can also understand that it would be quite difficult to acquire concerned material from such Acts related to one aspect of theory. For that reason the author has carefully chosen only four documents that have been mentioned before. It was due to the reason that small sample size give the opportunity to carefully read and analyze the document data. Even though it was a time taking process with small data size due to the fact that these documents are not embedded in an easy language that is explained before in this chapter of study.

2.4.2 Lack of available data

As already mentioned for study four policy documents are chosen carefully. It was difficult to find other related documents. However, this less or lack of data can encourage new research in this area of study and researchers can try to evaluate more document in this respect.

2.4.3 Lack of public opinion

One other limitation was lack of public opinion about these chosen Acts. This could be an important feature as it can help the researcher to understand what people think about government incentives and policies for EVs. And if there are any other social problems such as poverty, education,
unemployment that need to be solved first before solving the problems of air pollution or personal transport? Thus it would be important to know what general public consider the most important for them.

Another possible improvement to the study could have been interview the participant. This could help to gain greater information about participant awareness and attitudes towards such acts. Thus this method could have added important qualitative data. The methodology could have included the interviews or survey questions. For example; government policy makers, car and battery manufacturers, car drivers and general public etc. Some of the future research question may be related to study are as follow:

- Negative effects related with car batteries?
- Electric vehicles infrastructure issues?
- Diversity of battery technologies? Still unknown..
- Electric vehicles emissions, costs and maintenance related issues for policy makers?

2.4.4 Data verification

When evaluating these policy documents I thought about data verification present on the internet. Even though the data is obtained from government official website, still I would like to meet some authority in person to talk about it and what problems they had faced when formulating such documents.

2.5 Conclusion

It can be said that this study has many limitations. This study was primarily limited by its small sample size. The sample size could have been extended by including more Acts and policy documents. A large number of sample sizes would have benefits the result and gave the way to explain things in much better way. An earlier start/focus towards data collection would have given the chance to involve other actors mentioned in the theoretical party of study. However, the limitation of study could lead to the future research in this area. A great depth analysis of all Acts
can lead to understand how the policies are framed in the U.S. And one can focus on target groups mentioned in the Acts/policies for in-depth study analysis.

To conclude this chapter, it can be said that document analysis involves various steps such as searching, reading, skimming and interpretation. This process combines elements of content analysis and thematic analysis. Hence, document analysis helps researcher to identify study needs, background, a way of tracking changes and development. In short, document analysis can offer cost and time effectiveness and reliability that outweigh its limitations.
3. Theoretical background

This chapter helps the reader to become familiar with the system of innovation (SI) approaches/models and the national system of innovation (NSI) in respect to EVs technology. In theory, U.S NIS can work as a platform/hub to establish conditions and laws to allow the innovation to develop on its own. This chapter describes the U.S Nation Innovation system (NIS), how it works and how is it evolving by time and the factors that can influence on it.

3.1 Introduction

In the late 1980s a new conceptual framework appeared in the science, technology and innovation studies, ”The National Innovation System” (NIS) which suggests that the research system's ultimate goal is innovation and that the system is part of a larger system composed of sectors like government, university and industry and their environment” Godin (2007:04). The NSI framework has been elaborated in this part with the emphasis of relationships between different actors in a system that can explain the U.S innovation systems in respect to EVs. The development of EVs innovation is not without barriers and problems as it is a complex and uncertain process. The purpose of this chapter is to analysis the implication of NSI approach to one of the potential environmental vehicle technology, EVs in U.S.

Though EVs technology have existed for more than a 100 years in U.S., investments in the development are still restricted due to technology barriers (battery), expensive material, dominant internal combustion engine technology, and interest in hybrid vehicle technology.

The nature of EVs technology and its implication by key stakeholders such as manufacturers, suppliers, dealers, government, R&D departments, customers, innovators, NGOs and politicians etc., is important part of innovation system and all concerns needs to be satisfied before successful implementation of environmental technology innovations can take place in society.
3.2 An overview of system of innovation

According to Lundvall (1992:1) “theories in social sciences may be regarded as focusing devices.” One social device which may help us in this regard is known as system of innovation (SI) approach. SI concept in this study is used as a ‘focusing device’ which can be constructive for theoretical and practical purposes or understanding and integration of technologies. The identification of key factors will help the policy makers to see how EV technology can be affected and what policy support is needed in future for its diffusion in society.

For Lundvall (1992:2) “a system of innovation is constituted by elements and relationship which interact in the production, diffusion and use of new, and economically useful, knowledge.” Similarly, Freeman (1987:1) defines the concept of SI as “network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.” Definition of SI is well summarised by Edquist (1997) who identifies economic, social, political and organisational factors as significant part of SI. Following Edquist line of argument, one can safely say that he defines the SI as a process that cannot take place in isolation. It takes help from different actors in a network. SI approach addresses firms engaged in innovation and looks at how these can interact with each other, and how these are constrained and enabled by the environment, such as by the policy makers. This is very important characteristic of SI approach that could be used for EVs development which is to learn and complement with other present technologies. And it can eventually help to develop better cars and batteries.

Before further describing more about SI approach, it is important to understand what does ‘system’ means in the innovation process. According to Hillman (2008:29), “a system can be regarded as comprising a number of components and the relations between them. Due to the interaction between components, a system requires properties that the separate components do not have, i.e., a system is more than sum of its parts.” Thus for Hillman (2008) as well as for Carlsson et al., (2002) and Holmberg (2008) a system cannot act alone and it depends upon different actors for its success. Keeping in view Hillman, Carlsson’s and Holmberg perspective about system, we can perceive that
a system is a dynamic stable structure in the innovation process. It is dynamic as it keeps the things to work in a proper order. It can be assumed that system works as a hub for connecting different actors in a network in a unique way which results in the success of innovation process.

There are different approaches towards SI. One approach focuses on the regional strength of innovation system and other approach spots technology globally and internationally as a determining factor in the innovation system. Judging from the above discussions, it would be fair if one assesses innovation systems as categorized into national/regional, technological and sectoral. Before passing any firm judgement, it would be fair to present these approaches in order to understand the whole innovation process and system approach to the analysis of innovation in EVs:

<table>
<thead>
<tr>
<th>Approaches towards system of innovation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>National/Regional systems</td>
<td>Geographical approach. Studies innovation activities in a country or in a region.</td>
</tr>
<tr>
<td>Technological system</td>
<td>Technological approaches Studies how the development of technologies occurs and how it is inter-related.</td>
</tr>
<tr>
<td>Sectoral system</td>
<td>Institutional approach. Help us to understand the differences and similarities in organizational development.</td>
</tr>
</tbody>
</table>

As described above the innovation system perspective is applied on various levels such as: national innovation systems (Freeman and Soete, 1997), regional innovation systems (Cooke et al., 1997) and technological innovation systems (Carlsson and Stankiewicz, 1991). However, all approaches share a consideration of the interactive nature of successful innovation processes (Hessels & Lente, 2008).

According to Lundvall et al, (2006:228-229) “system of innovation has emerged as a framework for the growing body of literature that addresses the process of innovation both at the national, regional and even sectoral level.” Freeman and Lundvall have done a lot to stimulate research on NSI. Thus keeping in view these different approaches of SI, the NSI approach is chosen as a main theoretical approach for this study because it will help to expose the role of government in building national
system of innovation.

3.3 National system of innovation

In its broad sense the “NIS refers to the national network of institutions, both public and private and the policy initiatives for the development and diffusion of various technologies” (Lundvall et al., 2006:229). It can be assumed that in U.S NIS approach, national governments create policies and extensive infrastructure aiming to facilitate their industry to develop innovative products. In theory NIS put emphasis on companies to improve national competitiveness in the national and international market.

Mowery and Rosenberg (1993) mentions that NSI includes not only R&D activities but also relevant policies, training possibilities and technology itself. Moreover, authors are convinced that educational, governmental and financial institutions are equally important parts of NSI.

Dodgson et al., (2008:430) points out that “the dynamics of national innovation systems are a source of considerable academic and policy interest, especially when to address new competitive challenges they involve changing institutions and relationships within successful systems.” NIS can be useful and interesting approach in a way that it may involve the configuration and infrastructure of institutes and organizations at national level that structure the development and diffusion and of old and new technologies in different ways.

To summarize NSI arguments it can be said that it is a concept that allows for a deeper understanding of particular technology in a country (society). The causes of NSI processes are manifold as it emphasizes on interaction among different actors in the society. It takes into consideration institutional, technological and economic aspects that have been argued further in the study.
The concept of NSI relies on the understanding of the linkages between different actors involved in the innovation process as mentioned in the figure 2. The national government as an actor can perform better role in the acceptance and development of technology in the society.

3.3.1 Technological part of NSI

Diffusion and initiation of new technologies are one of the core characteristics of NSI, therefore it is important to take a closer look at the technological part of NSI. The success of EVs technology depends on underlying technologies but also market demand and infrastructure. Besides, there is a considerable complexity and uncertainty in EVs research and development (R&D) and customer’s feedbacks. Scientists and engineers are still struggling to build an ideal battery. Hall and Kerr (2003) suggest the concept of ‘technological trajectories’ to explain the relations of technology pushes and demand pulls. These specific technologies are chosen by factors such as market potential and demand, manufacturing costs, government policies and subsidies, environment and human health conditions. Thus car manufacturers or firms can do experiments and innovations in their products to find out whether those technologies/products can be a success or a failure. ‘In
relation to technological trajectories the role of network of externalities is not ignorable’ (Dhebar, 2001). In case of motor vehicles the network of externalities would include availability of fuel stations, battery charging or replacing stations, good road network and systems, public transport, car industry etc. These factors are demanded to pass the certain technology in society. However most of these factors can have adverse effects or hinder EVs development until these requirements are fulfilled.

Hall and Kerr (2003:491) conclude that “technological achievement is a necessary but not sufficient condition for successful innovation.” It is because success of technology also required significant changes in infrastructure and policies. Nevertheless, there are number of internal and external barriers in respect to alternative environmental technologies.

3.3.2 Government role in the NSI

It is usually considered that government plays a pivotal role in the development of innovative technologies. Hall and Kerr (2003:465) states that “governments play a major role in regulating intellectual capital laws, building infrastructure and instituting policies that speed the mass adoption of new technologies and consider major stakeholders in the innovation value-added chain.” Various types of innovations are supported in many diverse ways by different governments, according to their understanding of the concept of NSI (Dosi et al., 1988). Hall and Kerr (2003) further points out that emerging technology are usually supported through government grants, loans and external aids. These resources are governed by national research council's or R&D departments, which makes them a powerful actor.

Due to government intervention automobile companies in U.S. seem concerned about manufacturing alternative fuel vehicles. For instant in California, government have tough rules and regulations related to emissions from motor vehicles. They have advised the automobile industry to reduce greenhouse gas emissions by making fuel efficient cars and to use alternative renewable fuels (California Air Resources Board, 2012).
Due to U.S. government funding the work on electrochemical storage technologies can be pursued. In 1992 United States Advanced Battery Consortium (USABC) was established. The mission of USABC is to develop electrochemical storage technologies that can support electric, hybrid and fuel cells vehicles. The strategy of USABC involve long term promotion of R&D and engage different actors together such as automobile manufacturers, national laboratories, universities and other important stakeholders. Hence the main objective of USABC is to develop battery technology for EVs (United States Advanced Battery Consortium, 2012).

Another example of the role of the government is the Energy Independence and Security Act and the American Reinvestment and Recovery Act in U.S., which promote and support the development and purchase of plug-in hybrid electric vehicles (Skerlos & Winebrake, 2009).

Finally, public and private firms at national level with governmental support have the ability to manufacture quality products to compete on international market as visible in the case of Toyota Car Company:

“The firm started in the textile machinery industry late in the nineteenth century and already had a reputation for technical innovation when it was urged by the Japanese government in the 1930s to enter the motor vehicle industry” (Freeman and Soete, 1997:151).

This shows government realization and interest to engage various actors for the development of vehicle industry at national level. This has significantly changed the industrial behaviour and we can identify from the above example that the governments of Japan have provided the extensive infrastructure and platform for the establishment of technology. Likewise government of U.S. can also provide infrastructure and subsidies to automobile companies to achieve the goals for environmentally friendly vehicles. Moreover government can also stimulate the purchase of EVs by applying different financial incentives which is described in chapter 5.

To conclude this part it can be said that NSI approach helps to identify the role of government.
Government can act as a hub and provide the platform for the establishment of innovation policies for technologies. This co-operation among different actors can pave the way for further technological developments at national level. Finally, NSI approach will help us to understand the formation of social, technological and economic policies and serve as a useful tool to understand innovation and activities in the EVs industry in US. In short “the US Academy of Science has brought into its vocabulary the national innovation system and now uses it as a framework for analysis science and technology policy in the US” Lundvall, et.al (2002:214). This shows the importance of NSI perspective in policy making in the U.S. In the following chapter we can see that how U.S policies are developing and changing keeping in mind NSI framework.
4. Policy document analysis

This chapter describes the development of legislative acts that has been created to support the EV technology. 1992 Energy Policy Act was the first public policy that included plug-in hybrid electric vehicles and battery electric vehicles in their texts. However, the real breakthrough happened several years later with introduction of the 2005 Energy Policy Act (EPAct 2005) and the 2007 Energy Independence and Security Act (EISA 2007). The American Recovery and Reinvestment Act of 2009 (ARRA 2009) is a clear proof of the passage the U.S. government has taken, to reinforce and sustain the U.S. leadership position in the field of innovations via investing in transportation, environmental protection, and infrastructure. However, before explaining these laws/acts it will be better to understand how they are approved/processed and published in the U.S.

4.1 How Laws/Acts are made/passed in U.S.?

United States Constitution state in Article 1, section 1 that “all Legislative Powers herein granted shall be vested in a Congress of the United States, which shall consist of a Senate and House of Representatives” (United States House of Representatives, 2014). We can assume that all power of laws/political acts making in U.S. lies within Congress that consists of public elected members of Senate and House of Representatives. Keeping this definition in mind to pass any law following steps should be needed as mentioned by United States House of Representatives:

“first a electric member/representative sponsor a bill which is assigned to a committee for approval. If released by the committee, the bill is put on a calendar to be voted on, debated or amended. If the bill passes by simple majority (218 of 435), the bill moves to the Senate. In the Senate, the bill is assigned to another committee and, if released, debated and voted on. Again, a simple majority (51 of 100) passes the bill. Finally, a conference committee made of House and Senate members works out any differences between the House and Senate versions of the bill. The resulting bill returns to the House and Senate for final approval. The Government Printing Office prints the revised bill in a process called enrolling. The President has 10 days to sign or veto the enrolled bill” (United States Houses of Representatives, 2014).
After President of U.S. signed the bill, it can be available to the general public. For that purpose, U.S. Government printing office (GPO’s) Federal Digital System (FDsys) provides free access to official publications. With the help of FDsys one is able to search government documents and below is some features of FDsys:

- Access is free.
- About 50 different collections of Federal Government information are available.
- FDsys is easy to use.
- FDsys offers authentic, digitally signed PDF documents.
- Information is preserved for permanent public access.
- Search multiple publications at once.
- Conduct complex searches.
- Narrow, sort, and filter search results.
- Access documents in multiple file formats.
- Access meta data in standard XML formats.
- Browse by collection, Congressional committee, date, and Government author.
- Utilize a searchable online help system (U.S. Government printing Office, 2014).

Thus one can understand how the Acts/Laws are processed and published in U.S. Following are chosen laws/acts described below related to EV technology development that can also give more insight/understanding about policy making in U.S.:
4.2 Energy policy act of 1992

The Energy Policy Act of 1992 (EPAct) was enacted by the 102nd United States Congress with public law number: 102-486. The Act was introduced by member of U.S. House of Representatives as H.R.776 Rep.Philip R.Sharp on February 4, 1991. It was passed to House on May 27, 1992 (381-37). Later, it was passed the Senate approval on July 30, 1992 (93-3). It was reported by the joint conference committee on October 5, 1992 and agreed by the House on October 5, 1992 (363-60) and by the Senate on October 8, 1992 (voice vote). Finally, the bill was signed into law by President George H.W.Bush on October 24, 1992.

The Energy Policy Act (EPAct) of 1992 was designed to increase clean and renewable energy use and lessen the nation's dependency on imported energy and improve overall energy efficiency in the United States. The Energy Policy Act of 1992 is the first to define the term ‘alternative fuel' which is later used in other energy related documents and acts. According to section 301 the term ‘alternative fuel’ means:

- Methanol, ethanol, and other alcohols
- Blends of 85% or more of alcohol with gasoline
- Natural gas and liquid fuels domestically produced from natural gas
- Liquefied petroleum gas (propane)
- Coal-derived liquid fuels
- Hydrogen
- Electricity

The EPAct proposes several programs that are intended to promote the use of alternative fuel vehicles. For example, as declared in the section 307 annual awards program shall be established to recognize those Federal employees who demonstrate the strongest commitment to the use of alternative fuels and fuel conservation in Federal motor vehicles.
Section 405 provides opportunity for appropriate Federal agencies and individuals and organizations with practical experience in the production and use of alternative fuels and alternative fueled vehicles, for the purposes of promoting the use of alternative fuels and alternative fueled vehicles, establish a public information program on the benefits and costs of the use of alternative fuels in motor vehicles. This public information program will produce and make available an information package for consumers to assist them in choosing among alternative fuels and alternative fueled vehicles. Such information package should provide relevant and objective information on motor vehicle characteristics and fuel characteristics as compared to gasoline, on a life cycle basis, including environmental performance, energy efficiency, domestic content, cost, maintenance requirements, reliability, and safety.

Title VI – electric motor vehicles is purely devoted to promotion of electric or electric-hybrid vehicles. It is divided in two subtitles: (a) the Electric Motor Vehicle Commercial Demonstration Program and (b) Electric Motor Vehicle Infrastructure and Support Systems Development Program. Section 601 of the act provides definitions of the term ‘electric motor vehicle' means a motor vehicle primarily powered by an electric motor that draws current from rechargeable storage batteries, fuel cells, photovoltaic arrays, or other sources of electric current and may include an electric-hybrid vehicle; and the term ‘electric-hybrid vehicle' means a vehicle primarily powered by an electric motor that draws current from rechargeable storage batteries, fuel cells, or other source of electric current and also relies on a non-electric source of power.

Further in the respective document under the section 611-616 one can obtain information on the Electric Motor Vehicle Commercial Demonstration Program. This program in collaboration with the Electric and Hybrid Vehicle Program Site Operators, manufacturers and the electric utility industry intends to demonstrate electric motor vehicles and the associated equipment of such vehicles. But also accelerate the development and use of electric motor vehicles and evaluate the performance of
such electric motor vehicles in field operation, including fleet operation, and evaluate the necessary supporting infrastructure. Moreover for the encouragement of the purchase or lease of electric motor vehicle a discount of up $10,000 is offered. To carry out the activities under the program government has reserved $50,000,000 for the 10-year period.

Electric Motor Vehicle Infrastructure and Support Systems Development Program according to definition includes support and maintenance services and facilities, electricity delivery mechanisms and methods, regulatory treatment of investment in electric motor vehicles and associated equipment, consumer education programs, safety and health procedures, and battery availability, replacement, recycling, and disposal, that may be required to enable electric utilities, manufacturers, and others to support the operation and maintenance of electric motor vehicles and associated equipment. Further detailed rules and conditions are explained under sections 621 – 626. Total provision for this program is $40,000,000 for the 5-year period and allocation to the single project may not exceed $4,000,000.

To conclude, we can say that EPAct 1992 demands the review of the U.S national energy policy and the effects of energy usage on the environment. This Act supports the development of alternative fuel vehicles in the country. And U.S. Department of Energy (2011) issued guidelines as per demanded by the Act on incentives that different States can offer in promotion to alternative fuel vehicles. In short, the EPAct 1992 provides guidelines, technical support and financial incentives to encourage the use of alternative fuel vehicles.
4.3 The energy policy act of 2005

The Energy Policy Act of 2005 (EPAct 2005) was Enacted by the 109th United States Congress with public law number: 109-58 and became effective on August 8, 2005. It is also known as public health and social welfare Act. This Act was introduced in the House as House Representative Member Joe Linus Barton on April 18, 2005. It passed the House approval on April 21, 205 (249-183) with 132 roll call vote via clerk.house.gov and later got Senate approval on June 28, 2005 (85-12) with 158 roll call vote via senate.gov. It was then reported by the joint conference committee on July 27, 2005; agreed to by the House on July 28, 2005 (275-156, roll call vote 445, via clerk.house.gov) and by the Senate on July 29, 2005 (74-26, roll call vote 213, via Senate.gov). Finally, it was signed into law by President George W. Bush on August 8, 2005. The Energy Policy Act of 2005 (EPAct 2005) was the U.S. government attempt to address growing energy problems by providing tax incentives and loan guarantees for energy production of various types. The underlying ideology of the act is “to ensure jobs for our future with secure, affordable and reliable energy” (EPAct 2005:1).

In the section 706 of the EPAct 2005, the department of Energy is instructed to establish a research program to advance the commercialization of hybrid flexible fuel vehicles or plug-in hybrid flexible fuel vehicles. EPAct 2005 requires vehicles to achieve at least 250 miles per petroleum gallon. A total of $40 million is authorized for the program ($3 million in 2006, $7 million in 2007, $10 million in 2008, and $20 million in 2009).

Later in the section 711 the government orders the department of Energy to “accelerate efforts directed toward the improvement of batteries and other rechargeable energy storage systems, power electronics, hybrid systems integration, and other technologies for use in hybrid vehicles” (EPAct 2005:226).

Section 1341 is dedicated to set out the rules for providing a fuel economy credit of up to $2,400 for
light-duty hybrid electric vehicles and trucks. The fuel economy credit is based on efficiency gains over model year 2002 baselines. A conservation credit increases the fuel economy credit by up to $1,000 based on lifetime fuel savings. To qualify for the credits, the vehicles must meet certain emissions standards based on gross vehicle weight ratings (GVWR). The credit will phase out after a manufacturer has sold 60,000 qualified vehicles.

Even though the section 915 addresses the issue of battery reuse and disposal, the EPA 2005 does not sufficiently recognise the BEVs.

In short, The Energy Policy Act (EPA) addresses energy production and consumption in the U.S. and provides loan guarantees for entities that develop or use innovative technologies to avoid the by-production of greenhouse gases. This Act also provide basis for the increase amount of biofuel usage that must be mixed with gasoline. This Act involves consumer’s tax credit for hybrids and advanced technology vehicles. Also includes tax credit for renewable energy production such as biomass, wind power, geothermal, ocean and solar energy.

4.3.1 Act controversy

After the Energy Policy Act of 1992, Congress has worked on new energy legislation since 2001. And a bill was almost enacted in 2003 but it was ultimately failed when the Senate refused to approve a conference report developed by a limited number of Senators and Representatives. But in 2005, Congress worked again and drop several controversial provisions and finally The Energy Policy Act of 2005 results into a law” (The Federal Policy Act of 2005, ACEEE).

Provisions in the original bill that were not in the Act

- Limited liability for producers of Methyl tert-butyl ether (MTBE).
- Drilling for oil in the Arctic National Wildlife Refuge (ANWR).
- Increasing vehicle efficiency standards Corporate Average Fuel Economy (CAFE).
- Requiring increased reliance on non-greenhouse gas-emitting energy sources similar to the Kyoto Protocol.
The Washington post states that “bill is a broad collection of subsidies for U.S. Energy companies in particular nuclear and oil industries. During the debate over the bill's numerous subsidies, taxpayer groups questioned why thriving energy companies need federal aid to produce energy. But the bill's defenders say it is not realistic to expect newer and cleaner technologies to succeed their own. "They need a jump-start," said Tom Kuhn, president of the Edison Electric Institute (Washington Post, 2005).

According to Martha Marks of Santa Fe, president of the National Republicans for Environmental Protection that “their organization was disappointed in the final version passed by Congress as it did not give enough support to conservation, and continued to subsidize the well-established oil and gas industries that don't require subsidizing (NBRC News, 2005). The bill did not include provisions for drilling in the Arctic National Wildlife Refuge (ANWR) even though some Republicans claim "access to the abundant oil reserves in ANWR would strengthen America's energy independence without harming the environment (The National Center for Policy, 2005).

Hence the final bill of Energy Policy and Act dropped most of the controversial amendments that blocked passage of earlier versions, including authorizing oil drilling in the Arctic National Wildlife Refuge, relieving the petroleum industry of liability for the gasoline additive known as MBTE and exempting some communities from clean-air standards. Eco-friendly measures to tighten fuel-efficiency standards for automobiles and take a stand against global warming were deleted as well.
4.4 The energy independence and security act of 2007

The energy Independence and security act of 2007 (EISA 2007) also known as Long - term Energy Alternatives for the Nation Act. It was enacted by the 110th U.S. Congress and became effective on December 19, 2007 with a public Law number: 110-140. The title of this Act amended into Public Health and Social Welfare. This Act was introduced in the House as H.R.6. by Nick Joe Rahall on January 12, 2007. The committee consideration was: Ways and Means, Natural resources, budget, rules, transportation and infrastructure. It was passed House on January 18, 2007 (264-162, roll call vote 40 via Clerk.House.gov). And later passed the Senate on June 21, 2007 (65-27, roll call vote 226, via Senate.gov) with amendment. The House agreed to Senate amendments on December 6, 2007 (235-181, roll call vote 1140, via Clerk.House.gov) with further amendment. The senate again reviewed it and agreed to House amendment on December 13, 2007 (86-8, roll call vote 430, via Senate.gov). Finally, it was signed into law by President George W.Bush on December 19, 2007.

High oil prices and climate change concerns is underlying reasons for the Energy Independence and Security Act of 2007. The stated purpose of the act is “to move the United States toward greater energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles, to promote research on and deploy greenhouse gas capture and storage options, and to improve the energy performance of the Federal Government, and for other purposes” (EISA 2007:1).

Section 131 firstly addresses and explains the terms “electric transportation technology” and “plug-in electric drive vehicle”.

Respectively, electric transportation technology is understood as “technology used in vehicles that use an electric motor for all or part of the motive power of the vehicles, including battery electric, hybrid electric, plug-in hybrid electric, fuel cell, and plug-in fuel cell vehicles.”

While the term “plug-in electric drive vehicle” means a vehicle that (a) draws motive power from a
battery with a capacity of at least 4 kilowatt-hours; (b) can be recharged from an external source of electricity for motive power; and (c) is a light, medium, or heavy-duty motor vehicle.

EISA provides funding of more than $500 million for PHEVs, BEVs and other electric transportation programs. Just to mention few, for example, plug-in electric drive vehicle program, Dr. Andrew Frank plug-in Electric vehicle competition for institutions of higher education, domestic manufacturing conversion grant program and many more.

Plug-in electric drive vehicle program under section 131 is intended to "provide grants on a cost-shared basis to State governments, local governments, metropolitan transportation authorities, air pollution control districts, private or non-profit entities, or combinations of those governments, authorities, districts, and entities, to carry out one or more projects to encourage the use of plug-in electric drive vehicles or other emerging electric vehicle technologies" (EISA 2007:18).

The act also anticipates grants for institutions of higher education in order to create new, or support existing, degree programs to ensure the availability of trained electrical and mechanical engineers with the skills necessary for the advancement of plug-in electric drive vehicles; and other forms of electric drive transportation technology vehicles.

Domestic manufacturing conversion grant program within section 132 authorizes the secretary of Energy to establish a program to encourage domestic production and sales of efficient hybrid and advanced diesel vehicles and components of those vehicles. The program shall include grants to automobile manufacturers and suppliers and hybrid component manufacturers to encourage domestic production of efficient hybrid, plug-in electric hybrid, plug-in electric drive, and advanced diesel vehicles.

The US government with the help of advanced battery loan guarantee program hopes to establish a program to provide guarantees of loans by private institutions for the construction of facilities for the manufacture of advanced vehicle batteries and battery systems that are developed and produced
in the United States, including advanced lithium ion batteries and hybrid electrical system and component manufacturers and software designers (EISA 2007:22, Section 135).

Section 109 describes extension of flexible fuel vehicle credit program regulates a special bonus credit under the federal fuel economy laws (CAFE –corporate average fuel economy) for dual- fuel vehicles such as PHEVs and has been prolonged until 2019.

To conclude we can say that EISA 2007 increased the production of clean renewable fuels, U.S. energy security, research and development, and, provide greenhouse gas capture and storage programs, biofuel infrastructure and vehicle fuel economy. Besides, U.S department of Energy (2010) identify following “Federal energy management goals/requirements in EISA 2007 in different areas such as:

- Energy reduction goals for federal buildings
- Facility management/benchmarking
- Performance and standards for new buildings and major renovations
- High performance buildings
- Energy saving performance contracts
- Metering
- Energy-Efficient product procurement
- Office of management and budget (OMB) reporting
- Reducing petroleum/alternative fuel use”

Thus EISA 2007 seems to be a major step towards production of renewable fuels and U.S efforts to reduce dependence on oil. This act encourages energy efficiency and usage in buildings by developing modern domestic energy consumption infrastructure.
4.4.1 Act controversy

The House passed versions of the bill which contained two controversial provisions:

- “a renewable portfolio standard which required that utilities to produce 15% of their power from renewable energy and;
- a tax package which would fund renewable energy through the repeal of $21 billion in oil and gas tax breaks; the Senate failed to pass these provisions in two cloture votes” (Van Ness Feldman law and policy firm., 2014).

According to the Washington Post 2007 “On June 21, 2007, an attempt by the Senate Democrats to raise taxes on oil & gas by $32 billion was reportedly blocked by the Republicans”. The raise of taxes on oil and gas companies would have provided money and accelerated alternative fuel projects.

Title I of the original bill, the “Ending Subsidies for Big Oil Act of 2007,” denied certain tax deductions to producers of oil, natural gas, or primary products of oil or natural gas, and increased from five to seven years the period during which five major integrated oil companies must write off their expenditures on geological and geophysical studies related to oil exploration” (EPACT 2007).

Opponents of the bill argued that the act would "make America more dependent on foreign sources of energy as exploring domestic production and search can be costly”. For example, The United States Chamber of Commerce, 2007 said that “it supported the rapid development of alternative fuels but that the new technologies are not developed enough, and are insufficient to make any real difference” It can be said that more regulation on oil and gas industry could not be the solution to the energy problems. Some opponents of the bill included Democratic Senators Claire McCaskill, Mary Landrieu and Carl Levin.
4.5 The American Recovery and Reinvestment Act of 2009

The American Recovery And Reinvestment Act of 2009 (ARRA) enacted by the 11th United States Congress. It became effective on February 17, 2009 with public law number: 115-5. This Act was introduced in the House as H.R.1 by Dave Obey on January 26, 2009. It passed the House on January 28, 2009 (244-188) and Senate on February 10, 2009 (61-37). It was further reported by the joint conference committee on February 12, 2009 and agreed by the House on February 13, 2009 (246-183) and by Senate on February 13, 2009 (60-38). Finally, it was signed into law by President Barack Obama on February 17, 2009.

The global financial crisis has had a significant impact on every economy of the world, including the U.S. In order to address the rising problems, on February 13, 2009 President Obama and the Congresses passed the American Recovery and Reinvestment Act of 2009 (ARRA 2009). The nature of this act is to stimulate the U.S. economy. It is also known and referred as ‘stimulus package’. The US government hopes that with the help of the American Recovery and Reinvestment act of 2009, it will be able to save the existing jobs and create new ones as well as spur economic activity and secure economic growth in the long-term. Moreover the government is expecting to increase citizen trust through accountable and transparent government activities (ARRA, 2009). To guarantee transparency, the website www.recovery.gov was created, where the public can see how recovery funds are being spent by recipients of contracts, grants, and loans, and the distribution of recovery entitlements and tax benefits.

The Act is seen as extraordinary response to a crisis. With this fund the government expects to modernize the US infrastructure, enhance energy independence, expand educational opportunities, preserve and improve affordable health care, provide tax relief, and protect those in greatest need (ARRA, 2009).
The initial plan was to provide in total $787 billion, but in 2011 it was increased to $840 billion. When it comes to the alternative fuel vehicles, where the electric vehicles are included, the ARRA has to modernize the US infrastructure, enhance energy independence, expand educational opportunities, preserve and improve affordable health care, provide tax relief, and protect those in greatest need.

The Department of Energy, who is responsible for the energy programs, has been provided with $2 billion for grants for the manufacturing of advanced batteries and components. The money shall be used also to provide facility funding awards to manufacturers of advanced battery systems and vehicle batteries that are produced in the United States, including advanced lithium ion batteries, hybrid electrical systems, component manufacturers, and software designers (ARRA, 2009:24).

The ARRA in hope to create the energy efficient federal motor vehicle fleet also allocates funds for capital expenditures and necessary expenses of acquiring motor vehicles with higher fuel economy, including: hybrid vehicles; electric vehicles; and commercially-available, plug-in hybrid vehicle (ARRA, 2009:36).

The section 1302 is dedicated to the “credit for investment in advanced energy facilities”, which now also includes the (a) fuel cells, micro turbines, or an energy storage system for use with electric or hybrid electric motor vehicles; and (b) new qualified plug-in electric drive motor vehicles or components which are designed specifically for use with such vehicles, including electric motors, generators, and power control units, or other advanced energy property designed to reduce greenhouse gas emissions (ARRA, 2009:232). The advanced energy manufacturing tax credit is equal to 30 percent of the basis of eligible property placed in service in a taxable year as part of an advanced energy project.
The ARRA also has implications on the refuelling stations. Temporary Increase in Credit for Alternative Fuel Vehicle Refueling Property (Section 1123) modifies the credit rate and limit aggregated for property placed in service in 2009 and 2010. Qualified property is now entitled to 50 percent credit and the per-location limit increases to $50,000 for business property.

Further, part V entitled Plug-in electric drive motors, which is composed of sections 1141 – 1144, is dedicated to identify the different rules that are applicable for electric vehicle in regard to taxation and credits.

The section 1141 outlines the new law about the credit for qualified plug-in electric drive vehicles purchased after Dec. 31, 2009. To qualify, vehicles must be newly purchased, have four or more wheels, have a gross vehicle weight rating of less than 14,000 pounds, and draw propulsion using a battery with at least four kilowatt hours that can be recharged from an external source of electricity. The minimum amount of the credit for qualified plug-in electric drive vehicles is $2,500 and the credit tops out at $7,500, depending on the battery capacity. The full amount of the credit will be reduced with respect to a manufacturer's vehicles after the manufacturer has sold at least 200,000 vehicles.

Section 1142 introduce a special tax credit for two types of plug-in vehicles — certain low-speed electric vehicles and two- or three-wheeled vehicles. The amount of the credit is 10 percent of the cost of the vehicle, up to a maximum credit of $2,500 for purchases made after Feb. 17, 2009, and before Jan. 1, 2012. To qualify, a vehicle must be either a low speed vehicle propelled by an electric motor that draws electricity from a battery with a capacity of 4 kilowatt hours or more or be a two- or three-wheeled vehicle propelled by an electric motor that draws electricity from a battery with the capacity of 2.5 kilowatt hours.

Section 1143 is dedicated to conversion of the vehicle. The credit is equal to 10 percent of the cost
of converting a vehicle to a qualified plug-in electric drive motor vehicle and placed in service after Feb. 17, 2009. The maximum amount of the credit is $40,000. The credit does not apply to conversions made after Dec. 31, 2011.

Finally, as specified by the section 1144, starting from 2009 the Alternative Motor Vehicle Credit, including the tax credit for purchasing hybrid vehicles, can be applied against the Alternative Minimum Tax (AMT). Before these changes, the Alternative Motor Vehicle Credit could not be used to offset the AMT.

4.5.1 Act controversy

However, likewise other Acts this Act also has some opposition. Washington Post 2009 reported that “the stimulus package caused outrage in the Canadian business community, and that the government in Canada "retaliated" by enacting its own restrictions on trade with the U.S” (Washington Post, May 15, 2009). U.S. largest trading partner Canada seemed more concerned with this bill because some of the Canadian companies working in U.S. told to buy products made in U.S. Products. Also, the bill was not appreciated by all economic circles. “Economists such as Daron Acemoglu, Martin Feldstein, Nobel Prize winner Paul Krugman, Larry Summers and Nobel Prize winner Joseph Stiglitz, support this bill but other economist’s opposite it due to the debt incurred; these include Robert Barro, James M. Buchanan, Nobel Prize-winner Robert Lucas, Jr., Edward C. Prescott, and Vernon L. Smith. And the libertarian Cato Institute ran a full-page ad opposing this bill signed by about 200 economists in The New York Times and The Wall St. Journal on 28 January 2009” (Kathy Gill, 2009).

4.5.2 American Recovery and Reinvestment Act: Outcome

The Department of Energy in order to develop infrastructure and technology to address the nation’s energy issues, received $35.2 billion out of $90 billion of government investments and tax incentives. As of February 16, 2012 Department of Energy has spent $22.3 billion, supporting over
15,000 clean energy projects across the country. These investments has saved and created new jobs, increased the use of renewable electricity, reduced countries dependency on oil, set practices to increase energy efficiency and established the U.S. leadership in clean energy industries.

The department of energy has concluded that due to the ARRA of 2009, the electric vehicle industry is slowly but steady establishing roots in the US motor vehicle industry. The US government goal is to be able to produce batteries and components to support one million plug-in hybrid and electric vehicles on road by 2015. Every government investment has been complemented with at least equal amount of money from the industry side. The results of the ARRA investments has been collected and presented in the report of the Department of Energy (2012:2):

- **70 private companies and researchers in over 30 states** have received grants to help build the American advanced battery and electric vehicle manufacturing industry from the ground up.
- **Thirty** new advanced battery and electric vehicle component plants are opening across the country as a result of these investments.
- Before the Recovery Act, a 100 mile range electric vehicle battery cost **$33,000**. Because of the high-volume manufacturing the Recovery Act is spurring, those batteries will cost about **$16,000** by the end of 2013 and **$10,000** by the end of 2015.
- Before the Recovery Act, there were **less than 500** electric vehicle charging stations in the U.S. Because of the Recovery Act, there are **over 5,000** charges deployed today and there will be **over 18,000** by 2012.

### 4.6 Government policy for developing national innovation system

In this part I will try to show how by following the development of the policy acts it is possible to see the government input in building the national system of innovation. In the table 5 I have
presented in condensed way the policy acts and their aim, main points and what has been the focus when it comes to electric vehicles as well as to some extend the amount of investment the U.S. government has allocated.

It is necessary to point out that as the analysed documents are legal policy acts the language and style is also very official, full with legal terms and references to different parts and historical changes etc. The nature of such documents is to be very precise and well defined as it represents the government work and actions and serves as point of reference, however due to fact that these are legal documents one could say that special knowledge and education is required to enjoy reading them. Personally I think that such policy acts should be written to serve general public as it provides guidance as to how government works and how one should interact. The fact that I do not possess legal background, I interpret as contributory factor because it allows me to question every word and meaning without making certain professional assumptions.

But going away from the technical details and complexity of legal documents, the content is of strong interest for this study. This was also part of this study to discuss and show how public policy can affect and strengthen the national system of innovation by using example of EVs. Content analysis of the documents demonstrated how the interest and importance of EVs has been enhanced by the policy. Every policy is created as response to some events. Enormous dependency on oil and growing concerns about air quality and climate change has triggered U.S. to revisit their policies and make modification. The four policies that have been covered by this study aims at finding ways to decrease country dependency on fossil fuels. Transportation is one of sectors that heavily rely on supply of oil. In order to look for solution the U.S. government introduced the concept of alternative fuel vehicles (AFV) in their Energy policy act of 1992. This concept covers all possible fuels (except oil) that a car can drive on, therefore making a legal act suitable for almost everything. I see this as a problematic issue as it allows manipulations and wide interpretation of act; moreover it loses clear thread, focus. From the content of 1992 act it is not clear what the U.S. position on the
future of transportation sector is. Only with the Energy Independence and Security Act of 2007 it becomes clearer that the U.S. government plan to increase energy independence and reduce dependency on foreign oil supplies by promoting PHEVs and BEVs.

Table 2 Overview of the analysed policy acts

<table>
<thead>
<tr>
<th>Policy Act</th>
<th>The aim of policy act</th>
<th>Main points, focus</th>
<th>Investments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy Policy Act of 1992</td>
<td>to increase clean and renewable energy use and lessen the nation's dependency on imported energy and improve overall energy efficiency in the United States</td>
<td>Definition of AFV; Programs to promote the use of AFV at federal government level</td>
<td>$90,000,00 for the 10-year period</td>
</tr>
<tr>
<td>The Energy Policy Act of 2005</td>
<td>to address growing energy problems by providing tax incentives and loan guarantees for energy production of various types</td>
<td>A research program to advance the commercialization of hybrid flexible fuel vehicles or plug-in hybrid flexible fuel vehicles and to the improvement of batteries and other rechargeable energy storage systems</td>
<td>A total of $40,000,000 for the 4-year period</td>
</tr>
<tr>
<td>The Energy Independence and Security Act of 2007</td>
<td>Focus – research, commercialization and vehicle conversion</td>
<td></td>
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<td>-------------------------------------------------</td>
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<tr>
<td>to increase energy independence and security, to increase the production of clean renewable fuels, to protect consumers, to increase the efficiency of products, buildings, and vehicles</td>
<td>PHEVs, BEVs and other electric transportation programs to encourage the use of plug-in electric drive vehicles or other emerging electric vehicle technologies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Collaboration on a cost-shared basis to State governments, local governments, metropolitan transportation authorities, air pollution control districts, private or non-profit entities to carry out one or more projects</td>
<td>Grants to automobile manufacturers and suppliers and hybrid component manufacturers to encourage domestic production of efficient hybrid, plug-in electric hybrid, plug-in electric drive, and advanced diesel vehicles.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Education programs at universities</td>
<td>$500,000,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Focus – collaboration, knowledge transfer, research, commercialization

| The American Recovery and Reinvestment Act of 2009 | to stimulate the U.S. economy by modernizing the U.S. infrastructure, enhancing energy independence, expanding educational opportunities etc. | The research and manufacturing of advanced batteries and components | Credit for investment in advanced energy facilities and refuelling stations | Taxation and credits for the purchase of EVs and conversion of vehicle | Focus: research, deployment, infrastructure, pricing | $840 billion in total |

The policy documents were analysed by extracting all information and sections that concerned electric and plug-in electric vehicles. Even though electric vehicle technology is not new, it is still considered in the frame of this study as innovation as it continues to develop and evolve.

In the light of theoretical framework, one could clearly see with the help of political documents and case of electric vehicles, the pivotal role of government in building up system of innovations. As stated earlier, NIS refers to the national network of institutions, both public and private and the policy initiatives for the development and diffusion of various technologies. In an early 1992 the main focus of policy was raising awareness mainly among those who worked for the federal government. Later after more than 10 years the general situation has matured to the level where new
elements could be highlighted. The energy policy act of 2005 put emphasis on the research programs, improved standards and commercialization of technology. It is a step towards system of innovation as more actors been involved. Just two years later a new corrections was introduced to the Energy Independence and Security Act of 2007. By looking at the different sections and content, one can notice growing attention devoted to electric vehicles in comparison to the act of 1992 and 2005. The act of 2007 explicitly promotes purification of transportation, and provides support for research and collaboration. As we know a system of innovation is constituted by elements and relationship which interact in the production, diffusion and use of new, and economically useful, knowledge. The U.S. government is strongly supporting and promoting collaboration on a cost-shared basis among state governments, local governments, metropolitan transportation authorities, air pollution control districts, private or non-profit entities in order to boost strong, innovative, knowledge based economy.

Finally as stated earlier the government response to the economic crisis was the American Recovery and Reinvestment Act of 2009. Even though this is purely a tool to boost national economy and create new jobs, it also serves as example for the US government role in the nationals system of innovation. Such policies provide financial incentives to invest in research and innovation. Moreover the government has predefined the areas of interest and the deployment of electric vehicles as one of U.S. priorities in the sector of transportation.

One can conclude that it is priority because the government is allocating funds to multiple directions: industry, universities and research institutes, state governments and potential car purchasers. From this one can say that the government plays all cards to reach a goal of putting on roads one million electric vehicles by 2015. Besides, changes in legislative acts and programs along with changes in current technological, political and social environment force many U.S firms to create a division of labor in the U.S NIS. For example in case of EVs, the car components such as batteries, recharging points, and disposal and distribution points are going to be performed by different actors. This will creates a division of labor and different actors in a system will be
cooperating with each other likewise in theory they do it.

The allocation funds given to firms could help in structural changes which may affect industrial R & D and will increase firm’s reliance on other organization outside their boundaries/limits. For example, under the terms of National Cooperative Research Act during 1985-1994” US firms formed more than 450 'research joint ventures' (Link, 1996 in Mowery, 1998, p.646). To sum role of different actors such as universities R & D, industries, foreign industry will increase in order to cooperate with each other to solve many social, political, technological and environmental problems. However, there is always risk of failure involved in the whole process as many programs may be linked to organizational personal goals and objectives. Some failures could be in internal organizational infrastructural, poor communication between different actors, poor monitoring of the whole process, time factor, focusing much on technology or product and ignoring the other local, political and social factors. To solve such issues NIS approach could be a useful tool as it can urge continuous reformation of institutes and policies at the national level. This could be used to achieve the highest sustainable economic growth and to overcome many social, political and environmental problems within a country.

4.7 Is money answer to all problems?

Despite streamlines and focused policy, some argue that we are still locked-in in the dominant technology and that such fiscal policies are not going to solve the problems. Many fear that despite government incentives, the initiative and efforts first has to come from industry and consumers. The government funding cannot be seen as “easy money” for the experiment that is foreseen to fail. The industry and consumers has to take serious stand and commitment in long term.

Earlier in the study I present a vast range of barriers that is recognised in the other studies that delay successful implementation of EVs in the market. Here I would like to bring up some of the barriers that were also addressed at political level. First, it is clear that the issues with battery technology seem to be recognised by all involved parties and there is clear message from policy point of view.
that this problem (range, material, durability, price etc.) has to be resolved. Thus significant funding's has been allocated to remove this barrier.

Secondly, economic barriers in terms of high initial expenses of the electric vehicle also have been recognised by the government. The government contribution and response to this problem is tax relief and subsidies to purchase new car. Household can receive up to $10, 000 if they purchase electric vehicle. The government is also subsidizing the production of batteries in order to reduce the total cost of vehicle.

Energy policy acts reviewed and analysed in this study per se involved the environmental concerns - air pollution, climate change and dependency on fossil fuels. But it also occurred that some of the government financed research is aimed at safe and sustainable reuse or disposal of batteries.

As described earlier deployment of electric vehicles in the market largely rely on public acceptance. From the document analysis it became clear that government strategy has been from the very beginning aimed at raising awareness, steering informative campaigns and executing demonstration projects. Unfortunately it seems that it might take generations for changes to occur as it is about changing lifestyle. American society is built around heavy sports utility vehicles (SUVs), cheap and easy accessible oil.

Finally, one of the important legal and political barriers identified in this study is the fact that despite recognition of AFV’s already in early 1992, the actual breakthrough happened between 2005 and 2007. Such delay might depend on political lobby or individual political party interests to sustain existing technology, but it is only speculation as it is hard to prove. The document analysis showed that the government has put the biggest effort in building up infrastructure. Without government financial support such investments would most likely not be possible as it is still not profitable for private investors alone.
5. Conclusion and future work

This paper has discussed different issues related with EVs technology including economic, social, technological and environmental challenges. NSI approach has helped to understand that government, industry and people have a powerful role to play in encouraging or discouraging existing development and the production of EVs in U.S. Not all important innovations come from the scientific knowledge; some are initiated by situation and needs. Experiences of users seem to be an important factor behind market trends and product development. Firms usually innovate because they believe that there is knowledge and potential for profit. Besides, car companies in many parts of the world are experiencing pressure within the national context to develop environment friendly vehicles with least emissions. For that reason car companies will have to adapt different approaches for manufacturing their vehicles. In the case of EV technology, governments could encourage these industries by passing laws that could directly affect car manufactures.

The government should facilitate R&D institutes and manufacturing industry by providing them basic investment in infrastructure and human capital. Diffusion can be enhanced by programs that increase the number of people that are knowledgeable about the innovation and capable of applying it to the needs of industry.

The NSI provided a good framework for reorganization of different actors involved and helps to identify government role in the process. The automobiles companies and R&D institutes are main actors in the development of EVs. However national government role cannot be neglected and are highly significant. It is because government can encourage and provide funds for research in this area through university education, scholarships, rules and regulations, R&D support and creating social awareness and responsibility. Governments can also create a firm taxation policy which discourages the use of old vehicles with the propensity to produce more CO₂ emission. At the same time, they could create a tax-free system to those using cost effective vehicles and vehicles with less CO₂ emission. However, governments have a lot of considerations which they need to take in to account before making any new policy. First of all, they need adequate and reliable information
before passing any sound policies and laws. For example, how reliable these electrical vehicles and batteries are? What are the economic and practical implications of them? How safe are they and how one can measure the degree of usefulness in relation to the older models?

Therefore, it can be understandable that government role is very significant for encouraging these technologies as they have the capacity to boost the auto vehicle industry to manufacture environment friendly and fuel efficient vehicles. This pragmatic approach backed by any government at national level could gradually spread at international level. Furthermore, challenges that are linked with the development of EVs are not only connected to their internal organization but it is also connected with infrastructure, knowledge, competitiveness, relationship and interaction between different actors in the network.

As like other technologies in the development phase, EVs have serious challenges that must be solved before they can have a real impact on the market such as:

First, the biggest problem with the commercialization of EVs seems to be its costs. It cannot compete in price with other available technologies such as hybrid, gasoline vehicles which runs on combustion engines. Tax reduction, free parking and the mass production of EVs could be some of the solutions to lower their prices.

Second, the EVs are dependent on battery technology, which is not fully developed to satisfy the needs of users. There is a need for further research in material science to solve the problem of battery durability and weight.

Third, as said earlier lack of infrastructure and charging stations is considered a big problem. Due to small share of EVs in the market and unclear future prospects, it seems to be risky and unprofitable investment for private firms.

Fourth, source of electricity generation for EVs need to be taken into consideration. The electricity generated by fossil fuel could contribute to air pollution, therefore renewable energy, like solar or wind, should be part of solution. However maintenance and operation costs are currently
very high for renewable energy, which in turn increase the overall cost of EVs.

Fifth, due to limited range, weight of battery packs as well as high cost and unknown health side effects the **public acceptance** of EVs has not reached its maximum potential. Besides, there is also a possibility of **negative impacts on environment** due to batteries disposal since they might contain toxic elements and carcinogens. Therefore more research and investment is needed in electric battery production and safe disposal.

To conclude we can say that growing concerns about health and environment started a new era in the automobile industry. EVs are gaining fame again and more research is taking place in this area of mobility. But success of EVs largely depends upon public acceptance, technology development, distribution and government support and policies.
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