Dutch Electric Vehicle Innovation System

An exploratory business growth scenarios research for potential developments in Dutch electric vehicle industry

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More space for entrepreneurial initiatives, more space for innovation and modernisation. That is the route the Dutch government wants to go down. Entrepreneurs opening up new markets for the creation of ground-breaking products and services must be given more opportunities, more room to manoeuvre and be able to rely on proper regulations that stimulate market forces. For this, government support is increasingly less a matter of mere subsidies. It more and more involves advising, directing and supervising, as the success of innovations depends on many more factors than technology and funding alone. Government can influence knowledge development and knowledge sharing, by stimulating e.g. intersectional thinking and different sectors working together, such as the mobility, energy and ICT sectors.

At the same time, a smart incentive policy seeks the right balance between giving private initiatives room to manoeuvre and taking corrective action, as and when required. A policy based on ratio, analysis and a long-term vision. Therefore, government must continue to monitor the long-term objectives, seeking system innovations (the combination of long-term and short-term thinking), that enable the transition to sustainability and economic growth. Government incentive schemes must go hand-in-hand with criteria and conditions that ensure government funding is invested wisely.

Transitions can sometimes take generations to complete. The introduction of the electric car is such an example. This innovation appeared on the scientific stage decades ago, yet it may take another decade before mass production becomes a real possibility. The question whether government support for this phenomenon is or was worthwhile, should not be asked in retrospect, but during the course of the process. That makes monitoring a necessity. Will an innovation be successful or not? Who are the beneficiaries? How can bottlenecks be solved? What is more effective as a policy?

NL Agency has many years of experience in scouting, monitoring, supporting and helping to take government-driven corrective action in (energy) transition processes in the Netherlands. The emphasis sometimes lies on technological innovations, whereas on other occasions it involves knowledge programmes or promoting market introductions. At present, based on hundreds of programmes and experiences, a method has been developed for monitoring innovations: the Innovation sensor. This method supports policy officials and entrepreneurs alike, within a more coherent and broader context. They will benefit from being informed timely of developments and learning.

The Innovation sensor is viewing innovation in the Dutch energy supply from an evolutionary perspective of variation and selection in technology and institutions, in which these two should ‘co-evolve’ towards a sustainable energy supply. Demand-driven programming is a form of policy where the ‘bottom-up’ approach of variation in scientific research is linked to selection by market mechanisms. Demand-driven programming is at the basis of innovation policy and design of the Innovation sensor. To monitor the progress of the energy innovation we distinguish the levels of policy agenda, theme, program and research and practical projects (multilevel approach).

Main source of information for the Innovation sensor are innovation projects, subsidized by the central government. Innovation is reflected in research and development of new products and services. Product are usually developed step by step (variation) and its added value tested (selection) in the form of projects. The reason the focus is mainly on the innovation projects, subsidized by the
central government is simple: access to project information is guaranteed within NL Agency and required for accountability of public funds.

A second important source for the Innovation sensor are the interventions or activities in policy plans, programs, or Chamber letters for strengthening the innovation and the innovation system. Each of the four above-described levels of monitoring has its own control requirements, clients and thus information requirement. The Innovation sensor for each level and area of interest has dashboards, where the target group can follow developments in the portfolio of innovations, programs and projects.

In the development and implementation of the Innovation sensor, NL Agency is cooperating with scientific partners like TNO and the Universities of Utrecht, Nijmegen and Delft. Not only will this help to further improve and enhance the use of this method, at the same time mutual benefits come from the exchange of involvement. Researchers, and the students they supervise, can benefit from the rich source of data NL Agency can provide, and in turn NL Agency is well supported in its monitoring role by their analyses.

As the introduction of the electric vehicle to the Dutch market is an important test case for implementation of the Innovation sensor, and more specifically, the earning potential within this innovation system an important topic at present, we were pleased to notice that Ferdian Suprata intended to make this the subject of his thesis. In a relatively short time he has ‘unearthed’ a lot of information and has filtered and analysed this along the lines of a research framework, that coincides very well with the structure of the Innovation sensor. He has thus provided new insights for the implementation of the Innovation sensor in the electric vehicle case study and this leads for the support of entrepreneurs.

I think I speak on behalf of all my colleagues, when I say we enjoyed working with you Ferdian and wish you all the success in your future careers, if it be in business, research or government, or in between?

Utrecht, 15 August 2012

Drs. M.J.E. Willems
NL Agency
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First of all, it never occurred to me that many people have made significant contributions for the accomplishment of this master thesis as it is today. It has been a wonderful period of time and a pleasure to know all of those who have helped and supported me during the entire process of this master thesis.

To begin with, I would like to thank Victor Scholten, my first supervisor, for giving me an opportunity to do this master thesis under his supervision. Victor, your guidance, timely advice and supervision were valuable for the final product of this thesis. Thanks a lot for your great support.

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The Hague, 17 August 2012

Ferdian Suprata
Executive summary

Due to the global changes in economy, energy security and environment, international policy makers including the Netherlands are seeking for a new feasible solution to address sustainable transportation. Taking into account that 73% of oil in Europe is consumed by the transportation sector, the introduction of electric vehicles should be a first priority for saving the most critical source of primary energy (EuropeanCommission, 2010). Accordingly, the Dutch government intends to innovate by shifting from a fossil fuel based transportation network to a more sustainable fuel network. Some possible alternatives such as hybrid, bio-fuels, steam, and electric vehicles have been discussed for many years but many scholars vouch for electric vehicle (EV) as the best possible solution.

However, introducing electric vehicle to the Dutch market is not a straightforward task. It is a complex process in which economic, political, social and technological factors influence the Dutch electric vehicle innovation system. As this system needs to be improved, continuous environment scanning is a first crucial step. Therefore, the objective of this study is to analyze the current Dutch EV innovation system, which can help the Dutch government to improve the innovation development inside the electric vehicle industry by mapping out the views of potential electric vehicle developments and prosperous business models. This has led to the main research question:

What are the prosperous business growth potentials for the promising developments (products or services) within the Dutch electric vehicle innovation system?

In order to answer the main research question, this study used a methodology, innovation system analysis, which consists of three main analyses: basic analysis, context analysis, and variation analysis. In the basic analysis, an extensive literature study or desk research was performed to focus on the current development and foreseen innovation characteristics of electric vehicles. Included in the analysis were an investigation on the technical aspect, stakeholder analysis, barriers and potential innovation development areas. As a result, an electric vehicle technology map, a stakeholder map, several barriers, and the nine innovation development areas were discovered.

The context analysis was performed to understand the key characteristics of the environment, which might influence the current Dutch EV innovation system. In this analysis, a complementary analytical framework, named the Multi Level Perspective (MLP) and Strategic Niche Management (SNM), was used by looking at the interaction among three development levels: landscape, regime, and niche development. With regard to the regime development, the eight components of current transportation regime: distribution network, industry structure, markets, infrastructure, automobile artifact, culture, traffic systems and regulation, were investigated. For a large adoption of electric vehicles, those eight components need to be in favor of the electric vehicle. At the landscape development, the analysis continued with the investigation on political issues, environment change, macro economics, and society change. The outcomes of this landscape level have a considerable impact on the transformation dynamic of the current regime. Therefore, through a learning process and support of various actors, the EV niche could now be expected to compete against the existing combustion regime.
Promising developments

Through an investigation of the existing pilot projects, several potential developments (products or services) were identified for the Netherlands: Future Power Train, Battery Information Interface (BII), Battery Management System (BMS), Driver Guidance System (DGS), Smart Charging, Financial Services, Payment Services and Mobility Services. Further, it was aware that the Dutch ICT sector could play an important role in the forthcoming EV development. Thus, combining the automotive sector with the ICT sector would create a “unique” identity for the Netherlands in the EV development.

Based on the initial findings from the two previous analyses, the variation analysis was performed to look at future EV development options. In this analysis, the mentioned potential developments (products or services) and application areas of EV were further assessed by applying several criteria: market size, competition, resources, and integration. Concurrently, a qualitative research was conducted for examining the potential developments as well as for gaining new inputs to design possible business strategies and business models. A model for conducting the interview was conceptualized by integrating the Porter’s five force model (1998), Osterwalder’s business model framework (2010), and the role of government. In this model, the government was included since in practice a misalignment can occur which may hold the development process. Hence, the Dutch government is expected to become as a means to align the development activities within EV value chain. The proposed model is illustrated as follows: (the detail explanations is described on page 86)

Figure: Proposed model

Results from this third analysis indicated two most reliable products and services combinations, which are seen as short-term opportunities (less than 5 years development) for the Netherlands:

- **On the vehicle interface**: combinations among Battery Information Interface (BII), Battery Management System (BMS) and Driver Guidance System (DGS) – the combinations can be integrated with the routing planning and the navigation system. The aim is to reduce the range anxiety by optimizing the use of battery technology and giving the information about the availability of charging point.

- **On the infrastructure**: combination between smart charging and payment service – the combination provides ease of use, reliable and secure charging point. This includes the reservation system, central back-office system, and transaction system.
These two combinations present the real strength of the Netherlands. This is supported by the fact that the Netherlands has a strong market position in those combined products and services, and has a favorable industry support e.g. highly availability of knowledge as well as highly reputation firms.

**Business models and strategy**

For all electric vehicles value chain, the introduction of electric vehicles offers new opportunities and perspectives. Thus, the actors need to decide in which role they like to play in developing solutions for electric vehicles. Various business models, their implications, variations and specific roles of the actors for each development can be found in chapter 7. Nevertheless, in order to develop in a sustainable way several aspects should be considered: implement niche market strategy, open strategic collaboration, and focus on specific market segments e.g. logistics and distribution, commercial mobility and commuter traffic, mass transit (public transport, taxis, pooling cars), and company and government vehicles.

With regard to the business models, it is important to understand that one need to continuous investigate the customer needs and how the customers react to the value proposition. Further, being a first mover in this EV development may maintain the technological leadership. On contrary, late entrants may have less risk now but they also potentially miss out on strategic partnership that can be a major specialized asset in the future business models.

**The role of government**

The government should act as a catalyst to increase the overall performance and create a sustainable competitive country in the electric vehicle development by considering the following aspects:

- The need for maintaining long-term vision of electric vehicle development, facilitating and steering to the right electric vehicle development, increasing the awareness of using the electric vehicle in the society, connecting each collaboration projects, promoting and demonstrating the successful projects internationally, facilitating the process of developing charging infrastructure, and actively involving in the European negotiations.

- Policy creation on: standardization, open access to infrastructure and systems, energy supply and safety, maintaining tax incentive on EV end-user, and actively involve for the regulation of charging infrastructure on European Level.

To conclude, some concrete actions from the Dutch government can be expected to create more cluster regions for EV industry in the Netherlands and interconnect it globally. Strong points of the Netherlands, such as the advanced EV knowledge and presence of large creative ICT as well as automotive sector should therefore be promoted. Simultaneously, its weak points, such as the lack of venture capital or funding, can be solved by connecting Dutch firms with other countries and foreign venture capital firms. Last but not least, In the future one may assume that the interconnectedness of different actors can produce more business model innovations as well as new innovative products and services.

**Keywords**

Innovation systems, strategic niche management, entrepreneurship, business model, and Dutch electric vehicle.
## List of abbreviations

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<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation</th>
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<tbody>
<tr>
<td>AC</td>
<td>Alternating Current</td>
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<tr>
<td>BEV</td>
<td>Battery Electric Vehicle</td>
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<td>BII</td>
<td>Battery Information Interface</td>
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<td>BMS</td>
<td>Battery Management System</td>
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<tr>
<td>BPM</td>
<td>Belasting van Personenautos en Motorrijwielen (Dutch automobile tax)</td>
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<td>CBS</td>
<td>Centrale Bureau voor de Statistiek</td>
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<td>CCC</td>
<td>Connected Cruise Control</td>
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<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
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<tr>
<td>DC</td>
<td>Direct Current</td>
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<tr>
<td>DGS</td>
<td>Driver Guidance System</td>
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<td>D-incert</td>
<td>Dutch Innovation Centre for Electric Road Transportation</td>
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<td>DPI</td>
<td>Dutch Polymer Institute</td>
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<tr>
<td>e.g.</td>
<td>Example Given</td>
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<td>ESI</td>
<td>Embedded Systems Institute</td>
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<td>EU</td>
<td>European Union</td>
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<td>EV</td>
<td>Electric Vehicle</td>
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<td>EVD</td>
<td>International Business Cooperation</td>
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<td>FIS</td>
<td>Functional Innovation System</td>
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<td>GATT</td>
<td>General Agreement on Tariffs and Trade</td>
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<td>HTAS</td>
<td>High Tech Automotive Systems</td>
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<td>I2V</td>
<td>Infrastructure to Vehicle</td>
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<td>ICE</td>
<td>Internal Combustion Engine</td>
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<td>ICT</td>
<td>Information Communication and Technology</td>
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<td>Li-ion</td>
<td>Lithium-ion</td>
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<td>NEN</td>
<td>Netherland Standard Institute</td>
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<tr>
<td>Ni-Cd</td>
<td>Nickel Cadmium</td>
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<tr>
<td>Ni-Mh</td>
<td>Nickel Metal Hydride</td>
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<tr>
<td>NIMR</td>
<td>Netherlands’Institute for Metals Research</td>
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<td>NL</td>
<td>Netherlands</td>
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<tr>
<td>NOₓ</td>
<td>Oxides of Nitrogen</td>
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<tr>
<td>MLP</td>
<td>Multi Level Perspective</td>
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<tr>
<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>OPEC</td>
<td>Organization of the Petroleum Exporting Countries</td>
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<tr>
<td>PHEV</td>
<td>Plug-in Hybrid Electric Vehicle</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>Particulate Matter of 10 Microns</td>
</tr>
<tr>
<td>PSS</td>
<td>Product Service System</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>SME</td>
<td>Small Medium Enterprise</td>
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<tr>
<td>SNM</td>
<td>Strategic Niche Management</td>
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<tr>
<td>SO₂</td>
<td>Sulfur Dioxide</td>
</tr>
<tr>
<td>TU/e</td>
<td>Eindhoven University of Technology</td>
</tr>
<tr>
<td>TUD</td>
<td>Delft University of Technology</td>
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<tr>
<td>UT</td>
<td>University of Twente</td>
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<tr>
<td>V2V</td>
<td>Vehicle to Vehicle</td>
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<tr>
<td>WTO</td>
<td>World Trade Organization</td>
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<tr>
<td>4G</td>
<td>Fourth Generation</td>
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1. Introduction
This chapter describes an introduction for this research study. It starts with section 1.1 background information related to the research and followed by section 1.2 in which the research problem is described. Further, in section 1.3 the research goal and questions are described. Next, in section 1.4 the research framework is given and this continues with section 1.5 in which the research methodology is explained. Section 1.6 gives the contribution of this research study and finally in section 1.7 the outline of this thesis is given.

1.1 Background information
Historically in the early automotive industry, electric vehicle (EV) has been introduced to the market but yet it was unsuccessfully to start off large scale introduction. According to Chan (2002) EV was invented in 1834 and since 1930 the EVs have almost vanished from the scene. The main reasons are due to political, social, and technological issues especially the limitation associated with the batteries and the rapid advancement of combustion engine vehicle. Accordingly, combustion engine vehicle clearly becomes a dominant technology in the current automotive market (Schot et al., 1994).

The global changes including economic, political, environmental and energy security concerns related to petroleum dependence, made a renewed interest in several countries, including the Netherlands, to introduce sustainable transportations such as hybrid, bio fuels and electric vehicle (Beerda, 2009). The subsequent on this situation, at the European level the European commission is investing in sustainable transportation. Their aims are to reduce CO2 emissions as well as to ensure security of energy supply and to promote a broad use of renewable and carbon-free energy sources in the transport sector (EuropeanCommission, 2011a).

At the National level, The Dutch Ministry of Economic Affairs, Agriculture and Innovation in cooperation with the Dutch Ministry of Infrastructure and Environment, announced to promote an innovative solution in transportation sector by introducing electric vehicle in the transportation market in the Netherlands. The country aims to encourage introduction of approximately 200,000 electric vehicles on the road by 2020 and continue around 1 million electric vehicles by 2025 (MinistryofEAAI, 2011).

Electric vehicle is chosen because this sustainable transport promises higher system energy efficiencies, provides the opportunity to use any renewable energy sources e.g. solar and wind energy, zero CO2 emission, and zero noise nuisance compare with the other alternatives such as hybrid and bio fuels (Chan, 2002). The Netherlands emerges as an attractive proving ground for electric vehicle since the country relatively has a large amount of government initiatives, high degree of motivations to introduce sustainable transportation, a large amount of expertise and suppliers of the electric vehicle components, and a smaller landscape with high quantum of mobility in relatively shorter distances (MinistryofEAAI, 2011). According to the Dutch Centraal Bureau voor de Statistiek (CBS), 74% of the daily mobility of Dutch population for 2007 is between 0 and 10 km per day and followed by 90% of the range between 0 and 30 km and then 95% between 0 and 50 km respectively (CBS, 2010). In light of all the competencies, the Netherlands could emerge as the forerunner of the electric vehicle industry.

Learning from past experiences, introducing large scale electric vehicle is not a straightforward task. It is a complex process in which economic, social, political and technological factors influence the
development of technology. Furthermore, several barriers such as inferior technology, lack of infrastructure, lack of market or business model, and lack of strong commitments from various actors in the industry are influenced the EV technology development (MinistryofEAAI, 2011). Accordingly, the whole EV innovation system needs to be improved. Innovative solutions, applications or new technology developments are thus necessity.

The Dutch government implements the Dutch national systems of innovation to stimulate a sustainable electric vehicle. The concept of systems of innovation stresses on the understanding the link among the actors involved in innovation which seems to be the key to improve technology performance (OECD, 1997). This national system of innovation is facilitated by NL Agency.

**NL Agency**

Established in January 2010, the three agencies of the Ministry of Economic Affairs, Agriculture and Innovation, named the Netherlands Patent Office (Octrooicentrum Nederland), the International Business and Cooperation (EVD), and the Dutch Energy and Environment (SenterNovem) were merged to form one single new organization, named NL Agency. This organization became an agency of the Dutch Ministry of Economic Affairs, Agriculture and Innovations that implements government policy for sustainability, innovation, and international business and cooperation. The organization facilitates businesses, educational institutions and government for gathering information, getting advice, supporting financial, networking and regulation matters. It consists of five thematic divisions, named NL Energy and Climate Change, NL EVD international, NL Innovation, NL Environment and NL patent office.

The mission of the organization is: “The excellent implementation of international, innovation and sustainability policy and the implementation core values are involvement, reliability and ambition” (NLAgency, 2012).

In electric vehicle technology development, the national government has made great efforts to stimulate large scale of electric vehicle introduction in Netherlands focusing on two main themes: First, by setting up the Formula E-team. The stakeholders, beneath the direction of H.R.H. Prince Maurits of Orange, act as driving forces and have eliminated several major obstacles in the introduction of electric vehicles. Second, the government implemented certain measures to bring the following factors:

- Field trials and demonstration projects;
- the stimulation of charging and power infrastructure systems;
- the development and manufacture of electric vehicles and its components;
- the creation of consortiums and coalitions;
- Fiscal advantages;
- A policy to support the implementation of these measures.

Electric vehicle technology can be characterized as a niche market in which key actors especially the government will play a significant role to protect the current niche to develop by stimulating and facilitating the current niche development. Further with its uncertainties, the electric vehicle
technology is indicated as a dynamic market and open market where future responsibilities and the roles of all actors are highly dynamic and uncertain.

Recently, there are many technology developments in the electric vehicle industry. Among these technology developments, the integration of Information and Communication Technology (ICT) within electric vehicle innovation system is one of the promising forthcoming developments (Fortiss, 2012). According to D-incert (2011), the ICT plays as the backbones of electric vehicle technology development and it can be seen as a total concept of EV innovation system. Hence, several new innovative technologies, applications and services are emerging in the Netherlands. Examples are future power train, Battery Information Interface (BII), Battery Management System (BMS), Connected Cruise Control (CCC), Driver Guidance System (DGS), smart charging, financial service, payment service, and mobility service.

The adoption of technology can be done through a systematic approach which is commonly known as system of innovation or fourth generation (4G) of innovation (Ortt and van der Duin, 2008). Typically this system introduces innovation in alliance, parallel and integrated involving multiple actors. The coordination of this innovation system is happening through a network of partners in which firms or entrepreneurs are becoming the focus centre. Herewith, the current business growth strategies and business models are designed for matching the new market creation. A significant impact on the strategies and business models are thus expected to help the introduction large scale EV in the Netherlands. Hence, the main question that has to be answered is:

**What are the prosperous business growth potentials for the promising developments (products or services) within the Dutch electric vehicle innovation system?**

**The ICT within EV innovation system**

An important role of ICT within the automotive industry has been identified for many years. The ICT development in the form of electrics and electronics has been integrated inside the conventional vehicle on several common functions e.g. the improvement of driving performance, comfortable, and safety aspect (HollandAutomotive, 2010). According to recent research done by Fortiss, up to now the ICT has contributed around 30 to 40 percent of total value added in automotive construction (Fortiss, 2012). Moreover, the percentage of ICT contribution in automotive technology development, especially due to large scale introduction of electric vehicles, is estimated to increase significantly in the next couple of years (HTSM, 2012).

The integration of ICT within EV innovation system provides promising opportunities for the automotive sector, energy sector and ICT sector in the Netherlands (HTSM, 2012). It is expected that the ICT development within EV innovation system will discover several technology areas of innovation including smart mobility (intelligent vehicle on intelligent road), future power-train (efficient vehicles) and smart grids. Further, along with the increased technology complexities inside the vehicle, future revolution of ICT architecture inside the car is becoming crucial to support the future vehicle development. To conclude, the integration of ICT within electric vehicle innovation system is recognized as the backbone of the total concept of EV innovation system (Fortiss, 2012).

Nevertheless, even though the importance of ICT within EV innovation system is recognized appropriately, several challenges have appeared: What are the real opportunities for the
Netherlands and the potential business models accordingly. Hence, these challenges will be answered through this research study.

1.2 Research problem
Introducing electric vehicle in the Netherlands is a complex project. Transition phase from combustion vehicle to electric vehicle is not a simple task. Collaboration among subsystems and support from the government are needed to achieve its success. Rotmans (2005) explains the transition from one technology to another will result differently depend on the subsystems. On one side, the transition can be successful when it reaches a stabilization phase. On the other side, various possibilities such as lock-in, backlash and system breakdown during the take-off and acceleration phase can fail the technology development. Hence, the right technology and strategy should be implemented appropriately.

The speed of adoption for a new technology may vary between industries, e.g. radio and combustion vehicle. Since the first invention in 1905, the radio industry had been waiting for around 70 years before reaching the stabilization phase while since 1886 the combustion vehicle has still been developing in the acceleration phase (HartMann, 2010). Consequently, the opportunities and attractiveness among industries are different. In the following figure the process of technology adoption in the common s-curve is given. Based on the current situation, one may assume that the electric vehicle technology in Netherlands is considered between the development and take off phase.

According to Roger’s diffusion of innovation, for every new innovation cycle the most difficult phase is crossing the chasm (Rogers and Everett.M., 2003). This is happening after the early adopter phase and before reaching the early majority phase. During this phase return on investment (ROI) is generally expected to be achieved. Hence, the technology can be produced to a large scale and growing rapidly to reach the maturity phase. In the following figure the diffusion of innovations is visualised.
Innovation process is risky since it requires high investment with uncertain result (Urban and Hauser, 1993). The uncertainty is explicitly explained by Kamp (2008), who makes an investigation on the failure of introducing a wind power in the Netherlands. Similar results can also be found from different scholars which conclude the success rate of innovation system has not increased significantly in the last decades (Crowford, 1977) & (Wind and Mahajan, 1997). Being aware of this, current Dutch EV Innovation system needs to be analyzed and improved. Innovation solutions are thus necessity.

In order to answer all the challenges, one might start scanning the environment. This is exactly what this research study does. Continuous environment scanning is essential because of the growing complexity of the economic landscape, greater uncertainty, and severe market disruptions (Osterwalder, 2010). Additionally, since the innovation is in the context of system approach the knowledge management is another essential aspect, the interactions among the actors involved in the technology development are significantly important. The smooth operation of innovation systems depend on both tacit knowledge (know-how) exchange and codified knowledge in publications and patents (OECD, 1997). The mechanisms for the knowledge flows include joint industry research, public or private sector partnerships, technology diffusion and mobility of personnel. Therefore, the business, organization and technology aspects should be aligned and this leads to this thesis focus on adding value to the knowledge on how the technology can be brought to the market in order to achieve sustainable business potentials.

1.3 Research goal and questions
The objective of this research study is to analyze current EV innovation system, which can help the Dutch government to improve the current innovation development inside the electric vehicle industry by mapping out the views of potential electric vehicle developments and prosperous business models. The desire to explore this aspect of area is because the willingness to improve current EV innovation system so that it can reach its success to introduce electric vehicles on a large scale and create a Dutch sustainable competitive advantages.

The “promising” and “prosperous” refer to the products or services and business models that satisfy the future trend of Dutch EV innovation system to a maximum extent and achieve a win-win situation for all relevant actors. In order to achieve the research objective, the main research question is formulated as follows:
What are the prosperous business growth potentials for the promising developments (products or services) within the Dutch electric vehicle (EV) innovation system?

By answering the sub-questions in a structure manner, it becomes possible to give the answer to the main research question. In the following the overview of research sub-questions and its relevance towards the main research question are given as follows.

Sub-questions 1: What is the current Dutch EV innovation system? Which trends and barriers are presented in the current Dutch EV innovation system?

These first sub-questions are important step of the entire research since they define and set the boundary of this research study. Here, the focuses are on the exploration of electric vehicle technology, its dynamics and the context analysis. An overview of Dutch EV innovation system is described by looking at the technology map, stakeholder map, barriers and foreseen future developments e.g. market, industry structure and regulation. In order to support the analysis, the Multi Level Perspective (MLP) analytical framework from socio-technical study will be used.

Sub-questions 2: Which are the existing EV pilot projects in the Netherlands? What can be learned from the existing EV pilot projects? And how is the network formation?

Once the Dutch EV innovation system is defined and described properly, the niche development is analyzed by applying the Strategic Niche Management (SNM) analytical framework. Here, the experiences from the existing EV pilot projects are analyzed by looking at the expectation, network formation, and learning process. As a result, the knowledge that is gained from this second sub-questions will be used for looking potential developments that represent the strength of the Netherlands in the electric vehicle industry.

Sub-questions 3: What are the promising developments that contribute to the Dutch EV innovation system? What make these developments unique or attractive?

In order to answer these sub-questions, inputs from several organizations, named D-icert, NL Agency and InnoPays are incorporated. By combining these inputs with the study of various EV literatures, the promising developments including its value proposition and actors are identified.

Sub-questions 4: How does the current Dutch EV innovation system examines the promising developments? Which are the real opportunities for the Netherlands in the short time?

An important aspect of the success or failure of a new technology depends on the support from its environment. Hence, in these fourth sub-questions the promising developments are examined by several expertise or key actors which are currently involved in Dutch EV innovation system. As a result, answering these fourth sub-questions will add a valuable insight for finding real opportunities for the Netherlands, and its appropriate business strategy and business model.

Sub-questions 5: Which are the prosperous business models and business strategy? Under which condition can they be used? And how can the government support the promising developments (products or services) to become success in the market?
On basis of the information that is gained from the previous sub-questions, these last sub-questions aim to design the possible business models and business strategy. It starts with actor analysis. By doing this, it helps to gain an extra understanding on its current position in the market. Product analysis and market analysis are included to support this analysis. Further, the business models and business strategy are designed. Finally, validation from the intended actors is conducted.

However, since the EV technology developments are still in the niche market, support from the government is needed. Hence, these sub-questions include the answer for guiding the Dutch government on how to support the promising developments and the actors to become successful in the market.

1.4 Research framework
In this section the research framework is explained. A research framework is a schematic representation of the research objective and includes the appropriate steps that need to be taken in order to achieve the research objective (Verschuren and Doorewaard, 2010). Once such a scheme has been drawn up, the structure of the research is better. Additionally, this research framework can be used as a communication tool for all involved parties. In the following figure the research process, deliverables (chapters), and the relationships among them are given.

From the above figure, the research framework shows clearly how the different phases of the research are interconnected, and how the one step implies to the other steps. The horizontal arrows indicate the steps that are taken to answer the sub-questions and are divided into various chapters. Further, there are noticeably three phases of this research, named literature/desk research phase, field research phase, and design research phase which are integrated to the entire research process.
The vertical arrows indicate which knowledge is used and needed to answer the sub-questions. The “Ch” refers to Chapter indicator and the “S-Q” refers to Sub-Question.

1.5 Research methodology

This research study is based on exploratory research, which focuses and provides insights to a specific situation: the potential developments in Dutch EV innovation system. Accordingly, the case study is used as the research design. It is important to understand that by doing this case study research, the final conclusions are only valid within the natural setting boundaries, named in the context of Dutch EV innovation system (Verschuren and Doorewaard, 2010). As a consequence, the main goal is to obtain a general idea of the object as a whole.

This research uses multiple data collections including interviews, focus group and desk research. In order to reach the intended objective, this research project is divided into five research phases. In the following each of phases is described and illustrated.

1. Define phase

This first phase is dealing with designing this research project. This phase consists of background information, research objective, main research question and sub-questions, research framework, and research methodology. As it is mentioned in the earlier section, the research problem is based on the willingness to introduce large scale of electric vehicle in the Netherlands and this is in line with the objective of Dutch Ministry of Economic Affairs, Agriculture and Innovation. Hence, in this first phase the activities are mainly determining the scientific relevance and aligning it with the practical problem. By implementing a structural research framework, the research objective and the research questions are defined properly. As a result, this entire process becomes as a basic scientific foundation for this research study.

2. Literature / desk research phase

The second phase is performed to answer the research sub-questions 1, 2 and 3 respectively. Academic papers, journals, reports and textbooks are the most secondary resources that are used in this phase. Extensive literature study is made to gather all relevant information that becomes as knowledge for the rest of the study. Each sub-question has its own relevant literatures. In the first sub-questions, the most relevant literatures are coming from the theory of Strategic Niche Management (SNM) and innovation management study. They are mainly searched through the process which subsequently becomes the basic criteria to assess the current Dutch EV innovation system. In the second and third sub-questions, the literature studies from various EV pilot projects
are studied. Here, some relevant EV and ICT developments are observed. Additionally, prior studies, reports, presentation slides, articles and sites from D-icert, NL Agency, HTAS and Automotive.NL are examined to identify the relevant EV pilot projects.

Since the study is performed in collaboration between Delft University of Technology and NL Agency, the data and information from both sides make significant inputs for this research study. Prior studies and networking from NL Agency and D-icert clearly make a valuable contribution to this research study. Identifying several actors or organizations is mostly done through the given information from NL Agency and D-icert. On the other side, Delft University of Technology through its professor makes a significant contribution to the theoretical background or academic knowledge of this study.

3. Field research phase

The aim of this phase is twofold. First, it validates the finding data from previous phase. Second, it adds an extra knowledge to the existing theories. The both objectives are achieved through focus group and several interview sessions with several key actors.

The focus group is organized within the collaboration between Dutch Ministry of Economic Affairs, Agriculture and Innovation, and ICT office. This focus group consists of twenty members with a moderator leading the discussion for about two hours on the topic and concept or product. Members are chosen on the basis of their expertise in the topic in which the information is sought.

Regarding the interview session, the total interview is 21 interviews with different type of organizations or actors in the Dutch EV innovation system. All interviews are conducted in English and these semi structured interviews are mainly using open-ended questions. Each interview takes approximately one hour each in which the interviewee is asked according to the list of predetermined questions. The questions are focusing on validating and gaining extra information.

4. Design research phase

The purpose of this phase is to design the strategy on how the potential developments (products or services) can be successfully introduced to the market and how the relevant actors can contribute to the developments. The potential developments are selected based on the expert consultation as well as an extensive analysis by applying Porter’s five force model (1998) and Osterwalder’s Business Models (2010). Further, similar with the previous phase this phase conducts validation session by the intended actors or organizations.

5. Closing phase

In this last phase, this research study is closed by the conclusion, recommendation and reflection. The conclusion is drawn by answering the main research question while the recommendation is done for the Dutch government on how to improve the current Dutch EV innovation system. Lastly, the reflection of this research study is given and it ends with a final presentation.

1.6 Research contribution

The main contribution of this research study adds values to both scientific and managerial knowledge which are applicable to the real practical world situation. This study outlines a first step towards a
more systematic analysis of actor strategies in sustainable transitions by linking strategies described in the entrepreneurship literatures to the strategic niche management literatures. The focus is on the emerging entrepreneurs (start-ups) and entrepreneurial incumbent firms who play a crucial role in developing and commercializing the technology needed in a transition to sustainability.

The main analyses that are presented in this study are mainly concentrated on the validation of the promising developments (products or services) and generalizing a new knowledge to satisfy the existing theoretical knowledge. Hence, the final result of this thesis gives the entrepreneurs insight into the business opportunities due to the introduction of electric vehicles in the Netherlands.

1.7 Research structure
The structure of this study is illustrated in figure 5. It consists of nine chapters. Chapter 1 includes an introduction to the research topic and the research approach. Chapter 2 covers the fundamental theoretical background of this study. Chapter 3 discusses extensively the Dutch electric vehicle innovation system including the stakeholder map, technology map, trend and development, and barriers. Chapter 4 explains the existing EV pilot projects which are related to ICT development within EV innovation system. Chapter 5 provides the overview of promising developments inside Dutch EV innovation system and the value proposition. Chapter 6 consists of field analysis which conducts qualitative research. Chapter 7 presents possible business strategy or business models. Chapter 8 consists of conclusion and recommendation in which the main research is systematically answered. Finally, Chapter 9 includes the reflection and limitation of this research.
2. Theoretical background
This chapter covers the relevant theories that are used to support this research study. The theories, which are described in this chapter, are mainly coming from the theory of Strategic Niche Management (SNM), Innovation Management, Technology and Strategy, and Business Model. By linking strategies described in the entrepreneurship literature to the strategic niche management literature in the context of innovation process, this chapter presents a first step towards a systematic analysis of actor strategies in sustainable transition. In the following figure the research process and where chapter 2 fits in are given on the blue color.

Figure 6: The research process and where chapter 2 fits in

Section 2.1 explains the Multi Level Perspective (MLP) and Strategic Niche Management (SNM) which are used as a tool to analyze the innovation system and to answer the technology development. Next, section 2.2 presents the innovation management on how to manage the innovation process of new product development. Thereafter, section 2.3 tries to explore the role of technology and generic strategies that are commonly used to introduce technologies, products and services in the market. Next, section 2.4 explains the important of business model and section 2.5 proposes an integration model. Finally, section 2.6 discusses the analysis methodology of this research study.

Introduction of electric vehicles in the Netherlands can be seen as a national system of innovation. It requires number of changes e.g. the industries, infrastructure, services and regulations. Generally the concept of the national system of innovation focuses on understanding the linkage among actors involved in innovation and the flow of knowledge inside specific industry (OECD, 1997). The national system of innovation is defined as follows:

“... The network of institutions in the public and private sectors whose activities and interactions initiate, import, modify, and diffuse new technologies.”

- (Freeman, 1987)
“...The elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge...and are either located within or rooted inside the borders of a nation state“
- (Lundvall, 1992)

“... A set of institution whose interaction determine the innovative performance......of national firms”
- (Nelson, 1993)

By the definition, in a broad sense, the national system of innovation encompasses on the relation among the interrelated key actors who create, diffuse and exploit innovation. In contrast, in a narrow sense, the national system of innovation can be considered as a complex of innovation actors that are directly associated with the generation, diffusion, and appropriation of technology innovation. Hence, the national system of innovation is identical to a concept of system approach: organizations are not innovating alone but rather they depend on the quality of sub-systems such as research and development, users, intermediary, supportive infrastructure, and other stakeholders in different levels (Ortt and Smits, 2006).

The concept of system approach has been used broadly in socio-technical study. In this study the technology innovation is examined from both social and technological aspect e.g. in the theory of technological transition (Rotmans, 2001) or the technological innovation system approach (Hekkert et al., 2006). Consequently, focusing solely on the development of technology will not guarantee for the success of technology innovation. The innovation management study indicated similar results since in the last decades the success rate of technology development was not increasing significantly due to the constant failure rate of new product or service introduction (Ortt and Smits, 2006). Accordingly, in order to successfully introduce new innovation products to the market, one has to consider activities in multi-level system. In other words, the innovation has to be managed in the broader context including the trend or events on the three levels of development, named landscape (macro), regime (meso), and niche (micro) levels.

2.1 Multi Level Perspective (MLP) and Strategic Niche Management (SNM)
The socio-technical study broadly comprises the complementary Multi Level Perspective (MLP) and Strategic Niche Management (SNM) analytical framework for analysing the innovation dynamics of sustainable transition. The MLP is chosen as the basic approach to analyze the innovation and transformation processes by looking at the interaction between the three development levels, named landscape (macro) development, regime (meso) development, and niche (micro) development (Geels, 2002). While the SNM is used as a complementary tools since the concept of niches has been further elaborated. In this SNM approach, the societal experiments such as existing pilot projects are investigated as a way to create niches (Raven, 2005). In the following figure the link between MLP and SNM is illustrated:
Dutch electric vehicle innovation system

Figure 7: The SNM inside the MLP static view (Geels, 2002)

Multi Level Perspective (MLP)

Technologies are always part of a much broader system (Eijck and Romijn, 2008). According to Geels and Schot (2007), there are three levels model of innovation system, named niche-innovations, socio-technical regimes, and socio-technical landscape. Firstly, in the macro level the socio-technical landscape can be found. In this level the changes can take more time and usually takes in decades (Schot and Geels, 2007). Generally this level will form an exogenous environment such as demographics, political culture, lifestyles, and the economic system. The outcome of this level will have a considerable impact on the transformation dynamic of a regime.

Secondly, in the meso level the socio-technical regime exists. In this regime the dominant technology is appeared in the technological trajectories. This regime stabilizes the existing trajectories in many ways such as develop the innovation, regulation and standards, adaptation of lifestyles, infrastructure and competencies (Schot and Geels, 2007). Several actors are contributed to the technology development including scientist, policy makers, users and special groups.

Thirdly, in the micro level the new radical technologies (novelties) are appeared. Initially these novelties are unstable with low technology performance. Several important actors in this network including manufacturers, users, researchers, society, government or public institutions, and others are made significant role to protect these novelties through gradual experimentation and learning by networks of actors.

The multi level perspective in the dynamic view insists that the technology transition occurs through the interaction between three different levels. Change at the landscape level will create a pressure to the regime level. Accordingly, the destabilization of the regime will create windows of opportunity for the niche level. As a consequence, through a learning process, price or performance improvement and support of various actors, the niche will be developed to compete with the existing regime. In the following the figure of multi level of socio-technical study in dynamic view is given.
Strategic Niche Management (SNM)

Strategic Niche Management (SNM) is an analytical approach that is developed specifically to introduce and to diffuse new sustainable technologies through societal experiments. The aim is to contribute to a transition process in more sustainable development, through an integral combination of technological progress and system-wide social-institutional transformation (Raven, 2005). The SNM promotes the formation of socio-technical experiments in which various innovation stakeholders are encouraged to work together with the information, knowledge and experience. Here, those actors are focusing on an interactive learning process that is expected to facilitate the incubation of the new technology primarily niche’s.

SNM emerged from two bodies of literature, evolutionary theories on technical change and Constructive Technology Assessment (CTA). The former explains the process of technological change, while the latter aims to provide insights into managing this process. Experiments occur in protected spaces called 'niches', specific application domains for the new technology. Experiments create 'proto-markets', in which the relationship between the key actors is formed even though the technology is still in a laboratory phase. On successful incubation, a market niche can be developed gradually, in which the innovation can sustain itself commercially (Hoogma et al., 2002).

The SNM identifies the main process during the experiment in the niche development. These are including dynamics of expectations, network formation and learning process. All of these processes are within the context of multi-level mode. In SNM the role of users is the centre in the learning process (Raven, 2005). Hence, Hoogma (2002) distinguished between the first order and higher order learning. The first order means that learning for optimizing the current practices (Kamp et al., 2012). In other words, a certain goal should be achieved by finding the right means. The higher order learning means that learning about the changes in norms, values, goals, procedures or changing the rules (Kamp et al., 2012). The following table summarises the indicators that can be used to analyze the niche development. The details of each processes and indicators can be found in Appendix A.
In order to successfully experiment, the whole process has to be an interactive process. Niche creation is required a broad and diverse co-operating actor network (Kemp et al., 1998). According to Von Hippel (1986), the users have a vital role to play, rather being mere sources of market information (Hoogma et al., 2002). Further, this niche development process comprises the convergence and alignment of expectations. This means that it is important to develop a common core view about where the participated actors are going and with which technology development should be focused. In other words, actors’ strategies, expectations, beliefs, practices, outlooks, perceptions and views must go in the same direction and become more specific and consistent. Once this has been successfully aligned, the new network can be created. Networking is seen as an essential for the new learning and innovation and it is a core concept of the innovation system (Freeman, 1987) & (Lundvall, 1992). In the following figure the process in the niche development is visualized:

![Diagram of SNM process](image)

2.2 Innovation management

In this research study the Innovation management is used to answer on “how” to manage the process of innovation. The focus is on how to develop the new breakthrough technology, products or services and organization innovation by responding both internal and external environment (Ortt, 2011). This is important since the MLP and SNM analytical framework are not able to answer on how the technology should be further developed and managed.

Ortt and Smitt (2006) mentioned four general consequences of the trends in innovation management, named the end of linear model, the rise of the system approach, the inherent uncertainty and need for learning, and innovation becomes more entrepreneurial. These consequences can lead to different approaches to innovation management: strategic planning approach and adaptive approach.
In the last decade the fourth generation (4G) of innovation has been introduced. According to Ortt and van der Duin (2008), the 4G has evolved toward society and organizational context. In the society context, globalization is an important aspect. The society context is further explained as international competition increases, organization realizes the strategic important of technologies, and Information and communication technology (ICT) is playing an important role for internal and external business processes. In the organization context, the company strategies generally concentrate on the core competence, strategic alliances, and external networking becomes important. Implication of this situation leads to the development of new products and processes in which commonly becomes as core of the competition.

Firms or organizations, which reach the market faster and more efficient with new products or services that are matched with the needs and expectations to the target market, are predicted to be able to gain competitive advantages. On contrary, those who are not able to develop innovative products or services will gradually disappear in the market position and falter its financial performance. This place of activity is recognized as uncertainty in the innovation process. According to Urban and Hauser (1993), the innovation process is obviously having a risk since it requires high investment with uncertain result (Urban and Hauser, 1993). Similar results can also be found from different scholars which conclude the success rate of innovation system has not increased significantly in the last decades (Crowford, 1977) & (Wind and Mahajan, 1997).

**Innovation process in the new product development**

Being aware of the uncertainty, the innovation process needs to be taken carefully. Wheelwright and Clark (1992) proposed the funnel technique which describes the notion of innovation visually to structure the thinking on the product generation of alternative development options and combine those into a product concept. Generally, the development innovation process starts from a broad range of idea or inputs and gradually narrows and selects among them. Managing the development involves three different tasks or challenges (Richards, 2012). First, investigation phase is conducted by expanding the knowledge base and access information in order to increase the number of new product and new process ideas. Second, development phase is applied when the ideas generated have to be screened and resources focus on the most attractive opportunities. Finally, the third challenge is appeared to make sure the selected projects deliver on the objectives or goal. In the following figure the technique is illustrated:
Development and diffusion of new breakthrough technology

After the new product development process introduce to the market, there will be a diffusion pattern of new breakthrough technology in which commonly represented in the famous Rogers’s S-curve. However, the speed or the steepness of the curve can be different depends on many factors such as the attractiveness of the industry, the size of the market, unit of adoption, the performance of the technology itself, political and social factors (Ortt and Suprapto, 2011). Hence, for different adoption pattern will lead to different strategies. In other words, one has to adapt its technology strategy towards the adoption pattern of the new technology itself. In the following the generic pattern with the four phases is illustrated.

![Generic Pattern](image)

*Figure 11: The generic pattern with four phases (Ortt and Suprapto, 2011)*

The picture shows that there are four phases, named invention phase, innovation phase, market adaptation phase and market stabilization phase (Ortt and Suprapto, 2011). The new breakthrough technology development starts from the invention phase in which mostly the research and development (R&D) plays the most essential aspects. The innovation phase can be described as the creation and capture of value in new ways, often creating new rules of the games and new opportunities for competitive advantages (HartMann, 2010). In this innovation, the protection of the government towards the new technology is commonly found. Next, the adaptation phase is occurred in the situation which is usually the innovators dilemma e.g. performance of the new technology increases faster than customer wants or performance of new entrant faster than the existing company, technology substitution, emergence of a dominant design, and chicken and egg dilemma (technology requires an extensive system of complementary products and services not yet available) is happening. The adaptation phase begins after the first application and ends when a standard product is produced in an industrial production process and large-scale diffusion starts (Ortt and Suprapto, 2011). Finally, the dominant design is chosen and the market is stabilized accordingly.

2.3 Technology and strategy

The technology development is one of the main aspects of an innovation development. Without any innovation technology developments, one might find some difficulties to compete against its competitors and to maintain its market position. Hence, in the tight competitive market, the technology and strategy should be intertwined. In the following various technology strategies are discussed as follows.
Porter Five Force model

In the current management practice, the competitive strategy and its core of industry analysis, competitor analysis, and strategic positioning are now widely accepted (Porter, 1998). The competitive strategy proposed a framework for understanding the tight competitive market within the “five forces”. This framework explains the important differences among industries, how the industry evolves and facilitates the company to gain its sustainable advantage or a unique position in the market. In the following figure, the framework is presented.

![Porter's five force model](image)

Figure 12: The Porter’s five force model (Porter, 1998)

According to Porter (1998) the five competitive forces, named the entry, threat of substitution, bargaining power of buyers, bargaining power of suppliers, and the rivalry among existing firms will determine the attractiveness of industry and these will directly influence the strategy of one company. The details of each aspect are described in the Appendix A.

In order to manage the five competitiveness forces, Porter (1998) describes three potential strategies including overall cost leadership, differentiation, and focus. Cost leadership is applied if the company tends to gain its competitive advantages by applying economies of scale and other cost advantages e.g. cost reduction from experience, reduction cost in R&D and marketing, etc. Differentiation means that the firms or companies tend to focus on the uniqueness in the industry that is perceived well by the customers. Lastly, in order to maintain its current position, the companies or firms can focus on certain segments or customer groups in which one can serve its customer with tailored products. Hence, the extra values for specific customers are created. However, relying on one strategy will not guarantee to sustain the competitiveness but rather one has to consider combining those strategies wisely (Porter, 1998). In this situation firms are recommended to look at the optimal balance between the values drivers in which relying more on the customer satisfaction. Further, in practice it is rare seeing the trade-off has to be made.

In line with Porter’s three generic competitive strategies, Hartigh (2011) propose three main strategies in which one can focus on: the volume of production (volume), differentiation, and efficiency. The combination between two strategies may have some advantages e.g. competitive
Dutch electric vehicle innovation system

position, economies of scale advantage and business concept. This is illustrated in the following figure:

![Figure 13: Strategy to achieve sustainable competitiveness (Hartigh, 2011)](image)

**Game theory**

Game theory is perceived as the formal study of conflict and cooperation. The concept of game theory presents the individuals, groups, or firms independently to formulate, structure, analyze, and understand the difference strategic scenario. Brandenburger and Nalebuff (1995) differs the two types of games. First, the rule based games in which the interaction between players is occurred based on specific rules of engagement. For example, these rules are coming from contracts, loan covenants, or trade agreements. Second, the freewheeling games in which the interaction between players is occurred without any restrictions or constrains. For the rule based games consists of every action has its own reaction principle. The reaction will not always the same or equal. Hence, one needs to analyze or predict on how the others will react (including yours) to the actions as much as possible. Contrary, for the freewheeling games consists of what you bring to the game equals to what you get principle.

*“Successful business strategy is about actively shaping the game you play, not just playing the game you find.”*  
- (Brandenburger, 1995)

The game of the business is all about value creation and how to capture it. Brandenburger and Nalebuff (1995) introduce the value net that is a schematic map consists of supplier, customers, competitors and complementors. The value net framework of Brandenburger and Nalebuff (1995) extends the Porter’s five force framework by focusing on the profits or opportunities enhancing factor, a mixture of competition and cooperation (coopetition). In the following figure the value net framework is illustrated.
Strategy towards large scale diffusion

Ortt and Delgoshaie (2007) formed a model with five categories of factors, named the product, the system of complementary products and service around it, supplier and producers (supply-side of the market), customers (demand-side of the market), and the institutional arrangements. These factors are seen as an essential requirement for the large-scale diffusion. Accordingly, if one of these factors is not completed fulfilled, the large-scale diffusion cannot be implemented. Thus, the new technology or product will remain in the niches and the introduction to the market can be deferred (Ortt and Suprapto, 2011). In the following table each of the factors is described.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>The product can be defined and distinguished using three elements: the functionality provided by the product, the technology principle(s) used and the main components in the system (first tier of subsystems). The unavailability of (one or more components of) the product means that large-scale diffusion is not (yet) possible.</td>
</tr>
<tr>
<td>Complementary products and services</td>
<td>Complementary products and services refer to products and services required for the production, distribution, adoption and use. The product together with complementary products and services forms a socio-technological system. The unavailability of elements in that system means that large-scale diffusion is not (yet) possible.</td>
</tr>
<tr>
<td>Producers or Suppliers</td>
<td>The producers and suppliers refer to the actors involved in the supply of the product. Sometimes multiple types of actors are required to supple the entire system. In the case of a kind of coordination (network) is required. Sometimes actors with considerable resources are required, for example to provide an infrastructure. If one or more vital roles, resources or types of coordination are not in the socio-technological system, large-scale diffusion is blocked.</td>
</tr>
<tr>
<td>Customers</td>
<td>Customers means that a market application for the product is identified, that customer segments for these applications exist and that the customers are knowledgeable about the product and its use and are willing and able to pay for adoption. If applications are unknown or if customer groups do not exist, are not able to obtain the product or are unaware of the benefits of the product, large-scale is blocked.</td>
</tr>
<tr>
<td>Regulatory or Institutional environment</td>
<td>The regulatory and institutional environment refers to the laws and regulations that indicate how actors (on the supply and demand side of the market) deal with the socio-technological system. These laws and regulations can either stimulate the application of radically new high-tech products (such as subsidy that stimulates the use of sustainable energy) or completely block it (such as laws prohibiting something).</td>
</tr>
</tbody>
</table>

Table 2: Actors and factors necessary for large-scale diffusion (Ortt and Suprapto, 2011)
The technology strategy is depending on the technology process and the degree of uncertainty of the new technology. Hence, in case that pioneer company has invented a breakthrough technology and wants to introduce the technology to the market, Ortt (2007) indentified three main strategies, named a niche market, a mass market, and a wait and see strategy.

A nice market strategy means that the company is focusing on the small productions facilities allowing the production of specific products, adapted to the niche, and create specific marketing and distribution resources for this niche. This strategy can be very successful in the case of innovative products (Ortt et al., 2007).

A mass market strategy means that the company invests in large-scale production, distribution and marketing facilities. This strategy can be successful when the network effects in the market make the first mover to establish a strong position in the market quickly. A precondition of this strategy is that the company can protect the market by means of patents or holding unique knowledge that is difficult to copy.

Wait and see strategy means that the pioneer is not going to become as the first mover in the market but rather become as the follower. In this strategy, generally the company develops the technology, prepares for marketing and distribution, and monitors the market results until the technology in practice can be really commercialized. Here, the time to entry might bring different result. Further, this follower may also invest in venturing or take over the pioneer companies when the technology and the market are fully grown (Ortt et al., 2007).

According to Ortt (2007), a mass market strategy appears to be good when the diffusion take off in the short time after the invention. A niche market strategy tend to be implemented in scenario in which the technology takes long period of market adaption. A wait and see strategy considers as the best strategy when it takes long period in the innovation phase and market adaption phase. In the following table each of strategies is given in the context of adoption process.

**Legend:**

++: highly recommended  
+- : recommended  
- : not recommended

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Short time after innovation</th>
<th>Long time market adaptation</th>
<th>Long time innovation &amp; market adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass Market</td>
<td>++</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Niche Market</td>
<td>+-</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Wait and See</td>
<td>-</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

**Table 3: Scenario and strategy combination (Ortt et al., 2007)**

Commercialising and developing breakthrough technologies can be both very risky and very rewarding (Ortt et al., 2007). On one side, there is a possibility to gain the sustainable competitive advantage which will significantly contribute to company profits and growth. Here, the new technology has been considered as the source of new product categories, new markets and new industries (Christensen, 1997). For example Xerox with the photocopying machine and the Bell Company with the fax and the transistor.
On the other side, there are many companies or organizations involved with the invention of the new technologies but then they do not able to reap the benefit when the technology is on the large-scale (Ortt et al., 2007). Risky, high investment and uncertainty of market are the common reasons for this failure. According to Crawford (1987), generally the failure rate of new product development is around 35%. This percentage is expected to increase for the products based on breakthrough technologies. In order to reduce the risk and uncertainty, collaboration strategies with the various key actors can be proposed as a viable solution. Some possible strategies are including strategic alliances, joint ventures, licensing, or outsourcing (Schilling, 2005). Each of them is described as follows:

**Strategic alliance** – Two or more organizations formally or informally agrees somehow to cooperate together.

**Joint ventures** – Part of strategic alliance in which necessity to involve significant investment and legal entity.

**Licensing** – Part of contractual agreement between organizations or firms that give individuals or firms to use the intellectual properties from the others in exchange for royalties.

**Outsourcing** – Reducing development risk or cost by using other organization’s products or services rather than producing in-house.

### 2.4 Business model

Recently the business environment has slightly changed: having a great breakthrough technology does not guarantee the company’s success. Accordingly, the technology should be integrated with the business strategies and business models in order to achieve a sustainable competitiveness (Hartigh, 2011). Then, this leads to the next question on what the difference between business strategy and business model.

Osterwalder (2004) mentioned a simple definition of a business model as “the translation of a company’s strategy into a blueprint of the company’s logic of earning money”. However, from the different business layers that are described in figure 15, one can see that strategy, business models, and process models are addressing similar problems such as **how one can earn money in a sustainable way**.

![Figure 15: Business layers (Osterwalder, 2004)](image-url)

From the above figure, Osterwalder (2004) proposed three different layers, named strategic layer, business layer, and process layer. First, on the strategic layer contains the mission and vision of the
company. Second, the business model layer which focuses on the strategy into the elements and relates to how a company can earn money. Third, the process layer describes the work processes, supply chains, organization structures.

**Business model definition**

Historically Timmers (1998) was proposing one of the earliest business model definition in which he stresses the architectural and technology elements: “a business model is an architectural for the product, service, and information flows, including a description of potential benefits for the various business actors and their roles, a description of potential benefits for the various business actors, and a description of the sources of revenues”. Based on this definition, various alternatives were proposed from many disciplines but according to Osterwalder (2004) the business model can be defined as:

“A business Model is a conceptual tool that contains a set of elements and their relationships and allows expressing a company’s logic of earning money. It is a description of the value a company offers to one or several segments of customers and the architecture of the firm and its network of partner for creating, marketing and delivering this value and relationship capital, in order to generate profitable and sustainable revenue streams”.

- (Osterwalder, 2004)

**Business model in its environment**

As it is mentioned in the definition of business model, the business model is conceptualization of the company on how to earn money. It is understandable to look at the outside environment in which the business model is positioned. The change in the environment will change the strategic decision and thus change the business model of the organizations or firms. Osterwalder (2010) describes the four main environmental forces that influence the business model design space. The following figure describes the mentioned environment.

![Figure 16: Business model in its environment (Osterwalder, 2010)]
Components of business model

Figure 17 shows the nine components of business model. According to Osterwalder (2010) a good business model necessarily consists of customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. In the appendix A, the details of these nine components are explained.

2.5 Integration model

From the previous sections, various theoretical backgrounds, which are used to support this study, are discussed. However, rather than being fragmented, this section proposes an integration model which links the MLP, SNM, technology and strategy, and business model theory in the context of innovation process. This integration model will be used for the entire process of this research study.

Introduction of sustainable innovation is a complex process and from the past experience it showed that this usually took a long adoption process with a high possibility of failure. Accordingly, in order to successfully improve the current innovation process, a socio-technical study proposes a complementary framework, MLP and SNM framework, which is historically proven as a successful analytical framework of success and failure factors in the introduction of radical innovations such as wind energy, biomass, and public transport systems (Markard and Truffer, 2008).

As it is early described, the complementary framework is a powerful tool to conceptualize the outcome of technology transitions due to the relations among three different levels of developments: the niche development in which the novelties are created, the regime development which represents the current practices and routines, and the landscape development which consists of long term processes of change. Subsequently, by using this complementary framework one can give guidelines to the policy makers on how to effectively create a direction towards a sustainable transition for a radical innovation (Markard and Truffer, 2008). However, besides the successful story, the SNM literature has few details and practical on “how to do it” guidelines for involving actors in the niche development. Especially, it is not optimal in the situation in which the actor role and the actor strategies are essential for the success of innovation process (Markard and Truffer,
Furthermore, since the new breakthrough technology is generally dealing with high uncertainty and risk, the innovation process need to be managed properly.

In order to answer all the mentioned challenges, this study tries to integrate a new model by combining the socio-technical study with entrepreneurship study. Since the collaboration between key actors is seen as a core concept of the innovation system itself and an essential factor for the niche development (Freeman, 1987) & (Lundvall, 1992), the network is incorporated in the model. Within this network the same vision and perspective among key actors are expected to be created (Martin, 2000). Following the network formation, there is a need in strategic decision making to explore potential developments of emerging technologies (Markard, 2008). As a result, involving technology strategy and business model from entrepreneurship literature into the model is expected to complete the model. In the following figure the integration model is illustrated as follows.

**Figure 18: The integration model**

**Contribution to the existing theory (scientific)**

The contribution to the academic knowledge can be clearly seen as the theoretical, which was built, makes possible to integrate the MLP, SNM, technology and strategy, and business model theory in the context of innovation process. If one looks at the whole process, it is true that the technology strategy and business model theory contribute to improve the socio-technical study by emphasizing on the individual level or actor level. In return, the socio-technical study provides the technology strategy and business model theory to look at a broader context in which the three development levels, named landscape, regime, and niche level can play a significant influence for achieving the objective of the firms or organizations.

One of the limitations that might be found in this chapter is that although it uses reliable resources, the theoretical knowledge on this context is not proven yet. Therefore in the later chapters, this research study will have some value assessment and validating process in the practical case study of Dutch electric vehicle innovation system.
2.6 Methodology for analysis

In this section the methodology for exploring promising development (products or services) within the Dutch electric vehicle innovation system is discussed. From the previous sections, the basic idea is relying on the link strategies between socio-technical study and entrepreneurship study in which different actors may collaborate together. Consequently, the methodology for the analysis is divided into three main parts: basic analysis, context analysis, and variation analysis (Markard, 2008). In the following paragraphs each of them is discussed as follows:

Basic analysis

As a first methodology, this basic analysis focuses on current development of electric vehicles and foreseen innovation characteristics of electric vehicles. Therefore, this part includes the technical aspects e.g. various functions of electric vehicles, performance characteristics, application context and socio-economic aspects e.g. market development. Further, this analysis comprises the stakeholder analysis and the roles they play. As a result, this basic analysis provides an indication about the maturity of innovation system and set the boundary of this research study.

Context analysis

In the second methodology, the context analysis is performed to provide the environment analysis which might influence the current EV innovation system. In this analysis, the MLP and SNM analytical framework is applied. It starts analyzing the current landscape level; the analysis will include the ongoing trends which may influence the current socio-technical regimes. In this part, several aspects are investigated including political change, environment change, economic change, and society change.

The constant pressure from the landscape development will slowly put effects to the current regime which is dominated by combustion vehicle. Accordingly, the investigation on eight components of current regime such as regulations and policies, maintenance and distribution network, production system and industry structure, markets and user practices, fuel infrastructure, automobile (artefact), culture and symbolic meaning, and road infrastructure and traffic system are necessary. In order to successfully replace the current combustion regime, those eight components should be satisfied in favour for the electric vehicle.

Lastly, inside the niche development the force of landscape and regime will influence the network formation or actors in which later they will give its resources to support the experiments or pilots projects. Together with the high expectation, the experimental of pilot project will thus create a learning process. As a result, the new actors and network will be created. These cycles will continuously take place until this EV niche is becoming mature and able to change the current dominant combustion vehicle regime and landscape.

Variation analysis

Based on the initial findings from the previous basic and context analysis the third part of methodology deals with the future EV development. In this analysis various potential developments (products or services) and application areas of the electric vehicle are investigated. Next, a value assessment is performed to evaluate each potential products or services by applying several criteria:
market size, competition, resources, and integration. All of these criteria are derived from the value
net framework of Brandenburger and Nalebuff (1995) and Ortt & Delgoshae strategy towards large
scale diffusion model (2007).

Since the success of failure of a new technology is depending on the support from its environment, a
field analysis is performed. Therefore, the potential developments are examined by several expertise
or key actors which are currently involved in Dutch electric vehicle innovation system. This field
analysis is conceptualized by applying the porter’s five forces (1998) and the Osterwalder business
model framework (2010).

Finally, potential developments (products or services) and business models are further explored. This
last analytical step is based on the fact that each potential developments has certain characteristics
e.g. technical features, application context, potential users, and the target market which requires
specific resources and competences of the actors involved. Accordingly, certain actors or groups may
commit themselves to a particular products or services than others, and it may assign to specific role
in the innovation development.
3. The Dutch electric vehicle innovation system

This chapter answers the first sub-questions of this research study: What is the current Dutch EV innovation system? Which trends and barriers are presented in the current EV innovation system? Hence, the purpose of this chapter is to get an overview and in-depth understanding about the Dutch electric vehicle innovation system.

This chapter is an important step of the entire research since it defines and sets the boundary of this research study. Here, the focus is on the exploration of electric vehicle technology, its dynamics and the context analysis. An overview of Dutch EV innovation system is described by looking at the technology map, stakeholder map, barriers, and foreseen future developments e.g. market, industry structure, and regulation. Further, in order to analyse the Dutch EV innovation system, the Multi Level Perspective (MLP) analytical framework from socio-technical study will be used.

This chapter starts with section 3.1 in which the electric vehicle technology is described including the technology map. Next, section 3.2 describes the stakeholder analysis and section 3.3 explains the barriers and possible innovation development areas within Dutch EV innovation system. Section 3.4 describes the market development in the Netherlands and Europe. Section 3.5 presents the Multi Level Perspective (MLP) analysis and finally section 3.6 concludes this chapter. In the following figure the research process and where chapter 3 fits in are given on the blue color.

3.1 Electric vehicle technology

Historically the electric vehicle (EV) was invented in 1834 and it was very popular until the beginning of 1900 (Brower and Meijer, 2011). Electricity was seen as a radical innovation and became a new symbol of the new revolution industry. Additionally, the situation was supported by the landscape condition in society change due to the shortage of gasoline after the First World War. Several
investments were made in electric vehicle and the responds of the market were positive about the electric vehicle and its applications.

However, the situation changed noticeably in the 1918 (Brower and Meijer, 2011). The transportation regime was suddenly dominated by the internal combustion engine (ICE) vehicle and this situation continued for the period of the Second World War. Although, it was initially recognized that there were many negative impacts from using ICE vehicle but still the electric vehicle could not substitute the dominant ICE vehicle for providing sustainable transportation. Many experts agreed that political, economic, inferior technology developments and social aspects were the main reasons for the resistance. Subsequently, the EV disappeared from the market and up to now the ICE vehicle is clearly becoming a winner in transportation sector.

Due to current energy security, economic crisis, social changes, political instability in Middle East countries and the climate change in the first decade of the 21st century, a renew interest in sustainability has arise. Therefore, a new expectation was created to introduce a more sustainable solution in the transportation sector by again implementing electric vehicles to the global market (EuropeanCommission, 2011a).

### 3.1.1 Definition of electric vehicle

Currently there is no consensus on one single definition of the electric vehicle. However, this study suggests the electric vehicle can be defined in a broad and narrow context. In a broad context, the electric vehicle describes a terminology that covers both battery technology and fuel cell technologies. According to the German Federal Government (2009), the battery and the fuel cell technologies are mutually complementary and they need to be combined together e.g. Plug-in Hybrid Electric Vehicle (PHEV). In comparison, in a narrow sense the electric vehicle consists of only battery technology without including the fuel cell technology e.g. Battery Electric Vehicle (BEV). However, In order to clarify and make clear the ambiguous definition, this research study will focus on both the BEV and PHEV. Hence, the term of electric vehicle (EV) will refer to vehicle in which the electric power can be supplied by the grid. As a consequence, the Hybrid Electric Vehicle (HEV) and fuel cell vehicle will be not included in this analysis since it is relying merely on the existing combustion engine and the natural resources e.g. oil or gas as the main energy. The table below compares electric vehicles with other type of vehicles.
3.1.2 State of art electric vehicle
The electric vehicle (EV) is propelled by means of an electric motor which is driven by using a primary supply sources, namely rechargeable battery e.g. Nickel Metal Hydride (Ni-Mh), Nickel Cadmium (Ni-Cd), and Lithium-ion (Li-ion). The electric motor consists of rotating coils of wire that are driven by the magnetic force exerted by a magnetic field around an electric current which will transform the electrical energy into mechanical energy. In the following figure the basic characteristics of the electric vehicle as well as the conventional combustion vehicle are given.

![Figure 20: Schematic representation of an electric vehicle (Beerda, 2009)](image)

3.1.3 Advantages of electric vehicle
EV has several advantages compare to the conventional combustion vehicle. The electric vehicle promises higher energy efficiencies which leads to less energy use per kilometres, provides the opportunity to use any renewable energy sources e.g. solar and wind energy, reduces CO₂ emission significantly and zero noise nuisance (Kampman et al., 2010).

**Higher energy efficiencies** – One of the main advantages using electric vehicle is that the EV provides higher energy efficiencies compare to the conventional combustion vehicle. According to recent study done by CE Delft, the electric vehicle was concluded to leverage higher energy efficiency. The comparison was done by considering the efficiency factors from a “well-to-wheel” rather than “tank-to-wheel”. This means that the calculation starts from the beginning where the natural energy resources or sustainable resources are taken and ends with the transformation of electricity into kinetic energy done by the drive train of the vehicle. Below table 5 shows the comparison between the traditional Internal Combustion Engines (ICE) vehicle and electric vehicle (EV):

<table>
<thead>
<tr>
<th></th>
<th>ICE vehicle</th>
<th>EV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well-to-tank</td>
<td>83%</td>
<td>38%</td>
</tr>
<tr>
<td>Tank-to-wheel</td>
<td>15 - 20%</td>
<td>65 - 80%</td>
</tr>
<tr>
<td>Well-to-wheel</td>
<td>12 - 17%</td>
<td>25 - 30%</td>
</tr>
</tbody>
</table>

Table 5: Comparison fuel chain efficiency rates for ICE vehicle and EV (Kampman et al., 2010)

From the above table it is given that on one side the well-to-tank efficiency of the ICE vehicle is higher (83%), however, during the combustion process (tank-to-wheel) most of the energy turns into heat. Hence, it is only 15-20% translated into energy power for the vehicle and followed by 12 to 17%
for the whole well-to-wheel efficiency. The small different percentages between tank-to-wheel and well-to-wheel is mainly because there is a small amount of energy that is turned into heat due to the resistance of moving parts between the engine and the wheels.

On the other side, the well-to-tank efficiency of EV is expected about 38% which is lower than the ICE vehicle. Conversely, unlike the well-to-tank during tank-to-wheel process the EV can reach 65 – 80% efficiency. Thanks to the efficiency of battery technology the EV may reach much higher percentage compare with the conventional one. Subsequently, the total well-to-wheel efficiency of EV is about 25% to 30% which almost double compare the ICE vehicle. More over the 25% to 30% is still expected to be increased in the coming years since more sustainable energy will be used in the production process and more advanced technology development will come in the near future (Kampman et al., 2010).

**Opportunity to use renewable energy** – The electric vehicle provides opportunities for using renewable energy sources e.g. solar energy and wind energy in transportation sector. As a consequence, this leads to the reduction of oil demands and diversify the energy sources. Overall it will thus clearly improve the security of energy supply of the country. However, the challenge remains on the securing the energy supply and demand for the sustainable energy.

**Reduce CO\textsubscript{2} emission and zero nuisance** – The electric vehicle has zero CO\textsubscript{2} emission and produces no noise nuisance. Accordingly, this will improve the quality of human life by providing good local air quality benefits and reduction the noise pollution significantly.

Beerda (2009) made an emission analysis for the electric vehicle. This analysis includes the emissions of coal and natural gas which are commonly used as the main electricity supply in the Netherlands. In this analysis the CO\textsubscript{2} emission is calculated in gram per kilowatt-hour (g/kWh) unit of analysis. In the following table the results are given:

<table>
<thead>
<tr>
<th>Emissions</th>
<th>CO\textsubscript{2} emission (g/kWh)</th>
<th>Share in total fossil fuel electricity production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>863</td>
<td>43%</td>
</tr>
<tr>
<td>Natural gas</td>
<td>580</td>
<td>57%</td>
</tr>
<tr>
<td>Average kWh</td>
<td>702</td>
<td>100%</td>
</tr>
</tbody>
</table>

Table 6: CO\textsubscript{2} emission per kWh of fossil electricity produced in the Netherlands (Beerda, 2009)

Similar with the CO\textsubscript{2} emission in the following the calculation of PM\textsubscript{10}, NO\textsubscript{x}, and SO\textsubscript{2} emissions were made (Beerda, 2009). The assumption is that the electric vehicle uses one kilowatt-hour (kWh) per six kilometres including the tank-to-wheel efficiency of electric motors. Table 7 shows an overview for various fuel sources.

<table>
<thead>
<tr>
<th>Emissions</th>
<th>CO\textsubscript{2} emission (gram/km)</th>
<th>PM\textsubscript{10} emission (milligram/km)</th>
<th>SO\textsubscript{2} emission (milligram/km)</th>
<th>NO\textsubscript{x} emission (gram/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>208.1</td>
<td>0.006</td>
<td>8.9</td>
<td>0.10</td>
</tr>
<tr>
<td>Diesel</td>
<td>180.5</td>
<td>0.046</td>
<td>3.7</td>
<td>0.80</td>
</tr>
<tr>
<td>LPG</td>
<td>189.3</td>
<td>0.005</td>
<td>2.8</td>
<td>0.07</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>168.6</td>
<td>0.002</td>
<td>1.5</td>
<td>0.04</td>
</tr>
<tr>
<td>Electricity (fossil)</td>
<td>117</td>
<td>0.0005</td>
<td>29.2</td>
<td>0.10</td>
</tr>
<tr>
<td>Electricity (renewable)</td>
<td>0.0</td>
<td>0.0001</td>
<td>0.0</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 7: Overview emissions for various fuel sources (Beerda, 2009)
The following figure illustrates that electric vehicle has a significant reduction in CO\textsubscript{2} emission. By using electric vehicle on renewable electricity it can increase the “well-to-wheel” efficiency and reduce the CO\textsubscript{2} emission to zero.

![CO\textsubscript{2} emissions in g/km for various fuel sources](image)

**Figure 21:** CO\textsubscript{2} emissions in g/km for various fuel sources (Beerda, 2009)

### 3.1.4 Technology map

The electric vehicle technical framework can be broadly divided into three main attributes, named components, services and infrastructure. Based on EV literatures the following EV technology map was made. Each of the attributes and sub-attributes will be discussed briefly in the following paragraphs with the reference to the following technological map in the Figure 22.

![Technology map of electric vehicle](image)
The EV components (artefacts)

The technological framework of an electric vehicle comprises of tangible entities like the battery, drive train, wheels, design, safety equipments, materials, controller, and auxiliary units. In the following each of them is discussed briefly.

Battery - The battery provides the prime energy supply for the propulsion of an electric vehicle. This battery technology can be considered as the most critical EV technology component (Kampman et al., 2010). Battery innovation solutions are essential to encounter the current EV barriers especially related to the range anxiety. Therefore, the most challenges will remain on the size, the weight, the energy density, the life cycle, the price, and fast charging developments (D-incert, 2011).

Currently, the Li-ion polymer battery (LiFePO4) is mainly used in electric vehicle since it provides significant power density advantages over the lead-acid, Ni-Cd, and Ni-Mh battery. Battery is commonly classified by specific energy watt-hour per kilogram (Wh/kg) and power density watt per kilogram (W/kg). Below table 8 describes the comparison among the battery technologies.

<table>
<thead>
<tr>
<th></th>
<th>Lead Acid</th>
<th>Ni-Cd</th>
<th>Ni-Mh</th>
<th>Li-ion</th>
<th>Li-ion Polymer</th>
<th>Na-NiCl-Zebra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific energy (Wh/kg)</td>
<td>25-45</td>
<td>50-70</td>
<td>50-70</td>
<td>100-140</td>
<td>110-150</td>
<td>90-120</td>
</tr>
<tr>
<td>Theoretically possible energy (Wh/kg)</td>
<td>175</td>
<td>240</td>
<td>300</td>
<td>&gt;450</td>
<td>&gt;450</td>
<td>788</td>
</tr>
<tr>
<td>Power density (W/kg)</td>
<td>50-100</td>
<td>150-200</td>
<td>100-200</td>
<td>100-200</td>
<td>120-200</td>
<td>200</td>
</tr>
</tbody>
</table>

Table 8: The comparison among battery technologies (PhotonInternational, 2008)

In 2012 the battery cost is estimated to be € 620 per kilowatt hour (kWh) and this price will be expected to reduce significantly to reach € 150 per kWh in the future mass scale production (D-incert, 2011). This battery cost consists of the materials that are used in the batteries and other additional components e.g. cooling, casing, and battery management system that are used to control and complete the battery packs.

In the current situation, the lithium-ion battery commonly uses a carbon-based anode and a metal oxide cathode (Duleep et al., 2011). The next technology development will continue focus on the electrode and electrolyte materials, and chemistries to gain an improvement in the battery life, energy density, and reducing in battery size and weight. In the following figure, the battery technology roadmap is illustrated.
Drive trains - The drive train of the EV comprises the motors that provide for rotary motion, drive shafts that are responsible for the transmission of power from the source to the wheels, and the assembly consisting of the transmission that includes gears.

Wheels – The wheels are the rotary components that are responsible for the execution of propulsion after transmission of power from the primary power source.

Controller - A controller for efficient operation of the vehicle is mandatory. It determines the operating characteristics of the motor and the power source depending on the load requirements at any given time. This controller is an indispensable component of the electric vehicle.

Design - The vehicle design is an important component that accounts for reliability and the operational of vehicle. The electric vehicle designs are further classified into interior design and exterior design. The interior design is including the dashboard, cluster seats, windows, and chassis design while the exterior design involves the body and aesthetics shape of vehicle e.g. headlights, bumper design, spoiler design, etc. However, in the current situation the focus is on the improvement of the battery design.

Safety - A car would be incomplete or incompetent to be driven on the roads without the safety components like air bags, cluster warning indicators, alarms, seat belts and locks.

Materials – All vehicle components are made of materials that are appropriate for its uses. Generally, the materials are decided by a number of factors and it is selected by the designers or car manufacturers based on the strength, formability, conditions, reliability, endurance, etc.

Auxiliary components - The auxiliary equipments are a mix of essential accessories and luxury accessories e.g. air conditioning system, infotainment, the stereo, tool kits, first aid, etc. The auxiliary components are seemed to be essential parts of any vehicles on the road these days.

The services

Unexpected events are unavoidable as they are often not within our range of control. In this situation, services for the vehicles are another important aspect and commonly integrated with the purchasing a vehicle. Although some of them may be used at a later stage for an additional cost,
most of the services are made right from the first day of purchase or use the car e.g. insurance service.

Further, the services in the electric vehicle are also including mobility services and payment service. The mobility services can be part of integrated mobility solution for the city environment. Here, the integration is implicitly translated to the relationship among vehicle and infrastructure. Regarding to the payment services, it is often necessary to find a conductive mode of payment for the services that are offered e.g. the payment service for the charging point.

Another important service is related to the maintenance. Generally the maintenance deals with several activities e.g. repair, replacement, and recycling the spare-parts. Even though the components are designed for endurance and longevity, due to unforeseen circumstances one of many components could be damaged e.g. the replacement or service for the electric vehicle’s battery.

The infrastructure

There is no point in purchasing or renting a vehicle if there is no road to drive on. Infrastructure is the tertiary framework for the electric vehicles. Highways or dedicated lanes, energy sources, and charging stations or charging points are the requirement infrastructure for electric vehicles. As the driving range of electric vehicles is limited, an elaborate and well-distributed network of charging stations is required (D-incert, 2011). In the future the charging points can be expected to be integrated with the public utilities e.g. office buildings and public parking spaces. Lastly, the infrastructure would be incomplete without the manufacturing units that produce the vehicles and the supply chain that is responsible for the distribution of the electric vehicle to the end users through authorized dealers.

3.2 Stakeholder analysis

In this section the stakeholders of the Dutch electric vehicle innovation system are identified. Firstly, they are described including their interest and contribution. Secondly, the power positions of each stakeholder are explained. Thirdly, the relationship between each actor is illustrated in the stakeholder map. For the details, Appendix B shows all key stakeholders involved their interest, and what resources they contribute to the EV introduction.

3.2.1 The stakeholder’s components

The stakeholders of Dutch electric vehicle innovation system are categorized into five main categories, named Government, Research, Firms, Users, and Society. In the following each of them is discussed as follows:

Government

In the current EV innovation, the government acts as a catalyst to increase the overall performance and create a sustainable country competitive in the EV development. For a large scale EV introduction the government supports are mainly coming from European Union, The Dutch government as well as regional and local government. In the following paragraphs each of them is described as follows:
European Union – The European commission is investing in sustainable transportation. The aims are to reduce CO₂ emissions, to ensure security of energy supply, and to promote a broad use of renewable and carbon-free energy sources in the transport sector (EuropeanCommission, 2011a). A concrete example: The European commission supports Europe electro mobility initiatives by funding € 41.8 million Green eMotion programs in partnership with 42 partners from industry utilities, electric car manufacturers, municipalities, universities and research institutes (EuropeanCommission, 2011a). This initiative is aimed to exchange and develop tacit knowledge and experience in selected region in Europe as well as to facilitate the EV market in Europe.

Dutch Government - The Dutch Government is actively participating in the current electric vehicle developments. The three Dutch ministries, named the Ministry of Infrastructure and the environment, the Ministry of Education, Culture and Science, and the Ministry of Economic Affairs, Agriculture and Innovation are the major actors. However, in practice the other Ministries are supporting as well.

Regional and Local government – Each local region has their own interest in the development of electric vehicles. Therefore, it depends on the local government to promote and collaborate with the local community to gain commitment for electric vehicle implementation. Recently several municipalities including Amsterdam, Rotterdam, Utrecht, Brabant, and Friesland have been involved in EV developments. In the future it is expected that other regions will be involved as well.

University and research institutes

University and research institutes play an important role in the introduction of electric vehicles (Bahrami and Evans, 1995). In order to develop knowledge management, technological innovation, and education, D-incert was created under the initiative of three Dutch Universities, named TU/e, TUD, UT, with the University of Applied Sciences from Rotterdam and Arnhem/Nijmegen, and several companies such as NGInfra, Prorail, KEMA, Eneco, the ANWB, and Essent (D-incert, 2010).

University - Due to a high standard education system, the Dutch Universities produce many talented students with both a strong technical and business background. These students are prepared to become the next professional worker, professional researcher, and entrepreneurs who will undoubtedly contribute to the EV development.

Research Institute – Same as the Universities, the research institute contributes the EV technology diffusion through technology transfer and knowledge transfer. Examples of this research institutes are TNO, the Netherlands’ Institute for Metals Research (NIMR), the Dutch Polymer Institute (DPI), the Embedded Systems Institute (ESI), and the largest research centre in the field of energy in the Netherlands (ECN).

Firms

Firms are playing a significant role for the Dutch EV introduction. In the following several Dutch companies are mentioned:

Dutch automotive industry firm/company – Companies and firms are other important stakeholders in the EV industry. They are part of the creator for the technology diffusion and for the continuity of innovation system. Recently, The Netherlands has produced many successful companies in the
Dutch electric vehicle innovation system

automotive industry (MinistryofEAAI, 2011). All of these companies can be divided into three broad categories, named OEMs/Integrators, supplier to vehicle design, supplier to vehicle interface, and supplier for battery power.

In the Netherlands the OEM or integrators are including DAF, VDL, and some innovative start-ups e.g. Spijkstaal, Innosys Delft and Gemco E-Trucks. The suppliers to vehicle design (components or systems) are including Bosch Trans Tech, Akzo Nobel, Corus, DSM, Vredestein, SKF, etc. The suppliers to vehicle interface are including TomTom, Navteq, NXP semiconductors, etc. The suppliers for battery power are including ACTIA, MasterVolt, and Philips.

Service providers – The service providers are interested to support the EV industry. Several companies are including the insurance companies, lease agency e.g. Lease plan, Athlon Car Lease, and MisterGreen.

Infrastructure providers – These include the electricity suppliers e.g. Nuon, Essent, charge pole manufacturers e.g. Alfen and ABB Epyon, and distribution system operators e.g. TenneT and Enexis. In order to introduce EV in a large scale, service providers must definitely integrate with the other stakeholder’s components.

Foreign EV producers – The foreign EV producers have to internationally collaborate. Some foreign OEMs or integrators need to support the Dutch EV Industry. Examples of these OEMs or integrators are BMW, Mitsubishi, Nissan, Renault, Peugeot, VW, and many others.

Users

The user creates the demand of electric vehicle. Hence, it can be seen as a part of the whole EV development and success. Typically there are two categories of user, named Lead-user and end-user. Each of them is discussed briefly as follows:

Lead User – According to Urban and Hippel (1998), the lead users are those users that face needs which indicate general demand in the market place. It is usually happened in months or years before the product or service is introduce in the market place. This lead user can contribute a valuable insight regarding a solution of the technology needs, will invest more in obtaining a solution, and can become a forecasting tool for laboratory and market research. In this case the Government, lease agency, and taxi Company can become a lead user for the introduction of electric vehicles.

End user or customer – People who uses the product and service, they will create a large demand for electric vehicle in the market. By having large demand on electric vehicle, the large scale of economic can be achieved accordingly.

Society

In this last category, the society represents the rest of the stakeholders. These are including the venture capital or investors, other competitors, and Non Government Organization (NGOs). In the following each of them is described as follows:

Venture Capital/Investors – The venture capital or investors plays a crucial component in the contribution to the financial resources to introduce electric vehicle. Besides as a financial resource,
venture capitalists can also provide a valuable input on management, and network for the first stages of a firm’s development. The principal role of the venture capitalists is thus related to entrepreneurship by helping start-up companies to grow exponentially (Bahrami and Evans, 1995). However, in the current development venture capital is rarely available in the Netherlands.

**Other competitors** – These are companies who are currently not focusing on the EV but rather in other alternative vehicles such as bio fuels, hydrogen, steam, and combustion vehicles. They tend to resist the current EV development since they do have different interest. Several companies are including the automotive manufacturers and also the energy supplier e.g. Shell, Exxon Mobil, and other service providers. All of these companies might need some time to collaborate to produce electric vehicle.

**Non Government Organization (NGOs)** – This NGOs has interest on the protection the social interest and ecological e.g. Stichting Natuur & Milieu and Greenpeace. They contribute on creating a healthy natural environment.

### 3.2.2 Stakeholder in power interest matrix

After identifying each stakeholder’s components, in this section the power interest of each stakeholder is explored. All stakeholders are displayed in a power interest matrix. Within this matrix a communication strategy for the introduction of EV can be formulated based on four different approach mechanisms: monitor, keep informed, keep satisfied, and manage closely. The following figure gives an overview of the influence of the Dutch EV technology diffusion.

![Power matrix of the stakeholder](image)

**Figure 24: Power matrix of the stakeholder**

### 3.2.3 Stakeholder map

In this part the relationship of each stakeholder is illustrated. The stakeholder map covers the key actors which may use its resources to contribute to the electric vehicle innovation process. It starts from the international influences through the national level then follows by regional development. Further, it shows the importance of relationship among government, research institutes or universities, industry or firms, and users. The interaction among them has lots of influence to the success of EV introduction. In the following figure this relationship is illustrated.

---

**1. European Union**
**2. Ministry of Economic Affairs, Agriculture and Innovation**
**3. Ministry of Education, Culture and Science**
**4. Ministry of Infrastructure and Environment**
**5. Local/Regional Government**
**6. Universities and Research Institutes: TU/e, TUD, UT, TNO, etc.**
**7. OEMs/Integrators: DAF, VDL, Innoys DelR, Semco-E-truck, Spijkkstal, etc.**
**8. Suppliers to vehicle design: Bosch Trans Tech, Akzo Nobel, Corus, DSM, Vredestein, etc.**
**9. Supplier to vehicle interface: TomTom, Noveteq, NXP semiconductors, etc.**
**10. Supplier Battery: ACTIA, Mastervolt, Philips, etc.**
**11. Service providers: MisterGreen, Lease plan, Athlon Car Lease, etc.**
**12. Infrastructure providers: Nuon, Essent, Enexis, TenneT, etc.**
**13. International EV Supplier**
**14. Lead User**
**15. End user or customer**
**16. NGOs**
**17. Venture Capital/Investors**
**18. Other technology competitors**
3.3 Barriers and possible developments

In this section, the barriers and possible developments of current electric vehicle are explained by referring to the given technology map in Figure 22. It starts with the barriers then it continues to the possible and foreseen future developments.

3.3.1 Barriers

The main barriers of the EV introduction are including inferior technology components especially related to the limited range, battery recharge time and high cost of batteries. Another important barriers are confronting with lack of infrastructure, lack of market, safety issues, lack of engine noise, and lack of strong commitments between various stakeholders (Tsang et al., 2012).

1. Inferior technology components

According to previous study, the technological barriers are the most reason that EV cannot be able to compete against the combustion vehicle (Tsang et al., 2012). These technological barriers are categorized into three parts, namely limited range, long recharge time, and high cost of batteries.

Limited range – The range anxiety is the main concern for the customer to buy electric vehicle. In 2010 the recent EV technology development by using lithium-ion battery, the Tesla Roadster, is just capable to travel maximally 245 miles or 395 km on a single charge (Tesla, 2012). Although the trend shows a rapid improvement compare with the first and second generation of EVs, that only capable to have around 90 – 135 Km on full charge, the capability of current electric vehicle is still far behind the capability of current conventional vehicle.
Long recharge time – The charging points in the Netherlands are commonly used the new standard charging plug (type 2, mode 3). Hence, the charging time is around 6-8 hours for a full charge (Tsang et al., 2012). Within this long recharge time, electric vehicle is less attractive than the ICE vehicle that able to take only few minutes to refuel. Subsequently, the future technology development can be expected to reduce the charging time significantly or innovated solution like the Better Place battery exchange system and fast charging point may help to overcome this long recharge time barrier.

High cost of the batteries - The entire vehicle is constrained by cost. Recently due to high cost of the battery, the electric vehicle price is higher than the conventional vehicles. As the matter of fact, current electric vehicle costs 50% production cost and most of this cost is solely coming from the battery cost (Lytton, 2010). Although recent lithium-ion battery technology has been successfully reducing the battery cost, major technological improvements and implementation of economic of scale in the production process are still needed to reduce the battery price significantly.

2. Lack of infrastructure

Another concern or barrier in introducing electric vehicle is that the limitation of the infrastructure such as the charging station. In this case the chicken eggs dilemma is occurred as described by Melaina and Bremson (2008): a “three way” bind between key stakeholders (Tsang et al., 2012). Due to some difficulties to refuel, the electric vehicle customer is unwilling to purchase the electric vehicle since there is no market, and subsequently the fuel providers are not willing to provide the service for the electric vehicle.

Furthermore, parking space may add extra issues related to the infrastructure. As it is mentioned before the recharging time for electric vehicle in a single charge will take around 6 until 8 hours. Hence, the EV owners need to have some reliable parking space which they can recharge easily. This issue is even worse if one lives in the urban area like Amsterdam, Rotterdam, or The Hague due to the limitation of parked on public roads.

3. Lack of market

The demand of electric vehicles is still very small compared with the ICE vehicle. As the matter of fact, the conventional vehicle has been dominating the market share over 85% of the Dutch automotive market (CleanVehicleEurope, 2010).

4. Safety issues

The main safety issues are related to the collision safety, electrical hazards, and the absence of engine noise.

Collision safety – Electric vehicle has its own design and technology components that are differ from the conventional combustion vehicle. Hence, EV needs to be tested to meet the current collision safety standard.

Electrical hazards – There are some concern related to the material that is used in the current Lithium-ion battery, could cause dangerous in the case of short-circuited or overheated. Accordingly, the European Union introduces some common safety standards. Concurrently, many battery...
manufacturers are trying to find a better solution on developing safer battery technology e.g. Lithium phosphate batteries.

The absence of engine noise – Less noise that is produced by electric vehicle can create some problems as well. According to prior study, various safety groups are concerning the ‘silent’ vehicles especially in the urban intersection for people who visually impaired, cyclists, runners, small children, and other pedestrians (Tsang et al., 2012).

3.3.2 Possible innovation development areas
Results from the various mentioned barriers, possible innovation developments in current electric vehicle can be identified. The possible innovation development of electric vehicle in the Netherlands can be divided into nine areas, named integrated electric mobility, affordable electric vehicle, connected electric vehicle, smart charging, battery management, fit-for-use drive trains, safety electric vehicle, sustainable energy network, and sustainable battery (D-incer, 2011). In this part, inputs from D-incer are taken in to account. In the following each of them is discussed as follows:

**Integrated electric mobility** – One of the possible innovation development of electric vehicle in the Netherlands are delivering integrated mobility solution for the city environment. Here, the integration of electric mobility is implicitly translated to the relationship among vehicle, infrastructure and services. In order to implement the integrated solutions, one is recommended to focus on delivering consistency, user-friendly and affordable mobility concepts to the customer or end-user.

**Affordable electric vehicle** – In this innovation development, having an affordable electric vehicle can be seen as the main challenge. Promised technology development is identified as an important aspect to reduce the electric vehicle overall cost. However, another finding shows that innovation in business model can also be compromised as another solution towards the affordable electric vehicle. As a consequence, the success development from this innovation area will definitely bring a positive impact to the Dutch economy in general.

**Connected electric vehicle (EV)** – ICT will have a significant role for the innovation development in this innovation area. It is expected that with the help of new ICT development the communication from vehicle to its environment and vehicle to vehicle can be improved significantly. Several possible development are including safety, traffic management, gathering information or entertainment, navigation system, controlling and monitoring EV technology components, and data security on the mobility concept. Specifically in order to reduce the range anxiety, the connected EV will play an important role. For example by implementing the intelligence driver guidance assistant system inside the electric vehicle, the end-user or electric vehicle customer can intelligently communicate with its environment such as charging point, and parking places.

**Smart grids** – This innovation development is related to user-friendly, reliable, and secures changing infrastructures. The challenge remains in reducing the current recharging time and improve the balance between electricity supply and demand. In 2020 it is expected that the fast charging and slow charging are implemented at home and offices.

**Battery management** – In order to have reliable and affordable battery technology it is essential to develop an intelligence battery management system (BMS) which can control the charging and
recharging battery process efficiently. Further, this BMS can be used to monitor the battery so that it can extend the range radius and the battery life of the electric vehicle. This innovation area can be seen as the opportunity to resolve the current limitation of battery life time as well as increase the range of electric vehicle distance.

**Fit-for-use drive trains** - According to the Direct-Drive-In-Wheel (DDIW) principle the current electro-motors can still be possible to be developed efficiently. In the future, the electric vehicle can be powered directly from the wheels by placing the small electro motors in the wheels itself. The electro-motor is supplied from the battery source which is located in the front, back or middle part of the vehicle. Hence, there are lots of possible technology developments within this innovation area.

**Secure electric vehicles** – The future of electric vehicle has to deliver more secure transportation than the current conventional vehicle. However, in the current situation there are still many uncertainties about the safety aspects of current electric vehicle. As it is mention in the barrier section, the main safety issues are related to the collision safety, electrical hazards, and the absence of engine noise. Hence, the future safety aspects have to be developed by using a reliable technologies and materials which can counter the main issues accordingly. Innovation in this area will definitely be needed in the near future.

**Sustainable energy network** – In order to satisfy the future large-scale demand of electric vehicle, one has to improve the current electric infrastructure and the electricity network. Accordingly, to gain sustainable in electric mobility, the clean energy such as solar and wind energy will be used. However, the challenges remain on the finding a reliable link between renewable energy and electric mobility system, the balancing supply and demand of energy, and peak time of charging time. Hence several possible innovated solutions can also be expected from this innovation area.

**Sustainable battery** – The Netherlands can play an important role to introduce a sophisticated and an efficient reuse or recycling of battery technology. Some possible developments are including the improvement of battery materials, the second life battery application, the improvement of battery cycle time, and AC-DC battery technology.

### 3.4 Market development for the Netherlands and Europe 2020

The market share of electric vehicle by 2020 is expected between 2% and 5% (HTAS, 2009). High Tech Automotive Systems (HTAS) Netherlands made a research study for market opportunities for the Netherlands as well as Europe in the near future 2020:

In the Netherlands currently it is estimated around 8 million cars on the road. The trend shows positively regarding the introduction of new vehicle in the coming years and the growing rate is assumed about 5%. This means that there will be maximally 400.000 vehicles in the Netherlands by 2020. For the electric vehicle it is approximately expected to be around 100.000 electric vehicles on the road with the average price of the EV around € 30.000, - including the battery pack by 2020. Hence, combine the volume and price, by 2020 the market for electric vehicle in the Netherlands can be expected at least around € 3 billion per year (100.000 X € 30.000, -).

In Europe, similar calculation was performed. Currently there are around 250 million cars registered in Europe. Assume a modest share of 2% which means there will be around 5 million electric vehicles
Dutch electric vehicle innovation system

in Europe by 2020. Therefore, with one million electric vehicles per year there will be a market of at least € 30 billion electric vehicles per year by 2020.

3.5 The Multi Level Perspective for electric vehicle

Every organization, industry or sector is a part of a larger environment and concurrently to gain sustainable competitive advantage one need to look the innovation development in the broader context. In this section the Multi-Level Perspective (MLP) framework, which is described in previous chapter, is used to gain a better understanding about the environment or the innovation context by looking the three different of development levels, named landscape development or macro level, current regime development or meso level, and niche development or micro level. In the following figures the three levels are illustrated.

![Figure 26: The Multi Level Perspective (MLP) in static view (Geels, 2002)](image)

As it is described in the figure above, the introduction of electric vehicle is influenced by the current combustion vehicle regime as well as the electricity regime. Further, the scope of this study focuses solely on the BEV and PHEV development.

3.5.1 Landscape development or macro level

Since the 1880s the novelty of electric vehicle has been developed (Brower and Meijer, 2011). Hereby, the landscape development had immensely influenced on the electric vehicle introduction. In contrary, the result was obviously not as the expected one. In fact, the conventional combustion vehicle is dominant in the present market and showing a stable transportation regime. Due to the global changes including current macro political development, macro economics, environmental changes, and changes in social structure, there is a renewing interest for several countries in the world including the Netherlands to stimulate the electric vehicle. The external influences are discussed briefly as follows:

**Political issues** – The current political instability in the Middle East countries, the OPEC oil export embargo in the 1973, and the 1979 oil crisis might give a sign of the vulnerability of oil dependency (Brower and Meijer, 2011). These situations led to a major chaos to several industrialized countries due to the rise of oil prices and disrupted oil supply. Accordingly, the major developed countries especially those who are not having its own fossil fuel resources willing to reduce its oil dependency by diversify the energy sources towards a sustainable energy solution.

**Environmental changes** – The current global change in environment motivates several countries including the Netherlands to reduce the CO₂ emissions and the greenhouse effects. Hereby, the
Kyoto Protocols in 1997 required many countries to reduce the greenhouse effects and the collective CO₂ emissions in the period of 2008 until 2012 by an average of 8% below the 1990 levels (EuropeanCommission, 2010). By 2007 the European Union (EU) leaders made an agreement to set the European standard to cut its emission to at least 20% of 1990 levels by 2020 (EuropeanCommission, 2010). Further, based on the Cancun agreement in December 2010, the commitment continues as building comprehensive frameworks for the next climate action for the period after 2012 (EuropeanCommission, 2010).

**Macro economics** – The growth of economy, industrialization, and human population that is estimated to be nearly 9 billion in 2050 (UnitedNations, 2004), have influenced many people to concern about the scarcity of natural resources and climate change. In most places, the current fuel for transportation is derived predominantly from fossil fuel resources. As fossil fuels are depleted and are becoming increasingly expensive to extract it is becoming apparent that the transportation costs would significantly rise over time. Further, together with current economic crisis, the structural change in the transportation regime has been thus urgently needed. It is then the challenge for major automotive industries everywhere in the world to be more competitive by delivering sustainable products and sustainable services.

**Society change** – The shifting on the society will obviously influence the appearance of new niches. Factors in demographic change such as increasing households and population, increasing incomes, and increasing mobility or travel tend to encourage actors to seek more radical mobility solutions. In the modern society, there are some indicators that social attitudes and values are changing to become more environmental awareness of the problems associated with current transportation e.g. congestion, air-pollution and climate change (Björn Nykvist, 2008). Hence, it will effect to the current transportation regime and the niches development.

### 3.5.2 Regime development or meso level
The constant pressure from the landscape development or macro level will slowly put effect to the current regime which dominated by combustion vehicle. According to van Bree et al (2009) the regime for land-based road transportation is divided into eight components. These are including production systems and industry structure, markets and user practices, fuel infrastructure, automobile, culture and symbolic meaning, road infrastructure, and regulations and policies. In order to introduce the niche electric vehicle successfully to the market one has to satisfy these eight components (van Bree et al., 2009). All of these factors give the current regime its structure and stability. To be noticed, many of these components are already discussed in the previous section, technology map. The following figure describes each component of the current Dutch transportation regime.
Production system and industry structure – The current production systems are much relying on the current policies and market demands (FederationHollandAutomotive, 2010). Based on these two inputs combine with the other external factors such as the competitions and the suppliers, the car manufacturers are able to improve its technology to produce better quality products and services. At the present time many established car manufacturers such as BMW, AUDI, VW, Opel, Ferrari, etc seem continuously developing new products of the combustion vehicles and services while only small portion development of other alternative transportation like electric vehicle or PHEV.

The automotive industry structure has been shifted gradually in the value chain from vehicle manufacturers towards its supplier. The current trend shows that in the production system the vehicle suppliers are having more responsibility for the design and production of particular vehicle modules (van Bree et al., 2009). As a part of company strategy, many vehicle manufacturers prefer to implement an economic of scale through mass productions and to outsource the development and production processes of many modules to suppliers since it can significantly reduce its operation costs and decrease the development risks. Further the international corporations, product differentiation, and shifting towards Product Service System (PSS) are also becoming commonly used.

The prospects for the Dutch vehicle manufacturers are good and mainly dominated by car suppliers instead of the car manufacturers or the integrators (OEMs) (DutchAutomotiveIndustry, 2012). Three key developments that help strengthen and shape the Dutch automotive sectors are including the expansion of existing companies, the launch of new start-up companies (SME) and facilitating its growth, and the international acquisitions. Further the Dutch industry could develop to become a specific testing—ground for the introduction of the electric vehicle. Subsequently, the Netherlands can become an interesting place to study on how the electric vehicle would be implemented in a country.

Market and user practices – The automotive market is increasing rapidly in the 20th century and is becoming an important aspect in transportation industry (van Bree et al., 2009). The customer preferences and demands make the market separated into various segments. In the Netherlands the market automotive segments are indicated by letters which starts from letter A until N (DutchAutomotiveIndustry, 2012). Further, it will be divided into various types such as sedans, hatchbacks and station wagons. 

Figure 27: The socio-technical system of car-based transportation (van Bree et al., 2009)
The consumer expectation and the tight competition between car manufacturers have been resulting to significant improvement in current technology development. Accordingly, number of car attributes are increasing includes safety, reliability, power, acceleration and comfort. Here, the car manufacturers and suppliers are expected to satisfy these attributes.

**Maintenance and distribution network** – Together with the vehicle manufacturers, repair shops and distribution channels (dealer) made a significant impact for the success of current transportation regime. The Dutch has its own standard and procedure to maintain and guarantee a certain level of quality and safety. According to recent study, it is expected that the need for maintenance of an electric vehicle will be lower than the maintenance requirements for a conventional car (DutchAutomotiveIndustry, 2012). However, having a good maintenance and distribution seem essentials for the success large scale electric vehicle introduction.

**Fuel Infrastructure** – Oil companies and petrol stations are important factors for supporting the stability of current combustion vehicle regime. Generally, in every few kilometres there will be gasoline stations that are able to supply the oil or gas to the vehicle. Each gasoline stations normally derive from the conventional fossil fuel-based supply.

However, in order to introduce electric vehicle in large scale, one has to consider the number of challenges such as the way people charge their vehicle, the way the energy is distributed to the charging locations, the way the energy is generated and the way the energy is paid for.

**Automotive (artefact)** – Generally the automotive industry stimulates either direct or indirect actions to the world economies. Specifically the automotive industry in the Netherlands employs approximately 45,700 people which divided into OEM’s, suppliers, R&D institutions and other automotive components companies (DutchAutomotiveIndustry, 2012). Hence, the automotive industry is one of the main drivers of the Dutch economy.

However, despite several advantages that have been created, the current automotive industry contributed lots of disadvantages. These are mostly related to congestion, environmental degradation, traffic unsafe, landscape segmentation, and resource depletion (Nijkamp, 2012) . The current combustion vehicle technologies (artefact) are including Drive train (engine, transmission, and wheels), Suspension, Body (material and structural configuration), Accessories, and Controls Systems (brake system, and steering system) (Geels, 2002). Regarding the electric vehicle technology components one has to consider the technology map that is explained extensively in the previous sections. Those aspects are needed to the success of implementing electric vehicle.

**Culture and symbolic meaning** – Culture influences the usage of vehicle e.g. according to a research study in European and Asian countries people are tending to use smaller, economical and lighter cars than those who are in the United State. Further by using a vehicle, one can express themselves in several things including freedom, individuality, status, and esteem. By using the electric vehicle one can also create a symbol for sustainability.

**Road infrastructure and traffic system** – Same as the fuel infrastructure, the road infrastructure and traffic system are other important aspects. Consequences of the constant increasing number of cars, the traffic rules are certainly needed to reduce the amount of accident and control the traffic flow.
Concurrently, the road infrastructure is also needed to be adjusted to facilitate and support the increased traffic.

**Regulations** – Generally the regulation for transportation is made by the public authorities that operate on the international level (EU, WTO, and GATT), national government, and local government depending on the rules created. In the Netherlands cars are taxed with the normal EU VAT rate of 19% and an additional taxation called BPM (DutchAutomotiveIndustry, 2012). The BPM rate is considerable: a fixed rate of 27% of the ex VAT price plus a percentage that varies with the CO₂ production of the car. Very clean cars, like electric vehicles and full hybrids, are exempted from BPM. This fiscal advantage is meant to compensate for the on cost of the technology and turned out to be a very considerable market advantage in a price sensitive market. It boosted the market development of hybrids and can do so for fully electric vehicles as well.

### 3.5.3 Niches development or micro level

In the micro level the novelities or radical innovations are commonly developed. The result of these niches will either replace the regime practices or fail to emerge. Further, the role of actors through network plays a significant role to protect and shield the novelities since it is likely that the new technologies would not be survived due to uncertainty and instability.

There are several technologies niches emerged from the current combusted vehicle. These are including Fuel Cell Vehicles (FCV), Battery Electric Vehicle (BEV), Hybrid Electric Vehicle (HEV), Plug-in Hybrid Electric Vehicles (PHEV), Compresses Air Vehicles (CAV), and Natural Gas Vehicle (NGV). However as mentioned earlier, this study focuses solely on the **Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV)**. For the detail of this niche development, in the next chapter through the investigation of available EV pilot projects, the developments within this niche development will be explored. In the following figure the niche development is given.

![Figure 28: Niche development on the MLP approach (Geels, 2002)](image)

### 3.6 Chapter summary

This chapter explained the Dutch electric vehicle innovation system and the Multi Level Perspective (MLP) analysis to gain a better understanding of the innovation context. This is important since in the tight competitive market, the innovation process should be adapted to its environment. Further, following the innovation process as described in the previous chapter and the basic methodology of analysis, this chapter covers the investigation phase which consists of current development of electric vehicles and foreseen innovation characteristics of electric vehicles. As a result, this basic provided an indication about the maturity of Dutch EV innovation system and set the boundary of this research study.
In this study the nine innovation development areas, named integrated electric mobility, affordable electric vehicle, connected electric vehicle, smart charging, battery management, fit-for-use drive trains, safety electric vehicle, sustainable energy network, and sustainable battery were identified. Additionally, these innovation areas are necessary as valuable inputs for finding the potential products or services in the niche developments which will be explained in chapter 5. In the following figure the current stand of this chapter in innovation process is illustrated.

Figure 29: Current stand for chapter 3 in innovation process

It is recognized that the EV innovation system is a complex ecosystem including various technology components, services, infrastructures as well as many stakeholders. In order to introduce the electric vehicle successfully, one has to find innovative solutions which are not straightforward. The fact shows that EV was invented in 1834 but up to now the EV cannot compete against the dominant conventional combustion vehicle due to several barriers.

In this chapter, the electric vehicle is defined as a vehicle in which the electric power can be supplied by the grid. In other words, the term of electric vehicle includes the Battery Electric Vehicle (BEV) as well as the Plug-in Hybrid Electric Vehicle (PHEV). As a consequence, the Hybrid Electric vehicle (HEV) or fuel cell vehicle is not explored in this study.

Looking at the macro level, the transition of current combustion vehicle regime is influenced by the global changes including the macro economical, political instability, social change, and environmental changing which result in changing of preferences, policies or standards. Hence, these landscape developments put a constant pressure to the current transportation regime which is dominated by the internal combustion engine (ICE) vehicle.

In the first decade of the 21st century there is a renewed interest for introducing electric vehicle in the market. At this time, people are becoming more aware in sustainability since the series of natural disasters, economic crisis, political change, and society change are again putting pressure to the current regime. Accordingly, the new window opportunities are opened for introducing sustainable transportation such as electric vehicle.

Initially, the current actors in the transportation regime are tending to resist to the niche development due to their large investments in the current regime. They will thus ignore the change since it can affect negatively their current business. They prefer to have a more incremental technology development rather than the radical one. For instance, the current OEMs or car manufacturers use catalytic converters to solve the current technology problem to boost the car performance. Therefore, as long as the niche technology development is not sufficient to compete
against the current regime technology development, the dominant regime might not be changed. Further, the eight components (Figure 27) that were mentioned in the previous section and the key stakeholders have to be satisfied in favour for electric vehicle.

In the niche development, the key actors especially the government can play a significant role to protect the current niche to develop by stimulating and facilitating the current niche development like the Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV). Hence, together with the pressure on the landscape development and the improved niche development, a new regime can be opened.

The technology map consists of three categories, named technology components, infrastructures, and services. Each of them contributes to the introduction of the EV in the market. Here, the challenges still remain on the battery technology development (range anxiety, battery costs, and materials), the limitation of charging points, and the limitation of the services. And since the technology is still in the niche, this situation can lead to the chicken eggs dilemmas.

The stakeholders inside the current Dutch EV niche development are diverse. These can be divided into five main categories, named Government, Research, Firms, Users, and Society. First, the Government category includes European Union, National and Regional Government. Second, the Research category consists of three Dutch Technical Universities (TU/e, TUD, and UT), University of Applied Sciences (Rotterdam, Arnhem/Nijmegen), and Public Research Institutes (TNO, DPI, ESI, ECN). Third, the Firms in the Dutch EV niche market are mainly covered by various EV supplier components such as Bosch Trans Tech, Akzo Nobel, Corus, DSM, TomTom, NXP semiconductors, MasterVolt, and Philips but it has only fewer amounts of OEMs or Integrators: DAF, VDL, Spijkstaal, Innosys Delft, and Gemco E-Trucks. The service providers include Athlon Car Lease, MisterGreen, and LeasePlan, and the infrastructure providers include Nuon, Essent, Enexis, Epyon, etc and foreign EV producers or suppliers such as BMW, Ford, Toyota, etc. All these mentioned actors are completing the Dutch EV innovation systems. Finally, the fourth and fifth categories comprise the user category such as lead user and end user, and society category which includes other competitors, NGOs, and venture capital or investors. To be noticed: it is understood that the availability of venture capitals for supporting the electric vehicle development in the Netherlands is very limited. Together, all the key actors inside the system are interacting in a way towards the success of the Dutch EV introduction. However, it is not a straightforward task since in practice everyone has their own interests and wills. Accordingly, the Dutch Government should take its initiatives to become a facilitator and controller.

Finally, this chapter mentioned several innovation development areas for the Dutch industry: integrated electric mobility, affordable electric vehicle, connected electric vehicle, smart grids, battery management, fit-for-use drive trains, secure electric vehicle, sustainable energy network, and sustainable battery. These innovation development areas have to be translated to the real business which can definitively bring benefits to the national economy. Nevertheless, several challenges sill remain on finding the most potential developments (products or services). Therefore, the next chapter will explore the development phase by looking at available EV pilot projects in the Netherlands.
4. Electric vehicle pilot projects

After investigating and exploring the current Dutch electric vehicle innovation system, this chapter answers the second sub-questions of this study: Which are the existing EV pilot projects in the Netherlands? What can be learned from the EV pilot projects? And how is the network formation?

As it is explained in the earlier chapter, the existing EV pilot projects are investigated by using Strategic Niche Management (SNM) analytical framework. Dynamic expectations, network formation, and the learning process are used as the main indicators for the analysis. The pilot projects are mostly organized through the Formula E-team program. In total the Formula E-team program has been organizing nine pilot projects for testing the prototype electric vehicles and fifteen pilot projects for research and designed by HTAS (MinistryofEAAI, 2011). For the purpose of this research, this chapter selects and investigates twelve most relevant pilot projects. The selection of the pilot projects was performed with the input from NL Agency. As a result, the knowledge that is gained from these second sub-questions will be used for looking potential developments (products and services) that represent the strength of the Netherlands in the electric vehicle industry.

The twelve selected pilot projects include Prestige GreenCab, Greenwheels, Amsterdam Electrics, Rotterdam Electrics, Electropool Haaglanden, CityShopper, Connected Cruise Control (CCC), 360 EVT - eVehicle Battery Monitoring en Control System, Databox, Electrical Vehicles Intelligently Directed By E-aware Navigation Technology (EVIDENT), Innovation in the power train for EV, and Logica project. The overview of the mentioned pilot projects is discussed further in Appendix C.

Section 4.1 describes the dynamic of expectations and followed by section 4.2 which investigates the network formation. Further, the learning process is explained in the section 4.3 and finally section 4.4 concludes this chapter. In the following figure the research process and where chapter 4 fits in are given on blue color as follows:

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**Figure 30: The research process and where chapter 4 fits in**
4.1 Dynamics of expectations

The process of voicing and shaping dynamic expectations can be analysed by looking at the robustness, quality, and specificity in the development of Dutch electric vehicle. Expectations are a means of aligning actors, acquiring support and attracting resources as well as steering research and development (Mourik and Raven, 2006). While the expectation in the beginning is being broad and fragmented, after several experiments the new expectation seems to become more robust, rise in the quality, and more specific.

Robust (more support)

The aim of this process is to align the expectations of stakeholders and thus improve the robustness of the expectations. For the Dutch EV industry the creation of the Formula E-team program, which is a Dutch collaboration between Industry, Government, Lead User and Research Institutes, was a strategic move on behalf of the Ministry of Economic Affairs, Agriculture and Innovation to bring actors and together with their collaborating partners to focus ‘on a selection of subjects that will be vital for realising breakthroughs in electric mobility in the Netherlands’ (Ministry of EAAI, 2011). In doing so, the actors in the EV market now have a structured form of interaction, and thus the expectations of EV become more robust through shared understanding of individual expectations. Through the work of each pilot projects, local authorities, the Small Medium Enterprise (SME’s), and research institutes have also been engaged in the voicing of expectations stage and included within the network. As a result, this will strengthen support for the development of electric vehicle as whole, as each pilot projects reach different actors and include a more diverse range of ideas.

Support from the Government can be seen as various regions are involved in the current EV developments: Amsterdam, The Hague, Rotterdam, Utrecht, Nijmegen, North Brabant province, and many more. The government helped to shape the expectation on a societal level and this support was only possible through shared expectation among industry, institutes and Government. At the end, the success leads to the Government ability to guide research and acquire funds. A concrete example can be found as the province of North-Brabant has provided 2.8 million in incentives for innovation projects.

Another pilot projects show similar results in which more collaboration between the existing key actors with new actors are expected to be improved in the near future. A concrete example is the Amsterdam Electric project: since the start of the taskforce in 2009, the Amsterdam municipality has relations with most of the actors in the network. Those relations can be divided into operational ties and strategic ties. On one hand, for the installation of the charging points the operational ties were formed with actors like Nuon, Alliander, and Essent, and for selling the EVs as a package including the car, a charge point, a proper plug, and a card, the Amsterdam municipality collaborated with mobility service providers e.g. The New Motion, Mister Green, Elmonet, charge point producers e.g. EV-Box, Coulomb, RWE, ABB Epyon, and car manufacturers e.g. Nissan, Mitsubishi. On the other hand, the strategic ties were formed with e-laad.nl and Formula E-team.

Similar collaborations were also seen in other regions e.g. Rotterdam and The Hague, the collaboration among key stakeholders were gradually increasing. Specifically through the experiments, it was aware that supports from the charging manufacturers and service providers were crucial for the success of the projects. Not enough charging points in public places and long
duration of installation were considered as the main bottlenecks of the projects. Hence, involving the actors like Eneco, Stedin, and Alliander may influence new expectations.

On the other pilot projects, more supports from car manufacturers can be recognized appropriately. With the decision of experimenting Mitsubishi i-MiEV in December 2010 and Nissan’s Leaf in February 2011 under Prestige GreenCab pilot projects, the electric vehicle prototypes finally tested to the real market. Through this experiment it was understood that an advanced vehicle interface, a new vehicle design, a new battery technology, new services were needed to be implemented. Additionally, under other pilot projects e.g. Greenwheels and CityShopper additional supports were also coming from Peugeot and Renault. The availability of electric vehicle influenced the end result of the projects.

Further, the ICT sector is expected to be involved in the forthcoming development. The relationship among the established actors, which were mainly dominated by energy and automotive sector, with the new actors from the ICT sector could be clearly seen within the Rotterdam electric and Logica pilot project. On these experiments, it was aimed to gain experiences in charging infrastructure including customer identification and payment system. In other projects e.g. connected cruise control, EVIDENT and future power-train, a similar collaboration can also be seen as NXP semiconductor and TomTom worked together with the infrastructure companies e.g. ABB Epyon, e-land.nl.

Several pilot projects were constantly looking outwards to follow and adapt to external developments. Under 360 EVT project Sycada made an international partnership to benefit the economies of scale and collaboration with Germany e.g. RDM automotive. A similar approach could also be found since the Dutch province Limburg though its subsidy program of € 2.1 million aimed to develop and to produce an EV by 2014 in the collaboration with NedCar and Aachen University in Germany.

Support from research institutes and universities made a great exploration in research and development. TU/e, TUD, and TNO were actively involved in various HTAS pilot projects. In one way or another, those three institutes were able to contribute to knowledge transfer as well as to produce new innovative products or services.

**Quality (more evidence)**

The quality of the expectations is another important dimension of the voicing expectations process. This is the method of eliciting expectations and it requires determining the most relevant and powerful expectations. Beside the support of infrastructures and services for successfully introducing electric vehicles, it was identified that one of the key stakeholders is the consumer as market success is driven by the amount of EV purchased and in use. Although the technology improved significantly, synchronizing the technology improvement to the market was still missing in the previous experiments or at least it was limited. Hence, it has to be improved in the next experiments by including the lead user or end-customers.

In the earlier technology development, several barriers such as range anxiety, battery lifetime, and affordable electric vehicle were identified. These barriers resulted in the creation of several pilot projects that were organized via NL Agency or HTAS. Most of these projects succeeded in introducing
prospective users to electric vehicle and giving them the opportunity to test the electric vehicles including the new technology features. The results from these experiments were giving back into the design process.

The result and feedback of participants were part of a lengthy articulation process. First, the major technical problems were indentified, as these were aimed to improve the range anxiety and inferior battery technology. This feedback resulted in further R&D and gave direction to a new technological research. Second, user requirements and user needs were more clearly identified. Driving behaviours of the users had considerable influence on finding the solution of the barriers. An important result of this process was a clearer picture of the prospective user was created which helped to define the development of the niche and the network.

Specific (focus)

Specificity refers to a clear focus of the expectations and it is important to increase the quality of the design process. When a technological innovation is accompanied by uncertainty, the views of actors can be quite divergent (Mourik and Raven, 2006). EV literature often only states that the EV consumers have solely concern over battery life, high price of vehicles, and range anxiety (EuropeanCommission, 2011b). Accordingly, most of the investigated EV pilot projects were focusing on the technological side of those issues. However, through a greater consumer understanding via several experiments, it was understood that the integrated mobility solution, battery management, connected cars, smart charging, and smart grids were needed. Herein, the ICT and software are expected to be one of the key technologies in the vehicle of the future. This technology offers not only new solutions and applications for in car control system but also the communication between car to car (V2V) and car to infrastructure (I2V) communication.

Changing the vision and expectations contributed to the niche development by including the Dutch ICT sector. Here, the Dutch Ministry of Economic Affairs, Agriculture, and Innovation constructed a new program for a new EV pilot project in which the ICT sector will play an important role. To begin with, the Ministry had set up top discussion about electric vehicle in which the ICT industry sector was involved. The aim of this focus group is to find the potential of ICT development within the introduction of electric vehicles. The group consisted of several key actors within electric vehicle innovation system and ICT sector. Results from this discussion gave an impact to the forthcoming electric vehicle technology development. In appendix G, the results of this focus group are given.

4.2 Network

The second process that is investigated in SNM is the dynamic development in the composition of network. Organizations involved with the coordination of activities concerning adoption of an innovation can be identified as actors in a network. Generally in the EV niches development the network formation consists of producers, lead users, regulators, and other social groups as it is mentioned in the stakeholder analysis from the previous chapter. The collaboration among these actors plays a significant role to sustain the technology development, the creation of new expectation, and understanding the new requirements and demands (Raven, 2005).
Network formation

From the investigated pilot projects in the earlier Dutch electric vehicle technology development, the social network consisted of lead user, technology suppliers, government, established firms, and research institutes from the automotive sector and the energy sector. These actors cooperated in stimulating the implementation of fully electric vehicle in the Netherlands. The network was small which only limited number of people participated but the alignment in the network was high. This alignment were organized through Formula E-team program which clearly described the vision and expectation to introduce electric vehicle around 200,000 electric vehicles on the road by 2020 and followed by 1 million electric vehicles by 2025 (MinistryofEAAI, 2011). However, through the experiments the electric vehicle network has been relatively increasing in the later phase.

With regard to 6 testing prototype electric vehicle, the car manufacturers were mainly dominated with Nissan, Mitsubishi, Renault and Peugeot. Together with the energy suppliers such as Nuon, Essent, Alliander and mobility providers such as The New Motion, the experiments were tested in several regions e.g. Amsterdam, Rotterdam, The Hague, and Utrecht. Concurrently, related to the other 6 research and designed by HTAS, several incumbents e.g. TomTom, NXP semiconductor, Logica, Technolution were promoting collaboration projects with several research institutes or universities e.g. TUD, TU/e, and UT to develop new developments (products or services) within the Dutch electric vehicle innovation system.

The grid operators have established a foundation to stimulate the charging infrastructure. This foundation ‘Stichting E-laad.nl’ is focused in the consequences for the electricity grid when EVs are charged. The foundation also provided charging points to the EV users and municipalities. In additional, 25 Dutch companies and governmental organizations have formed a consortium (DC-TEC) for a tender of 3000 EVs. By joining their demand, prices can drop and a market can be created. The vehicles should compete with ICE cars concerning total cost of ownership, load capacity, load volume and acceleration. The driving range has to be between 100 and 150 kilometres.

From the existing network it can be seen that part of the network has been continuing in the development of electric vehicles. As the mobility was increasing, the new smart mobility program organized by HTAS was influencing the new vision of the Formula E-Team, which was created to bring solutions for the congestion reduction and increasing safety of using ICT, sensor, and communication systems. Hence, in this part several new actors from Dutch ICT sector were included in the project of electric vehicle technology.

The trend shows that several new Small Medium Enterprises (SMEs) e.g. The New Motion, EV-Box, Mister Green, SAM, Technolution, Clifford, and ABB Epyon (before it was Epyon), etc were included in several EV pilot projects. These start-ups are mostly the success products from the University spin-off. Together with the current incumbent or existing firms, research institutes and Government, they completed the current electric vehicle network. In the following the network formation from the investigated EV pilot projects is illustrated:
Furthermore, in every region the network was formed among various key stakeholders: local authorities, electricity companies, charging station manufacturers and car manufacturers. In the Netherlands, the most activities on the EV development are located in Amsterdam. Comparing to other cities in the Netherlands and Europe, Amsterdam was considered as the leader in charging infrastructure development. However, through the experiments it was recognized that other regions were also catching up in term of EV development. Therefore, it is expected that the experience that was gained in Amsterdam can be applied or implemented in other regions. In the following figure the network formation in charging infrastructure in Amsterdam region is illustrated as follows.

**Figure 31: The network formation from the investigated EV pilot projects**

**Legends:**

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>🍑</td>
<td>This symbol represents the name of pilot project</td>
</tr>
<tr>
<td>🌈</td>
<td>This symbol represents the Government</td>
</tr>
<tr>
<td>🚩</td>
<td>This symbol represents the Research Institutes category</td>
</tr>
<tr>
<td>🏖️</td>
<td>This symbol represents the Firm category</td>
</tr>
<tr>
<td>🌿</td>
<td>This symbol represents the Network organization</td>
</tr>
</tbody>
</table>

**Table 9: The legend of figure 31**
Dutch electric vehicle innovation system

Figure 32: The network for EV charging infrastructure in Amsterdam

From the above figure on the charging infrastructure development Nuon, Amsterdam Electrisch, The New Motion, and Allander represent the actors which have the largest influences on the network.

4.3 Learning processes
The ultimate niche process of the SNM approach comprises various types of learning processes that are involved during the development of the EV. The interaction between different actors and various niche experiments concludes in a better understanding about the technology and its implications on the society (Raven, 2005).

In the earlier phase, the learning process from previous EV pilot projects was mainly dominated by the first-order electric vehicle technical components such as battery technology, drive train, and economic learning with limited consideration on potential of large number of ICT firms involving in the electric vehicle technology development. Hence, the focus was efficiently exploiting on the current knowledge or optimising the existing practices for solving the current technological barriers.

In the later phase as the inter-firm alliances and networks were growing gradually, the second-order of learning was achieved through an interaction of those new networks. The new network formation involving ICT firms was able to change the value and belief of the current system. A concrete example, due to lack of charging infrastructures and inferior battery technology, involving new parties such as electricity, services, and ICT companies were able to reduce the barriers. In this situation, the interaction between those actors stimulated the second-order learning in which firms developed and innovated the new knowledge.

Learning was well organized via HTAS and NL Agency on behalf of Dutch Ministry of Economic Affairs, Agriculture, and Innovation under Formula E-team project, through various research programs and intensive participation on the parts of automotive industry, government, research institutes, and lead users. The whole learning process resulted in a large amount of knowledge on the electric vehicle technology development. Although it did not yet result in a dominant design, the learning can be still considered successful since it produced the new knowledge and new network formations that were useful for further electric vehicle development.
4.4 Chapter summary

This chapter explained the summary of analysis based on the investigated pilot projects by applying the Strategic Niche Management (SNM) analytical framework. Dynamic expectation, network formation, and the learning process were used as the main indicators to analyze the available EV pilot projects. The details of each investigated pilot projects are described in Appendix C.

As a part of development phase in the innovation process, this chapter was able to indicate that the integration of ICT within the Dutch electric vehicle innovation system could become a solution to withdrawn the main barriers such as inferior battery technology, range anxiety, and affordable electric vehicle. As a result, this chapter became a direct input to the next chapter to describe the potential products or services. In the following figure the current stand of this chapter is illustrated as follows.

![Figure 33: Current stand for chapter 4 in innovation process](image)

The Formula E-team program consists of 9 pilot projects for testing the prototype of electric vehicles and 15 pilot projects for research and designed by HTAS. Among those pilot projects, this study focused on 12 most relevant EV pilot projects. The selected procedure was performed with input from NL Agency. As a result, the selected pilot projects were including Prestige GreenCab, Greenwheels, Amsterdam Electrics, Rotterdam Electrics, Electropool Haaglanden, CityShopper, Connected Cruise Control (CCC), 360 EVT - eVehicle Battery Monitoring en Control System, Dabox, Electrical Vehicles Intelligently Directed By E-aware Navigation Technology (EVIDENT), Innovation in the power train for EV, and Logica project.

Conclusion from the investigated pilot experiments, the Dutch EV niches development was developed well. This could be seen as the expectation or vision and network formation were dynamically improving compare with the prior development. As a result, the ICT developments and ICT firms were recognized as an important aspect for the success of further electric vehicle development. In other words, through the experiments it was aware that the Dutch ICT sector could play an important role in the forthcoming development. Further, it was aware that the investigated pilot projects could be indicated as a potential products or services which will be covered in the next chapter.

In the earlier phase, the network was rather small consists of lead user, technology suppliers, government, established firms, and research institutes from automotive sector and energy sector but
along the time this has been increasing gradually. A fact shows that in the last development several ICT firms were involving in the various pilot projects.

Finally, the learning process was identified by the first-order learning and the second-order learning. The first-order learning was achieved by optimising the existing practices. The developments were focusing on the improvement of the current technological barriers e.g. inferior battery technology and power train. However, in the later phase the second-order learning was achieved as the inter-firm alliances and networks were growing gradually, the new expected value was able to change the goals or vision of the existing one. In this case, involving an ICT sector within the forthcoming electric vehicle development will slightly bring a new opportunity for the country.
5. Promising developments (products or services)

Based on the analysis done in the previous chapter, the trend indicates a shift towards the integration of ICT development within the Dutch EV innovation systems. According to the Vice-President of the European Commission, Neelie Kroes, (2010) “electric vehicles are where ICT and green cars truly meet”. Here, the automotive industry and ICT industry should stand side-by-side (EuropeanCommission, 2011b).

This chapter answers the third sub-questions of this study: What are the promising developments that contribute to the Dutch EV innovation system? What makes these developments unique or attractive? In order to successfully answer these sub-questions, this study uses a prior study made by D-incert combine with the investigated EV pilot projects. Further, since the importance of ICT development is recognized appropriately by HTAS and D-incert, the scope of this study limits to potential developments (products or services) which are only related to the ICT development.

Section 5.1 starts describing the enabling role of ICT. Next, section 5.2 explains the potential products or services. Section 5.3 discusses the value assessment and finally section 5.4 concludes this chapter.

In the following figure the research process and where chapter 5 fits in are given on the blue color.

![Figure 34: The research process and where chapter 5 fits in](image)

5.1 The enabling role of ICT

An important role of ICT in the form of electrics and electronics within automotive industry has been recognized for many years (Fortiss, 2012). The ICT has been developed for improving the car performance, comfortless, and safety aspect. According to research done by Fortiss, up to now the ICT development has been contributed for around 30 to 40 percent of total value added in overall automotive construction (Fortiss, 2012). Along with the growing electric vehicle demand the percentage is estimated to increase since the ICT can involve in various innovation areas e.g. integrated electric mobility, connected electric vehicle, smart grid, battery management, fit-for-use...
drive train, sustainable energy network, and sustainable battery (D-incert, 2011). Hence, the ICT development can be recognized as the backbone of the total concept of EV innovation system (Fortiss, 2012). The following figure shows the role of ICT in the EV development.

![Figure 35: The enabling role of ICT for electric vehicle (D-incert, 2011)](image)

Further, according to Gereon Meyer (2011) the enabling role of the ICT within electric vehicle development can be summarized by:

- Enhancing efficiency of power and energy routing among internal technology components within the vehicle e.g. integration between battery packs, electro-motors, and grids;
- Controlling and monitoring the power electronic converters to electric-motors and wheel;
- Actively enhancing the safety aspects;
- Assisting the driver for the availability of energy and power of the vehicle.

### 5.2 The potential products or services

In this section the potential developments (products or services) are identified. Since this study is in the setting of the Dutch environment, the potential developments are selected in the context of Dutch EV innovation system. The selection is performed by combining the prior study from D-incert with the investigated EV pilot projects from the earlier chapter 4. As a result, eight potential products or services are selected: future power train, Battery Information Interface (BII), Battery Management System (BMS), Driver Guidance System (DGS), smart charging, financial services, payment services, and mobility services.

With regard to the existing pilot project one can conclude that in the most cases the potential products or services are usually appeared from the experiments in the niche development. In the following table the correlation between the existing pilot projects and the potential products or services is given as follows.

<table>
<thead>
<tr>
<th>Existing pilot projects</th>
<th>Project Leader</th>
<th>Potential Products or Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation in the power-train for EV</td>
<td>All Green Vehicles</td>
<td>Future power train</td>
</tr>
<tr>
<td>360 EVT</td>
<td>Sycada</td>
<td>Driver support tools and BII</td>
</tr>
<tr>
<td>Dabox</td>
<td>MisterGreen</td>
<td>Battery Management System (BMS)</td>
</tr>
<tr>
<td>EVIDENT, Prestige GreenCab</td>
<td>TomTom, Prestige GreenCab</td>
<td>Driver Guidance System (DGS)</td>
</tr>
<tr>
<td>Logica (CiMS)</td>
<td>Logica</td>
<td>Smart charging development</td>
</tr>
<tr>
<td>Connected Cruise Control, EVIDENT</td>
<td>TU Delft, TomTom</td>
<td>Mobility services</td>
</tr>
</tbody>
</table>

Table 10: The existing pilot project and the potential products or services
In the following paragraphs each of potential products or services is briefly described as follows.

**Future power train** - In future power trains, lots of improvements can be developed to make the power train more compact, cleaner, lighter and cheaper. Focusing on the improvement of technology components such as integrated power train with energy management system might be beneficial for the future electric vehicle.

**Battery Information Interface (BII)** - This is a product (software) or service which can give an overview of important information about the battery conditions. The technology developments within this BII can include the control and power conditioning system, the battery storage, and the range. Herein, the focus is on the human-battery interaction.

**Battery Management System (BMS)** – This is a product (software and micro-electronics) or service which is integrated inside the battery cell or battery pack. This BMS provides solution for the optimalization of the battery usage by estimating real time data information, providing longer battery lifetime, improving battery lifecycle and creating a second-life battery. In other words, the efficiency (range), the durability, the cost structure of an electric vehicle is directly influenced by this BMS development.

**Driver Guidance System (DGS)** – This is a product (software) or service which provides necessary information about the availability of charging points including time and place. This product or service is integrated with the routing plan, navigation system, and the driving behaviour of the user. Further, this DGS can also be integrated to other services such as mobile services and infotainment.

**Smart Charging** – This is a product or service which can provide ease of use, reliable, and secure charging infrastructure. This smart charging can be built on the road, parking place, house, and other public places.

**Financial services** – This is a financial service which can support a new business model for the battery-packs investment, charging infrastructure, local smart grids, and lease mobility model.

**Payment service** – This is a service which is related to the transaction (payment) process at the charging station. This payment service should deliver a reliable and a simple payment process. For example: payment to the charging station can be done by applying a subscription model or simply include the charging price inside the lease price. Further, another possibility is that this payment service can also apply for mobile payment service.

**Mobility services** - This is a service which delivers an integrated solution with other alternative transportsations e.g. trams, bus, and train, and with other public places e.g. parking place, restaurant, and office building. Hence, this mobility services can provide a sustainable solution for the whole mobility demands in the future.

### 5.3 Value assessment

After the potential products or services are identified, this section performs the value assessment. The aim of this value assessment is to determine the value proposition of each potential products or services. As a consequence, the result from this value assessment can be used as an input for answering the business strategy or business model in the later chapter. This value assessment is divided into three main steps. In the following paragraphs each of them is described as follows.
First step

In the first step, the value assessment is presented in the matrix table which consists of the previous findings, named the potential innovation development areas and the potential products or services. The possible innovation developments of electric vehicle in the Netherlands, as it is mentioned in chapter 3, are divided into nine areas: integrated electric mobility, affordable electric vehicle, connected electric vehicle, smart grids, battery management, fit-for-use drive train, secure electric vehicle, sustainable energy network, and sustainable battery.

From the previous section, the potential products or services are identified: future power train, Battery Information Interface (BII), Battery Management System (BMS), Driver Guidance System (DGS), smart charging, financial services, payment services, and mobility services. In the following matrix table the findings are presented including its relevancy.

<table>
<thead>
<tr>
<th>Innovation development areas</th>
<th>Potential products or services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated electric mobility</td>
<td>Future power train</td>
</tr>
<tr>
<td></td>
<td>Battery Information Interface (BII)</td>
</tr>
<tr>
<td></td>
<td>Battery Management System (BMS)</td>
</tr>
<tr>
<td></td>
<td>Driver Guidance System (DGS)</td>
</tr>
<tr>
<td>Affordable electric vehicle</td>
<td>Smart charging</td>
</tr>
<tr>
<td>Connected electric vehicle</td>
<td>Financial services</td>
</tr>
<tr>
<td>Smart grids</td>
<td>Payment services</td>
</tr>
<tr>
<td>Battery management</td>
<td>Mobility services</td>
</tr>
<tr>
<td>Fit-for-use drive train</td>
<td>xx</td>
</tr>
<tr>
<td>Secure electric vehicle</td>
<td>xx</td>
</tr>
<tr>
<td>Sustainable energy network</td>
<td>x</td>
</tr>
<tr>
<td>Sustainable battery</td>
<td>x</td>
</tr>
</tbody>
</table>

Table 11: Potential developments in relation with innovation areas (D-ncert, 2012)

From the table above all potential products or services are identified as short-term opportunities (D-ncert, 2012). It means that all the potential products or services are promising to be developed less than 5 years from now. The “X” indicates a low relevancy to the given innovation development areas while the “XX” shows the strong relevancy to the given innovation development areas.

One may argue that in the connected electric vehicle innovation development area, there is a strong relevancy with products or services including Battery Information Interface (BII), Battery Management System (BMS), Driver Guidance System (DGS), and smart charging. In this innovation area, ICT will have a significant role implementing for example the intelligence driver guidance assistant system inside the electric vehicle, the end-user or electric vehicle customer can intelligently communicate with its environment such as charging point, and parking places. Hence, one may also conclude that those mentioned products are having strong...
relevancy in the smart grid innovation development area (presented in blue colour). As a result, with the integration of new ICT development, communication from vehicle to its environment and vehicle to vehicle can be improved significantly.

**Second step**

In the second step, the value assessment continues with the evaluation of each potential products or services by applying several criteria: market size, competition, resources, and integration. All of these criteria are derived from D-incert prior study by applying the value net framework of Brandenburger and Nalebuff (1995) and Ortt & Delgoshae strategy toward large scale diffusion model as it is mentioned in chapter 2.

First, the value net framework is extended from the Porter’s five force models by focusing on the profits or opportunities enhancing factor: a mixture of competition and cooperation (coopetition). Second, the Ortt and Delgoshae’s model forms five categories of factors, named the product, the system of complementary products or services around it, suppliers and producers, customers, and the institutional arrangements. The combination of these two models results in the criteria that are applied to evaluate the potential products or services. The following table explains each of those criteria including the score.

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td><strong>Market size</strong>&lt;br&gt; Limited market size in terms of employments (FTE). Cluster region is not available yet. Limited or no export potential but expected to grow. Products or services are in the pre-development phase in the product life cycle.</td>
</tr>
<tr>
<td>+</td>
<td><strong>Market size</strong>&lt;br&gt; Average market size (&gt;20 FTE). Cluster region is on the development phase. Small export potential but expected to grow. Products or services are in the development phase in the product life cycle.</td>
</tr>
</tbody>
</table>
Dutch electric vehicle innovation system

| ++ | Huge market size. Cluster region is available. Part of the turnover is on the export potential. Strong domestic demand. Products or services are in the take-off or acceleration phase in the product life cycle. |
| ++ | Tight competition to maintain the top position. Products or services are not easy to be substituted. Possible for maintaining the niche market. |
| ++ | Available raw material, suppliers, knowledge or science, and investment capital are proposing uniqueness to the Netherlands. |
| ++ | Fully integrated with other EV developments as well as with the Dutch economy. Strong synergy and collaboration with other EV developments. |

Table 12: The criteria (D-incert, 2012)

Third step

In the third step, each of potential products or services is evaluated by applying the above criteria. Detail evaluation results of each products or services can be found in Appendix D. The following table shows the score matrix of potential products or services.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Future power train</th>
<th>Battery Information Interface (Bill)</th>
<th>Battery Management System (BMS)</th>
<th>Driver Guidance System (DGS)</th>
<th>Smart charging</th>
<th>Financial services</th>
<th>Payment services</th>
<th>Mobility services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market Size</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Competition</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Resources</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Integration</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 13: The score matrix of potential products or services (D-incert, 2012)

5.4 Chapter summary

This chapter described an important role of ICT development within the Dutch electric vehicle innovation system. The ICT functions as an enabler in various innovation development areas such as integrated electric mobility, connected electric vehicle, smart grid, battery management, fit-for-use drive train, sustainable energy network, and sustainable battery. Relate to these potential ICT developments, the Dutch industry has the opportunities to boast its automotive industry by involving the ICT sector in the EV developments. Verification of this can be found in the prior study made by D-incert and HTAS.

Combining the automotive sector with the ICT sector creates a “unique” identity for the Netherlands. Regarding to the Dutch ICT sector, the Netherlands has its competitive advantages since the country is a leader software producer’s country in Europe and has lots of supporting factors e.g. talented labour, advanced knowledge, lots of ICT firms, good ICT infrastructure, and the government supports (Atzema and Visser, 2002). In light with its competencies, the Dutch industry can thus compete internationally and maintain its sustainable competitiveness.
In the current EV introduction the ICT can provide solutions for major barriers by enhancing efficiency of power and energy routing among internal technology components within the vehicle e.g. integration between battery packs, electro-motors and grids, by controlling and monitoring the power electronic converters to electric-motors and wheel, by actively enhancing the safety aspects, and by assisting the driver for the availability of energy and power of the vehicle. In other words, the ICT can be seen as the backbone of the total concept EV innovation system by providing efficiency internally within the vehicle and externally by enhancing communication with other vehicles and its infrastructure.

From the technology perspective, it is known that the current EV is not perfect yet. The focus on the technology development is needed to divide it into two parts, named the short-cycle element and long-cycle element. In the long-cycle element one can consider the development on battery development while in the short-cycle element; the ICT can play a significant role. All kinds of ICT developments inside EV can help to solve the current technology barriers e.g. related to the battery barrier the ICT can solve it by implementing a battery management system and smarter navigation systems. The short-cycle element can also give an influence to the user adoption and markets since it can bring some “surprise effect” to the user e.g. the new EV can use digital keys via mobile phone. Hence, it is wise to promote the collaboration between ICT and EV industry for the electric vehicle development.

In this chapter the potential products or services were identified: Future power-train, Battery Information Interface (BII), Battery Management System (BMS), Driver Guidance System (DGS), smart charging, financial services, payment services, and mobility services. Each of them was recognized as short-term opportunities. Further, in order to evaluate properly, this chapter performed the value assessment which explained the value proposition of each potential products or services. As a result, this chapter was able to suggest various products or services to be introduced to the market. If one look at the whole innovation process that was described in the theoretical background, chapter 2, the following figure shows the current stand for this chapter.

The limitation that can be found in this chapter is that even though the potential products or services are identified properly, several challenges are still appeared: immediate potential developments and the business model. Therefore in the next chapter, this research study will conduct field analysis to validate the previous findings and to gain some extra knowledge accordingly.
6. Field analysis or expert consultation

An important aspect of the success or failure of a new technology is depending on the support from its environment. Hence, the promising developments are examined by several expertise or key actors which are currently involved in Dutch electric vehicle innovation system. Followed from the previous chapter, the scope of this chapter limits to potential candidates which are related to the EV - ICT development.

This chapter describes a validation process from the previous findings by conducting several interview sessions with several expertise or key actors. Accordingly, this chapter answers the fourth sub-questions of this research study: How does the current Dutch EV innovation system examine the promising developments? Which are the real opportunities for the Netherlands in the short-time? As a result, this chapter provides a valuable input for finding a proper business strategy or business model.

This chapter is structured as follows. Section 6.1 explains the procedure for the interview. Section 6.2 describes the conceptual model. Section 6.3 gives the interview results and analysis. And lastly, section 6.4 concludes this chapter. In the following the research process and where chapter 6 fits in are illustrated. The blue color represents the current stands of this chapter.

6.1 Procedure for the interview

This section consists of the basic procedure that is used to prepare the interview session. Hence, this section explains sampling process, interview questions, and procedure of data collection including reliability and validity, and data collection process. In the following paragraphs each of them is discussed as follows:
6.1.1 Sampling process

The sampling can be defined as a process of selecting sufficient number of right element from the population (Sekaran and Bougie, 2009). This sampling process is important since selecting a proper sample affects the result of this study. Concurrently, this research follows the concept of saturation as guiding principle during the data collection.

The target population of this research study is the expertise or key actors that are involved in the Dutch electric vehicle innovation system. The sample size of this study presents 21 different companies or organizations. NL agency and Delft University of Technology are confirmed that this amount is sufficient representation of all important stakeholders for the Dutch EV development. In the following the selection process of the candidates is explained.

**Step 1: Selecting the category**

In the first step, the selection on the categories is performed. The category is divided into three, named Government, Firm or Organization, and Research. These categories are selected based on the earlier concept of system of innovation as important elements for the success of Dutch EV innovation systems.

**Step 2: Selecting the company or the organization**

In the second step, the selection of companies is performed. The companies are selected based on the relevancy to the potential developments. This confirms to the earlier investigated EV pilot projects as well as the prior study of D-incert and HTAS. Accordingly, the inputs from several organizations, named NL Agency, HTAS, and D-incert are incorporated. In the following table, the list of selected companies or organizations is given.

<table>
<thead>
<tr>
<th>Category</th>
<th>Company or Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>NL Agency</td>
</tr>
<tr>
<td></td>
<td>Automotive NL</td>
</tr>
<tr>
<td></td>
<td>E-laad.nl</td>
</tr>
<tr>
<td>Firm or Organization</td>
<td>ABB Epyon</td>
</tr>
<tr>
<td></td>
<td>Better Place</td>
</tr>
<tr>
<td></td>
<td>Drive Train Innovations</td>
</tr>
<tr>
<td></td>
<td>EVConsult</td>
</tr>
<tr>
<td></td>
<td>Innopay</td>
</tr>
<tr>
<td></td>
<td>KEMA</td>
</tr>
<tr>
<td></td>
<td>Logica</td>
</tr>
<tr>
<td></td>
<td>MisterGreen</td>
</tr>
<tr>
<td></td>
<td>Navteq</td>
</tr>
<tr>
<td></td>
<td>NXP Semiconductor</td>
</tr>
<tr>
<td></td>
<td>Prestige GreenCab</td>
</tr>
<tr>
<td></td>
<td>Sycada</td>
</tr>
<tr>
<td></td>
<td>Syntens</td>
</tr>
<tr>
<td></td>
<td>TomTom</td>
</tr>
<tr>
<td></td>
<td>Ubiqu Access</td>
</tr>
<tr>
<td>Research</td>
<td>Delft University of Technology</td>
</tr>
<tr>
<td></td>
<td>Eindhoven University of Technology</td>
</tr>
<tr>
<td></td>
<td>TNO</td>
</tr>
</tbody>
</table>

Table 14: List of selected companies or organizations
**Step 3: Candidate profile**

Once the companies are selected, a list of potential candidates is prepared. Similar with the previous step, with the inputs of NL Agency, HTAS, and D-incert, the potential candidates are selected. The interviewee candidates should meet the following characteristics:

- They should have good knowledge about the Dutch electric vehicle market;
- They should familiar with electric vehicle technology development and preferable with ICT technology development;
- They should have decision making power or have consultant role within the company;
- They should have or work at least on a higher educational level.

As a result the following table shows the list of candidates including its company and its function.

<table>
<thead>
<tr>
<th>Category</th>
<th>Company or Organization</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>NL Agency</td>
<td>Advisor Electric Vehicle</td>
</tr>
<tr>
<td></td>
<td>Automotive NL</td>
<td>Manager Innovation</td>
</tr>
<tr>
<td></td>
<td>E-laad.nl</td>
<td>Manager Technique E-laad</td>
</tr>
<tr>
<td>Firm or organization</td>
<td>ABB Epyon</td>
<td>VP Business Development</td>
</tr>
<tr>
<td></td>
<td>Better Place</td>
<td>Country Program Integrator</td>
</tr>
<tr>
<td></td>
<td>Drive Train Innovations</td>
<td>Director or Owner</td>
</tr>
<tr>
<td></td>
<td>EVConsult</td>
<td>Owner</td>
</tr>
<tr>
<td></td>
<td>Innopay</td>
<td>Director</td>
</tr>
<tr>
<td></td>
<td>KEMA</td>
<td>Project Manager</td>
</tr>
<tr>
<td></td>
<td>Logica</td>
<td>Managing Consultant Smart Energy</td>
</tr>
<tr>
<td></td>
<td>MisterGreen</td>
<td>Co-founder MisterGreen</td>
</tr>
<tr>
<td></td>
<td>Navteq</td>
<td>Director Marketing ADAS</td>
</tr>
<tr>
<td></td>
<td>NXP Semiconductor</td>
<td>Manager New Business</td>
</tr>
<tr>
<td></td>
<td>Prestige GreenCab</td>
<td>Strategic Project Manager</td>
</tr>
<tr>
<td></td>
<td>Sycada</td>
<td>Managing Director</td>
</tr>
<tr>
<td></td>
<td>Syntens</td>
<td>Innovation &amp; Network Consultant</td>
</tr>
<tr>
<td></td>
<td>TomTom</td>
<td>Advance Development Manager</td>
</tr>
<tr>
<td></td>
<td>Ubiqu Access</td>
<td>CEO</td>
</tr>
<tr>
<td>Research</td>
<td>Delft University of Technology</td>
<td>Chairs Transport &amp; Planning section</td>
</tr>
<tr>
<td></td>
<td>Eindhoven University of Technology</td>
<td>Chairs the Dynamics &amp; Control section</td>
</tr>
<tr>
<td></td>
<td>TNO</td>
<td>Business Development</td>
</tr>
</tbody>
</table>

Table 15: List of candidates including the company and the function

**6.1.2 Interview questions**

The goals of conducting the interview session are to validate the previous findings and to gain additional information for developing the business model or business strategy. Therefore, the interview questions are made to meet these main objectives. The interview questions are constructed in three different themes. In the following paragraphs each of them is described as follows:

- First theme is related to the vision and expectation – Most of the questions are aiming to know on how one perceived the future electric vehicle in the Netherlands.
- Second theme is related to the potential developments (products or services) – In this part the main goal is to validate the previous findings related to the barriers and potential
developments. As a result, the actors should be able to mention some real opportunities for the Netherlands.

- Third theme is related to the Business Strategy or Business Models – In this part most of the questions are made to gain additional information the Business Strategy or Business Models for the real potential developments.

The detail of the interview questions is presented in Appendix E.

6.1.3 Procedure of data collection
In this research design, the reliability is achieved by demonstrating the operation of the study including the data collection procedure repeatability and end-up with the same results (Yin, 2009). In other words, if in the future a later researcher will conduct the same research design and procedure, the research findings or conclusion should arrive at the same results. The reliability of the interview session is evaluated and guaranteed by considering the following aspect:

- Testing the interview is performed prior to the real interview session with several people within NL Agency. This test aims to indicate the quality of the research questions and to test the repeatability aspects.

The validity of this research study is achieved by considering three different aspects. Each of them is explained as follows:

- The interview questions are designed on the basis of the theoretical background;
- Research questions are reviewed by Delft University of Technology professors and NL Agency;
- The list of interviewees are made based on an extensive selection procedure and inputs from D-incert, HTAS, and NL agency which can guarantee the validity of the answers given from the interviewees.

6.1.4 Data collection process
In this part, the whole process of the interview is explained. After identifying the research questions and the selected candidates, the preparation of the interview were made. It started with creating an interview protocol and a standard invitation letter. The details of these two documents can be found in Appendix E.

Next step is to approach the respondent; asking for their willingness to be interviewed. Here, the interview protocol and the invitation letter were sent to the interviewee candidates. Once the interviewee candidates agreed to participate in the study, the date and time for the meetings was set to be scheduled as agreed between both parties. Most of the interview was done within one hour and mostly conducted at the interviewee’s office. In the following the interview program is given.

<table>
<thead>
<tr>
<th>Number</th>
<th>Step description</th>
<th>Step content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>Introducing each party.</td>
</tr>
<tr>
<td>2</td>
<td>Explanation</td>
<td>Explaining the research content, the goal, and the duration of the interview.</td>
</tr>
<tr>
<td>3</td>
<td>Building trust</td>
<td>Explaining the secrecy of the answers e.g. probability of using the voice recorder, the confidential of the</td>
</tr>
</tbody>
</table>
Dutch electric vehicle innovation system

<table>
<thead>
<tr>
<th></th>
<th>Information, and the result of this research.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Executing questions Starting the discussion by executing each of interview questions.</td>
</tr>
<tr>
<td>5</td>
<td>Conclusion Conclude the interview session and evaluate the answer e.g. completeness, relevance, and validity.</td>
</tr>
<tr>
<td>6</td>
<td>Close Thank the interviewee.</td>
</tr>
</tbody>
</table>

Table 16: The interview program

6.2 Conceptual model

This section describes the conceptual model that is used to conduct the interview. In this conceptual model, several properties, which could be related to the core concept, are identified. Most of the properties are coming from the earlier context analysis about Dutch electric vehicle innovation system on chapter 3, the porter’s five forces, and the business model in its environment as it is described by Osterwalder (2010). As a result, the properties including its short descriptions are listed below.

**Company’s or Organization’s contribution** - The contribution of each company or organization to the EV development is diverse. Most likely it is related to the type of organization or its core business.

**Future perspectives** – The opinions about future perspective of Dutch automotive industry and Dutch ICT industry could show some interesting indicators for measuring the alignment of perspectives of organizations in the introduction of the electric vehicles in the Netherlands.

**Electric vehicle advantages** - The advantage of electric vehicle indicates the role of electric vehicles for the introduction sustainable transportation in the Netherlands.

**Barriers** – The current barrier in EV development might also indicate the opportunity for companies to produce potential developments or solutions. Generally, the main concern is on the battery technology. However, in practice it can also relate to other barriers such as lack of infrastructure, lack of market, lack of service, and high price of electric vehicle.

**Potential developments** – In the current EV development, there are many potential developments such as future power-train, Battery Information Interface (BII), Battery Management System (BMS), Connected Cruise Control (CCC), Driver Guidance System (DGS), smart grids, smart charging, financial services, payment services, and mobility services. Given the mentioned potential developments, it could be interesting to investigate other potential developments.

**Opportunities** – The number of potential developments (products or services) indicates the opportunities for the Netherlands. Nevertheless, it would be interesting to distinguish the short-term and long-term opportunities.

**Actors** – The actors are a central role for the product or service development. Hence, it is interesting to discover who are the companies or organizations that may have an important role for each potential development. This should also include the end user and university or public institutes.

**The market** – Investigating the market might help to investigate whether the potential products or services are attractive to be developed. This might lead to increase or decrease the number of companies who want to invest.
Support from the industry - The industry force looks at various indicators such as the availability of resources, supplier, competitors and substitutes. Hence, the industry support might influence the motivation for developing the products or services. For example: if there is enough material resources and knowledge in the Netherlands, one can develop battery technology.

Support from the Government – Since the EV market is considered as a niche market, the government support will play an important role. However, the challenge remains in which type of supports can be expected to be involved?

Once the properties are identified properly, each property is categorized into three themes: Vision and Expectations, Developments (products or services), and Business Models. The categorization is displayed in the figure below:

![Diagram of properties categorization of electric vehicle development](image)

**Figure 38: Properties categorization of electric vehicle development**

In the following figure, the relationship between properties is illustrated. The aim is to see the influence between properties that might have influence each other. Among 10 properties, which are mentioned before, there are in total 12 clear relationships: 9 bidirectional relationships, 2 one-sided relationships, and 1 multiplicative relationship.
In the following paragraphs each of them is described as follows with the reference of figure 39:

1. **Future Perspective : Actor & Contribution** – A bidirectional relationship that represents the vision and expectation. It is probable that the actor’s perception about the future of Dutch EV industry will influence the actor activities. Hence, with its various resources, the contribution of each company or organization to the EV development may be varying.

2. **Actor & Contribution : Market** – A bidirectional relationship that shows the company’s or organization’s contribution might have a significant influence to the growth of EV market and vice versa. Changing in the market might also have influence to the company’s or organization’s contribution.

3. **Actor & Contribution : Products or Services** – A bidirectional relationship that indicates the contribution of an organization or a company to the EV development might result in new products or services. Simultaneously, the improvement of new products or services may significantly influence the contribution of company or organization for EV development.

4. **Products or services : EV advantages** – A bidirectional relationship that represents the correlation between the products or services to EV advantages and vice versa. A new Driver Guidance System (DGS), Battery Information Interface (BII), or Battery Management System (BMS) in EV development might gain an extra advantage for the EV usage.

5. **Products or services : Market** – A bidirectional relationship that shows a product marketing cycle. The emergence of EV market influences the growing of new products or services and vice versa. Both sides are highly related each other.

6. **Industry support : Market** – A bidirectional relationship that represents the industry support can influence the emergence of the market. One may assume that the availability of capital investment, knowledge, and supplier may support the EV market transitions.
7. **Industry support**: Opportunities – A bidirectional relationship that might influence each other. Whether there is an opportunity or not, it may influence the industry support which is willing to invest on the new EV development.

8. **Barriers**: Opportunities – A bidirectional relationship. Since there are various barriers in the current EV development, the number of opportunities is growing rapidly in various development areas. Both sites are highly related each other.

9. **Opportunities**: Actor & Contribution – A bidirectional relationship which clearly shows a direct influence each other. The motivation for this relationship is similar to the Actor & Contribution: Products or Services – if there are opportunities the number of actors and their contribution may increase significantly.

10. **Barriers**: Future perspective – One-sided relationship. The existence of barriers influences the future vision and expectation of EV industry, e.g. an unsuitable battery and range anxiety reduce the expectation of future EV industry.

11. **EV advantages**: Future perspective – One-sided relationship. Similar to the previous relationship, the EV advantages have significantly influence the future vision and expectation of EV industry.

12. **Government**: All derived code – This is a multiplicative relationship. The Dutch government acts as a catalyst to increase the overall performance and create a sustainable country competitive in the EV development. Hence, the government role significantly influences the other derived properties.

6.3 **Interviews, results and analysis**

This section describes and analyses the data gathered from the interviews. The data analysis is divided into several steps. First, the interview is transcribed. Next, the words and phrases that could be relevant for the research are highlighted. When selecting the keywords, the frequency of appearance of the keywords in the transcripts is taking into account. To be noticed: during the interview session, each of the keywords was displayed in different variations and alternatives.

The respondents in general could not always formulate a perspective on specific areas e.g. future perspectives of Dutch automotive industry and Dutch ICT industry, potential products or services, and the business model. The reason is perhaps because the respondents are mainly concentrated to issues that are only related to their own expertise and their interest. In the following paragraphs, the data from the interviews are discussed and analysed for each of given properties.

**Vision and Expectation**

The vision and expectation theme is investigated by looking at 3 properties, namely the company’s or organization’s contribution, future perspectives, and the electric vehicle advantages. In the following paragraphs each of them is discussed as follows.

“There is a possibility to integrate the Dutch automotive industry and Dutch ICT industry. There is a future bright of those combinations. We can become the best supplier country in automotive industry and combine with ICT we can integrate the total solution.”
Government category

Company’s or organization’s contribution

Contribution of companies and organizations to the EV development is diverse. Nevertheless, the contribution is highly related to the type of organization and its core business. From the government category, the contribution is mainly focusing on providing network, developing various projects, supporting financial, promoting knowledge transfer, and developing regulations and policies.

Looking at the firm category, the contribution is based on its core business. Each of them is described precisely in Appendix F. Besides developing the products or services, some of the respondents mentioned that they also invest in charging infrastructure and become a lead user for electric vehicle. From the research category, most of them contribute on the technology transfer, developing various projects and knowledge supplier. In the following table the values of company’s or organization’s contribution are given.

<table>
<thead>
<tr>
<th>Category</th>
<th>Company’s or Organization’s contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Providing network, developing various projects, supporting financial, promoting knowledge transfer, developing regulation and policy.</td>
</tr>
<tr>
<td>Firm</td>
<td>Developing charging infrastructure, developing hardware and software, providing services, supplying vehicle component, supplying knowledge, supplying vehicle interface, supplying vehicle system, providing network, providing insight to the needs.</td>
</tr>
<tr>
<td>Research</td>
<td>Knowledge supplier, providing technology transfer, developing various pilot projects.</td>
</tr>
</tbody>
</table>

Table 17: The values of company’s or organization’s contribution

Future perspectives

Only a small number of respondents could give a clear perspective of future Dutch automotive industry as well as Dutch ICT industry. On contrary, a large number of respondents gave their perspective on either one of them.

Most of the respondents stated that the Dutch automotive industry and Dutch ICT industry have good opportunities to become a key role in electric vehicle development area. When looking at the current vehicle itself, the respondents mentioned that a large number of ICT developments has been involving in automotive development for many years in the form of electronics e.g. navigation system, Anti-lock Braking System (ABS), etc. For the future development the respondents believed that more and more ICT development will involve in the automotive industry.

For the Dutch automotive industry many respondents believed that the current Dutch automotive industry will stay as an important player for supplying automotive components to the OEMs or car manufacturers. This is supported by the fact that the global trend growth shifted from OEMs to suppliers especially in electronics, software and embedded systems. A fair number of respondents mentioned that the chances for the Netherlands may not be related for producing the car as well as producing the battery but rather it should be on the development of automotive components e.g. power-train and ICT development areas e.g. system within the car and system that integrates the car with its infrastructure. Specifically for the ICT part, the Netherlands has a huge potential to further develop.
For the Dutch ICT industry many respondents believed that there is a huge chance to reap the benefits of being the first mover as well as becoming an important player in the EV innovation system development. In the following table the values of future perspectives are given.

<table>
<thead>
<tr>
<th>Category</th>
<th>Dutch Automotive Industry</th>
<th>Dutch ICT industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Future bright specifically in the supplier components.</td>
<td>Future bright in the services provider.</td>
</tr>
<tr>
<td>Firm</td>
<td>Many opportunities specifically in the supplier components e.g. electrical component, power train.</td>
<td>Many opportunities specifically in the development areas e.g. communication car to car and car to infrastructure, integrating smart devices, and developing various services as well as various applications.</td>
</tr>
<tr>
<td>Research</td>
<td>Lots opportunities in the components.</td>
<td>Lots opportunities in service and application areas.</td>
</tr>
</tbody>
</table>

Table 18: The values of future perspectives

**Electric vehicle advantages**

The electric vehicle would be expected to be an improvement for the environment. The EV is clearly a beneficial as it promises higher energy efficiencies which leads to less energy use per kilometres, provides the opportunity to use any renewable energy sources e.g. solar and wind energy, reduces CO₂ emission significantly, zero noise nuisance, may solve mobility issues, and less maintenance cost. However, it was mentioned from several respondents of the interviews that the current method of calculating the contribution to the environment should be further developed to be more accurate and can be accepted among all the involved stakeholders. Another important message is regarding to the zero noise nuisance. Although it can be accepted as a beneficial aspect, it needs some adaptation to adjust with the silent car. Further, other respondents stated that in general the electric vehicle may also solve current mobility issues. The main arguments were because by introducing electric vehicle there is an opportunity to introduce car sharing or car pool especially in the green city environment.

Some respondents also discussed the topics related to the economic benefits of the electric vehicle, since the electric vehicle can generally result in a reduction of fossil fuel consumption. This would lead to decrease the dependency of oil producing countries, which could have a positive effect on the economy by lowering the demand for fossil fuels. In the following table the values of electric vehicle advantages are given.

<table>
<thead>
<tr>
<th>Category</th>
<th>Electric Vehicle Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Reduce CO₂ emissions, zero noise nuisances, opportunities to use renewable energy, higher energy efficiency, and economic benefits.</td>
</tr>
<tr>
<td>Firms</td>
<td>Environment friendly, less CO₂ emissions, zero noise nuisance, and opportunity to use sustainable energy, solving mobility issues, and economic benefits.</td>
</tr>
<tr>
<td>Researches</td>
<td>Less CO₂ emission, zero noise nuisances, may solve the mobility issues, and economic benefits.</td>
</tr>
</tbody>
</table>

Table 19: The values of electric vehicle advantages
Developments

Generally the respondents stated that the electric vehicle is not yet in the mature state. The electric vehicle still has some issues and disadvantages that should be further developed before the electric vehicle is ready for large scale adoption. However, some respondents mentioned that it is a part of innovation development process; hence every barrier can be seen as a challenge and opportunities for the electric vehicle development. In this part, the development theme is investigated by looking at 3 keywords, namely the barriers, products or services, and opportunities. Each of them is discussed in the following paragraphs.

“....every barrier can also be considered as an opportunity. Without a barrier we should have much bigger barriers that are simply the barriers that we cannot apply to the needs...So barrier is also generating some kind of basement in the whole process.”

Research category

“Dutch automotive industry and Dutch ICT industry are typically in the last couple of years very strong in the innovation part. We have been developing a number of key innovations that have been developed as strength between the industry and the knowledge centre. In this part the Netherlands has a very strong point and this should be explored further...So if it comes to build a new entire car then we are not very strong. This is more for the country like Germany or France which are very strong in this area.”

Firm category

Barriers

When looking at barriers on the current electric vehicle development, all respondents (100%) mentioned that the real main barrier is the Battery. As a consequence, the other barriers such as range of anxiety, lack of infrastructure, lack of market, lack of services, and high cost of vehicle are appeared in the current practice. Regarding to the lack of infrastructure not all of respondents stated that the lack of infrastructure is a real barrier for the introduction of electric vehicle. The general argument was because in the short-time they foreseen lots of more charging infrastructure (fast charging and slow charging) will be implemented in the Netherlands. On contrary, a smaller number of respondents stated that the lack of charging infrastructure still exists especially in the big city like Amsterdam.

With regard to the battery technology, some of the respondents stated clearly that in general there was an important need for technical change or improvement in the battery technology. Further, the size, the material, and the cost of the battery were mentioned as other issues that have to be solved in the near future. According to the respondents, the current batteries could be considered to be too large and too heavy. A number of respondents discussed that the price of the current battery packs is too high which results in higher overall costs of the current electric vehicle. Some ideas were proposed by separating the electric vehicle and the battery pack during purchase. For examples: the OEMs or car manufacturers should sell the car and lease the battery separately, or shifting the responsibility to lease company to cover these barriers towards its end-users.
The respondents mentioned that the current battery is having low durability. The situation is even worse especially when one is driving under varying service temperature (extreme weather condition) and varying usage behaviour. Other issues were mentioned by various respondents related to the lifetime of the battery and the life-cycle of the battery. Here, using the fast charging technologies, for example, for charge and recharge activity can shorten the lifetime of the battery as well as the life-cycle of the battery. Therefore, it results in a large uncertainty for the owner of the electric vehicle, Lease Company, and fleet company. Some of respondents stated that it is thus needed to monitor and study the use of the battery during its lifetime to be able to determine the durability and loss of durability and to determine its remaining value over time.

The last issue is related to the capacity of the battery. Some of the respondents stated that the current capacity of the battery is sufficient enough for supporting daily travelling needs of the users, while other respondents discussed that it should be increased significantly. For those who claim sufficient capacity generally used the argument of the practice user needs e.g. daily mobility for around 50 until 100 kilometres per day while the average range distance of electric vehicle should also be able to provide enough capacity for driving between European cities e.g. drive from Amsterdam to Paris or Brussels to Hamburg. However, the argument for an increase of capacity is often that there is a mismatch between what users need and what users think they need.

Beside the mentioned barriers, several respondents mentioned that there is a need to change to current design of the electric vehicle. They stated that there is a good opportunity to develop a vehicle that is completely different when compared to the current vehicles. In additional, other respondents stated that the electric vehicle should look like the first prototype of electric vehicle in the 1800s. Further, there were some related issues to the standardization and interoperability on the European policy. These are mainly related to some general standards which are needed for the introduction of electric vehicles in large scale adoption especially in the European market e.g. standard plug, charging infrastructure, and payment system. Finally, the safety of the current electric vehicles was also discussed by a smaller number of respondents. There is no clearly defined guideline for safety testing of electric vehicle at the present time. Hence, in the short-time there should be developed standardized safety tests for electric vehicles. In the following table the values of the barriers are given.

<table>
<thead>
<tr>
<th>Category</th>
<th>Main barriers</th>
<th>Other barriers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>Battery and total cost of electric vehicle.</td>
<td>Lack of infrastructure, lack of market, lack of services.</td>
</tr>
<tr>
<td>Firm</td>
<td>Battery and total cost of electric vehicle.</td>
<td>Lack of infrastructure, lack of market, lack of services, design of electric vehicle, standardization and interoperability on European level.</td>
</tr>
<tr>
<td>Research</td>
<td>Battery and total cost of electric vehicle.</td>
<td>Lack of market, design of electric vehicle, safety.</td>
</tr>
</tbody>
</table>

Table 20: The values of barriers

Products or services

There are a number of potential products or services which can be developed in the current electric vehicle developments. Smaller number of respondents stated that there is clear need to develop a
new battery technology. This was significantly related to the main barrier of current electric vehicle. However, a large number of respondents mentioned that there are various products or services that can be developed with regard to the ease of use and efficiency aspects. These are explicitly creating opportunities for the ICT development including several potential areas such as the communication within the vehicle components but also communication between car to car and car to infrastructure.

“In the certain niche market for electric vehicle you have two distinguishes categories: the SMEs such as Gemco Truck and Sycada, and the incumbents such as NXP and TomTom. The incumbent players can still be mainstream suppliers for the basic components while the SMEs have to provide the mobility solution like in taxi transport or public transport and to solve the mobility problems for urban areas. I believe the more you can offer a system solution the more short time you can reach the business... Let’s look at the mobility and the integration of infrastructure.”

Government category

With regard to the new breakthrough battery technology development, a number of respondents were pessimistic. A small number of respondents made comparison between the battery development and electronics by looking at the Moore’s Law: “the number of transistors on integrated circuits doubles approximately every two years”. Here, it was clearly mentioned that the Moore’s law is hardly apply for the battery development.

Further, there were lots of discussions about the charging part of electric vehicles as well as smart grids. A large number of respondents mentioned that it is difficult to find a sound business model for smart charging and smart grids while a number of respondents stated that the smart charging has a short-term potential for the Netherlands. For those who claims smart-charging as a short-term potential is mainly used an argument that the market of smart-charging indicates a positive trend in EV charging market and within smart-charging there are lots of ICT development which is not discovered yet. In the following table several products or services including possible functionalities and applications, which were mentioned during the interview, are given as follows:

<table>
<thead>
<tr>
<th>Products or services</th>
<th>Functionalities and Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery Information Interface (BII)</td>
<td>Driver supporting tools, overview battery condition</td>
</tr>
<tr>
<td>Battery Management System (BMS)</td>
<td>Battery monitoring system, control system.</td>
</tr>
<tr>
<td>Connected Cruise Control (CCC)</td>
<td>Control and advice the best speed, headway and lane to the driver, connected car system</td>
</tr>
<tr>
<td>Driver Guidance System (DGS)</td>
<td>Telematic, navigation system, real-time range estimator, route planning (driver coaching) applications, availability and, road information, weather or temperature information, map service provision.</td>
</tr>
<tr>
<td>Financial services</td>
<td>Financial support on the battery-pack investment, charging infrastructure, local smart-grids, and lease mobility model.</td>
</tr>
<tr>
<td>Future power-train</td>
<td>Electronics components, sensor, communication between components, integrated circuits for infotainment e.g. car radio.</td>
</tr>
<tr>
<td>Payment services</td>
<td>Safe and reliable payment system, paying online and offline, card systems or mobile phone payments.</td>
</tr>
<tr>
<td>Re-use and recycling the battery</td>
<td>Second life product, end of life and recycling.</td>
</tr>
<tr>
<td>Smart Charging</td>
<td>Home charging, status charging point, interoperability register system, fast charging, central back-office of charging station, smart charging algorithm, open charging communication protocols, manage and</td>
</tr>
</tbody>
</table>
Dutch electric vehicle innovation system

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Grids</td>
<td>Monitoring system of the usage of energy, demand site planning system, grid connections, control system.</td>
</tr>
<tr>
<td>Mobility services</td>
<td>Integrated application with public transports, car-sharing programs.</td>
</tr>
<tr>
<td>Combination of all products or services as a testing ground country</td>
<td>EV knowledge country (testing ground).</td>
</tr>
<tr>
<td>Others</td>
<td>Smart appliances or smart devices, smart working, application which can detect the car existence, application which distinguishes various type of charging e.g. fast charging, slow charging, battery exchange, application which can control the energy use for Plug-in Hybrid (PHEV), applications which can give overview of electricity availability and electric bicycle or electric scooter.</td>
</tr>
</tbody>
</table>

Table 21: The values of products or services including possible functionalities and applications

Opportunities

As numbers of barriers, and potential products or services were discovered during the interview, there were various real opportunities for the Netherlands that were discussed. However, as it is expected, when it was asked to distinguish the short-term or long-term opportunities most of the respondents were not able to answer easily. The consensus agreement was because developing new products or services in the electric vehicle domain is generally considered as a long-term game with high degree of uncertainty and a large investment cost. In other words, no one would be able to guarantee for the short-term profits or benefits (less than 5 years). Nevertheless, it was understood that there is a need for the Netherlands as a country to distinguish between developments which should be occurred in the short time (less than 5 years) and developments which can be occurred in the long time (more than 5 years).

A small number of respondents stated that to be able to answer short-term opportunities, it is highly depending on the type of business that one is currently active at. In other words, it was mentioned that it is needed to explore more details into the domain of each business. However, on the abstract level a smaller number of respondents stated that the short-term opportunity is highly related on the embedded system and service provisioning. **The more one can offer a system solution the more short-time one can reach the business.**

“I think the chances are obviously not related for producing a car. This trend has left sometime a go. I don’t think the chance is having or producing the battery either. So what left for Dutch automotive industry or Dutch high-tech industry is specialised developments in the certain components. Power train is one of them. And I also see the opportunity in the ICT arena that has to do with the systems in the car itself but also systems that integrate the car with the infrastructure for example with smart grids, and integrating smart appliances or smart devices and houses..So there is a whole cluster around this that is giving a number of business opportunities.”

Firm category

Some respondents clearly addressed that one should also look at other domains such as Plug-In Hybrid Electric Vehicle (PHEV) and pure Hybrid vehicle. The main argument was because of the facts that in the last 3 years there are many companies having financial difficulties (bankruptcy) in EV
development and the situation is even worse since the Dutch EV market is not growing as it is expected. Accordingly, a small number of respondents argued that one should have a business which can be flexible developed to different domains e.g. provide products which can be used for EV as well as PHEV or Hybrid or combine products with services.

Several respondents believed that the short-term opportunities for the incumbents can still be in the mainstream of component supplier to the OEMs or car manufacturers while for the SMEs the short-term opportunities are in the areas for solving mobility solutions e.g. interface with infrastructure, navigation technology and vehicle parameters. Some respondents mentioned that Future power train, Connected Cruise Controls (CCC) might not be easy to develop since one needs to have a close relation with OEMs or car manufacturers while Driver Guidance System (DGS), Battery Management System (BMS), Battery Information Interface (BII), smart grids, smart charging, mobility services, financial services, and payment services were seen as a short-term opportunities.

“If I look at the power of the Netherlands then I will look at two things: First, I strongly believe in the connected cruise control in combination with Driver Guidance Systems...I see that the Netherlands can be a perfect testing area for this like in Helmond. The Netherlands should be seen as a playground for these kinds of services. Second, I also believe in payment services and mobility services (interoperability in the Netherlands) should also be as export products for the Netherlands...Smart charging in combination with payment services - this is a good combination but I see some difficulties to earn money."

Research category

A number of respondents stated that the DGS, BMS, BII, payment service and mobility service have highly opportunity to become export products or services to the international market; hence these can be seen as short-term opportunities. With regard to smart grids and smart charging large number of respondents agreed if the Netherlands is not investing right now the country can miss the chances to reap the benefits of being the first-mover. Although there was a concern about how to earn money for both smart charging and smart grids, a number of respondents see a growing international market for charging infrastructure. There are still opportunities in which ICT can play a significant role in the smart-charging areas. Lastly, a small number of respondents argued that there is a long-term opportunity to develop re-use and re-cycle the battery. The main argument was because re-use or re-cycle battery technology is still considered as a R&D project. A number of respondents mentioned that this is more related to the university or research institute projects.

Besides all the mentioned potential products or services, there were large number of respondents stated that there is a clear opportunity to develop an entire concepts or solutions (testing facilities) for the introduction of electric vehicles. Several respondents mentioned that a cluster around Helmond, green city concept like Amsterdam, and green airport concept like Schiphol international airport have the opportunities as a show case demonstration of electric vehicle introduction. Those concepts can also be an export product for the Netherlands. In the following the value short-term opportunities for the Netherlands are given as follows:
Table 22: The values of short-term or long-term opportunities

From the above table, the number represents the amount of vote from the respondents with regard to interview question number 6. The higher value indicates that the products or the services are more favourable as a short-term opportunity to be developed (less than 5 years). The colour represents the possible combinations that were mentioned during the interview. Hence, in the following table the order of combinations is given as follows:

Table 23: The combination opportunities

From the table 23, one can conclude that the most frequent mentioned is that the combinations among Battery Information Interface (BII), Battery Management System (BMS), and Driver Guidance System (DGS), and followed by the combination between smart charging and payment service. These two combinations show the most favourable choices from the respondents as short-term opportunities (development should be occurred less than 5 years).

Business Models

Once the real opportunities have been identified, the possible business strategy or business models were discussed during the interview. First, the business models were discussed by looking at the outside environment in which the business model is positioned. These are including the potential actors, market force, support from industry, and support from government. Second, it continued to look at the current innovation phase, the potential strategy, and the potential business models. For
A large number of respondents mentioned that the business model is highly related to the domain of each business or the company core business. So in other words, each company or organization has their own models on how to earn money. However, the respondents stated that it is important to understand without sound market perspective and business models there will be no real innovation. Here, according to the respondents the Dutch government has an important role to support the market creation as well as a launching customer.

On the conceptual level, the sound business model that might be used for the mentioned potential products or services are including the possibility of combining product-service model, subscription model, licensing model and price-based model. The motivation is explained properly in Appendix G. Further, a large number of respondents stated that it is very important of getting to know the total cost of ownership (TCO) to help the customer and enterprise to manage direct and indirect cost of a new product or service. In addition, All respondents (100%) agreed that one should take into account for the possibility of an open strategic collaboration (strategic alliances) based on a fundamental agreement towards creating a win-win situation for the EV large scale adoption.

6.4 Chapter summary
This chapter discussed the field analysis or expert consultation process. As it is mentioned the aims to conduct this qualitative research are to validate the previous findings and to gain extra knowledge information that can be used as an input for finding a proper business strategy or business model. As a result, this chapter showed several real short-time opportunities for the Netherlands.

The target population of this research included the expertise or key actors that currently active in various developments within the Dutch electric vehicle innovation system. The sample size of this research included 21 different companies or organizations, which were divided into three main categories: Government, Firm, and Research. The amount of interview sessions conformed to the agreement with Delft University of Technology and NL Agency, as a proper sample size of this research study. The companies were selected based on the relevancy to the potential developments which were related to the EV-ICT development. This confirmed to the earlier investigated EV pilot projects as well as the prior study of D-incert and HTAS.

The interview questions were made to meet the main objectives. Hence, the interview questions were constructed in three different themes: the vision and expectation, potential developments (products or services), and the business strategy or business models. Based on the result of the interviews, the data analysis was performed.

The result of this chapter was able to conclude that besides there are various numbers of barriers in the current EV development, the vision and expectation on future Dutch industry in EV development are still positive. This is perceived as there are many opportunities for the Dutch industry in EV development that are not yet discovered. The Netherlands has lots of potentials for supplying the vehicle components to the OEMs or car manufacturers, developing services, and setting up a testing ground. Nevertheless, the successes will highly dependent on other supporting factors such as the market, industry support, government support, and commitment among actors.
Related to the developments, this chapter concluded two most reliable combinations as short-term opportunities for the Netherlands. These are including:

- On the vehicle interface - combinations among Battery Information Interface (BII), Battery Management System (BMS), and Driver Guidance System (DGS) - the combinations can be integrated with the routing planning and the navigation system. The aim is to reduce the range anxiety by optimizing the use of battery technology and giving the information about the availability of charging point.

- On the infrastructure – combination between smart charging and payment service - the combination provides ease of use, reliable, and secure charging point. This includes the reservation system, central back-office system, and transaction system.

On the conceptual level, the collaboration strategy among various key actors are the keys success of all potential products or services and sound business models that might be used for the mentioned potential products or services are including the possibility of combining product-service model, subscription model, licensing model and price-based model.

Since the electric vehicle technology is indicated as a dynamic market and open market where future responsibilities and the roles of all the actors are highly dynamic and uncertain, in the next chapter the business model or business strategy and the role of government with regard to potential products or services combinations will be further analyzed.

The limitation that can be found on this chapter is that although the selected combinations products or services are coming from reliable candidates, in practice these candidates support solely on the view of importance ICT development within EV development and they are actively involved in the current EV-ICT developments.
7. Business models design and role of Government

Based on the insights from the previous chapters, the aims of this chapter are to design possible business model or business strategy for the two combinations of products and services, named the combinations among Battery Information Interface (BII), Battery Management System (BMS), and Driver Guidance System (DGS), and the combination between smart charging and payment service, and to give an indication to the Dutch government on how to support the promising developments and actors to become successful in the market. Therefore, this chapter answers the fifth sub-questions of this research study: Which are the prosperous business model or business strategy? Under which condition can they be used? And how can the government support the promising developments (products or services) to become success in the market?

The foundation of the analysis is based on the framework of Osterwalder (2010), Orrt (2007), and Porter’s five force model (1998) and the data is based on the inputs from previous chapter as well as literature study. This chapter is structured as follows. Section 7.1 starts with the introduction. Next, section 7.2 describes the EV and EV charging market. Section 7.3 explains the products and services analysis. Section 7.4 discusses the role of Dutch government. And finally section 7.5 concludes this chapter. In the following figure the research process and where chapter 7 fits in are given on the blue color.

7.1. Introduction

The Netherlands is currently the first mover on EV development and the market leader for the charging point development (Weeda et al., 2012). This means that the country should continue to innovate in various EV developments in order to maintain technological leadership as well as to reap increasing returns advantages.
This chapter is framed to realize a sustainable future for the potential products or services themselves and to reap the benefits from the EV market by 2020. The initial target EV market segments, that this research has identified, are including:

- Logistics and distribution;
- Commercial mobility and commuter traffic;
- Mass transit such as public transport, taxis, pooling cars;
- Company and Government vehicles.

All the mentioned target market should be applicable for both national market as well as international markets. From the previous findings, the combinations among Battery Information Interface (BII), Battery Management System (BMS), and Driver Guidance System (DGS), and the combination between smart charging and payment services are seen as a short-term opportunities and export products for the Netherlands. These are supported by the fact that the Dutch industry has lots suppliers as well as the knowledge to develop those mentioned products and services. Here, one can expect that the Netherlands can secure its current position as an innovative country in charging market, ICT development, supplying components to automotive industry, and power electronics. However, since the development of products and services involves various stakeholders, one should take into account for the possibility of an open strategic collaboration (strategic alliances).

### 7.2 The EV and EV charging market

According to Roland Berger consultancy, by 2020 the total market value of electric vehicle in Europe is estimated to be around €30 until €100 billion based on around 4 to 5 million electric vehicles (NLAgency, 2011a). Similar result can also be found by recent HTAS study which estimates there will be at least €30 billion market value for around 5 million electric vehicles in Europe by 2020 (HTAS, 2009). Based on these two estimation figures, one may assume that the electric vehicle industry is an attractive market which offers lots of new opportunities and horizons. The following table shows the realization of electric vehicles and charging points in various countries across Europe. The result shows that the amount of electric vehicles and charging points is increasing considerably between year 2010 and 2011.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total amount of electric vehicle</th>
<th>Total amount of charging point</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In 2010</td>
<td>Per January 2012</td>
</tr>
<tr>
<td>Austria</td>
<td>223</td>
<td>1047</td>
</tr>
<tr>
<td>Denmark</td>
<td>400</td>
<td>749</td>
</tr>
<tr>
<td>Finland</td>
<td>17</td>
<td>70</td>
</tr>
<tr>
<td>France</td>
<td>1400</td>
<td>4000</td>
</tr>
<tr>
<td>Italy</td>
<td>2700</td>
<td>3100</td>
</tr>
<tr>
<td>Norway</td>
<td>3400</td>
<td>5326</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>395</td>
<td>1182</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>8353</strong></td>
<td><strong>15474</strong></td>
</tr>
</tbody>
</table>

Note: In Austria, Finland, Italy and France there are some missing data on the number of charging point

Table 24: Comparison realization in 2010 with per January 2012 (Weeda et al., 2012)

Similar with the EV market, the EV charging market is attractive and promising. Recent study done by Pike research estimates that a total of nearly 7.7 million charging locations worldwide will be
available by 2017 and for more than 4.1 million EV charging stations will be installed across Europe by 2020. In the following figure the forecast of EV charging station revenue is given by region.

![Chart showing EV charging station revenue by region](chart.png)

**Figure 41: Estimated total EV charging station revenue by region (PikeResearch, 2011)**

From the above figure, the Asia Pacific region is expected to lead the global EV charging equipment sales and followed by the Western Europe region which will be dominated by Germany, France, the United Kingdom, the Netherlands, and Italy (PikeResearch, 2012).

As the number of electric vehicle is expected to grow, the development of charging infrastructure is necessary for supporting the future EV demands. Energy sources, parking place, charging stations or charging point are necessity for the electric vehicle introduction. A network of charging point has to be developed so that everyone can recharge their vehicle anywhere and anytime. The trend indicates there is a possibility for implementing charging point at home but also in public places such as in petrol station, companies, supermarkets, hotels, restaurants, and parking places. Pihlajaniemi (2009) translated the trend for the recharging process in spatial planning as it is illustrated in the following figure.

![Diagram showing recharging in spatial planning](diagram.png)

**Figure 42: Recharging in spatial planning (Pihlajaniemi, 2009)**
The EV market development can be seen as two-sided markets or two-sided networks which stand for two distinguish groups of users interoperate each other. This means that the more EV user on the market, the more attractive it becomes for the electric vehicle industry as well as the charging point industry and vice versa. In the following figure, the development of EV charging market model is illustrated as follows.

Following from the figure above, there are two parties who have their own specific interests. First group consists of EV user or charging customer. This charging customer or the EV user should be able to have access on various charging stations and service providers, and to pay based on the amount of energy and services that they use without any limitations.

Second group consists of charging supplier which provides an offer charging facilities to the consumers. This charging supplier can be private individuals, restaurant, parking company, financial lease companies, utilities companies, and public organizations e.g. E-Laad or municipality. Since it requires a huge front investment cost, a possible business model can be comparable as a telecommunication business model: the charging point supplier installs the charging points and allows its customers to use for a monthly contract fee and increased it by a variable amount based on the use.

It is important to understand that both groups may have its own service providers which could be somehow interconnected each other so that a large scalability can be achieved in practice. It would be ideal if the service provider is a firm who has experience in operators business or ICT business. For example: IBM can be a charging operator or service provider. Since it is not on its current core business, IBM can lease the charging point equipment by another party.

Another example of the service provider is The New Motion which was founded in 2009. The company provides leasing car e.g. Nissan Leaf including a charge point and card. In cooperation with various investors, the company also invests on the fast charging in public places e.g. restaurant and fuel stations.
For all EV charging value chain partners, the introduction of electric vehicles offers new opportunities and perspectives (ABB, 2011). The actors need to decide in which role they like to play in developing solutions for electric vehicles. For electricity provider there is a challenge for a new market with potential customers, services, and income. It is the same for Telco’s, travel and credit card providers, and parking operators. However, since the charging point may consume enormous amount of electric power, the grid owner or grid operator may experience the challenge on the grid load. They may need to develop an intelligence grid which can supply reliable electricity in the near future. In the following two business models for charging infrastructure and mobility solution are discussed as follows.

**Charging infrastructure model**

The charging infrastructure is the area where most of utility companies e.g. Nuon, Essent, and Eneco have their natural core strength. Similar to the existing electricity production value chain, the grid companies e.g. Stedin, Alliander, and Enexis are used to maintain and to operate the grid. Consequently, possible value propositions on this charging infrastructure are including building the charging points, retailing charging points, installing the infrastructure, operating the infrastructure, maintaining the infrastructure, measuring and billing services (Ernst&Young, 2011). Further, since the value chain includes supplying reliable electricity, the value propositions should also include the generation, transmission and distribution of the electricity. Following the business model framework of Osterwalder (2010) the emerging business model in charging infrastructure model is given as follows.

**Customer segments** – A number of respondents mentioned that the largest business opportunities are business customers (companies) and public authorities (government). The business customers (companies) may include fleet company, malls, restaurant, and parking places which are mostly interested in the marketing and publicity aspect of setting up charging infrastructure for electric vehicles. Also focusing on the public authorities such as municipalities may create benefits since they are willing to become the lead user in EV adoption. A fair number of respondents stated that it is also important to focus on private customers especially those who are willing to pay for.

**Value propositions** – Several respondents argued that offering a package solution e.g. complete service including a maintenance contract can create more values to its customers. Other important aspects are being able to guarantee the electricity distribution in effective way and to deliver a large variety of services towards the customer needs.

**Channels** – Using the established channels e.g. sales channels is recommended. It is also suggested to secure partner channels with a car manufacturer. Securing such partner channels with a car manufacturer e.g. Nissan, Mitsubishi, and Renault could be substantial advantage of the business model as a whole. Another important partner sales channels with parking place e.g. Q-Park.

**Customer relationships** – Numerous respondents stated that local and regional utilities should establish personal relationship with the community and maintain a trust relationship with them. Further, the customer support should be excellent to offer the highest possible service in the established network. The customer will experience a lot of benefits on time, quality and money when the companies can carry out such extensive support policy. This should be done not only during the operating phase but also by purchasing the equipment (charging point).
**Key resources** – One of the main key resources should be related to the charging point or charging station itself. Ideally this includes slow charging, fast charging, and smart charging. In this case the utilities companies should partner with charging point manufacturers e.g. ABB Epyon or Alphen. Relate to smart charging points, it is highly recommended to include other services e.g. payment system as well as IT systems. Hence, finding proper partners in this area are critical. In the Netherlands several potential companies are including Logica, Accenture, Travel Card, and Cap Gemini.

**Key activities** – The respondents stated that the main key activities should include maintaining, installing the equipment, metering and invoicing the energy usage. Further, a small number of respondents mentioned the possibility to promote electricity trade. This is expected to create extra values to the end-users.

**Key partnerships** – A large number of respondents agreed that partnership in the charging solution is essential aspects to have a sound business models and to explore more resources, capabilities, and channels. Strategic partnerships with e-laad.nl and Formula E-team are necessary for success implementation. While for the operational purposes, collaboration with car manufacturers, mobility service providers, charging point producers, ICT companies, and Government are extremely needed.

**Revenue streams** – The revenue streams result from value propositions successfully offered to customers by establishing billing and payment systems. The pricing mechanism can be done by implementing monthly flat rates for charging services based on prices per kWh (ABB, 2011). According to several respondents, other possibilities are to apply dynamic pricing models and flexible tariffs by introducing the charging profiles to the customers. Based on their chosen profile, several charging scenarios are possible for different charging times and different costs e.g. if the drivers prefer to have a fast charging it may cost higher energy bill compare with those who prefer a slow charging. Nevertheless, for supporting these kinds of activities, communication among grid, charging point and the user is an essential factor for the success.

**Cost structure** – One of the challenges is about investment in fast charging and public charging stations. This may require high investment cost and it is not certain to have ROI in the short time (Ernst&Young, 2011).

**Mobility solution model**

In this part the possibility of mobility solution model which represents the strength of lease mobility is discussed. This mobility solution can include the direct retailing or leasing electric vehicles, electric bikes or electric scooters, charging solutions, and other services e.g. information of car status, integrating public transport. Following the business model framework of Osterwalder (2010) the emerging business model in mobility solution model is given as follows.

**Customer segments** – The customer segment does not differ from the mentioned customer segments in the early chapter. The biggest opportunities are including company and government vehicle, private customers, logistics and distribution, and commercial mobility and commuter traffic.

**Value propositions** – The respondents mentioned that the value towards its customers can be created by offering electric vehicle, electric scooters, and e-bikes in transportation sector. Further,
this can also include the possibility for offering charging point on the client side and delivering integrated public transportation solutions. Good examples of this mobility solution model are Athlon car lease, Mister Green, and Elmonet which offer electric vehicle, electric scooters and e-bikes in combination with access to a public charging network for private customers. A fair number of respondents stated that the value proposition of this mobility solution could also be enhanced by providing its customers have access to “free parking” in inner city areas.

**Channels** – The optimal distribution channel would be to sell through direct sales channels. However, since it may deal with risk and uncertainty several respondents argued that having partner sales channel will be beneficial for the success of the business model.

**Customer relationships** – Depends on customer segments the customer relationship can be vary. For example Car2Go has customer relationship through its presence in social networks which actively gaining the feedback directly from its customers.

**Key resources** – The assets are including electric vehicle, electric scooters, electric bikes, and charging point. Further, when it comes to mobility solutions the respondents argued that some IT systems and software developments are needed to offer various mobility solutions. Being able to integrate various IT resources in one database might be beneficial.

**Key activities** – The most important activities are including service provisioning, marketing and sale aspects. In this case, the respondents mentioned that product or service differentiation is important aspect for success.

**Key partnerships** – In order to have sustainable business model, most of the respondents agreed that strategic alliances with car pools, car fleet companies, charging manufacturers, ICT companies, car manufacturers, service providers, and Government are necessary.

**Revenue streams** – Revenue can be achieved not only from retailing the sale of electric vehicle, electric scooters and e-bikes but also from monthly leasing price and service charges.

**Cost structure** – The respondents mentioned that high investment is required for the tangible assets e.g. electric car, e-scooter, and e-bike and for charging point. Further, a large number of respondents stated that there is a large uncertainty around residual value of the electric vehicle as well as the battery which can lead to higher costs.

### 7.3 Products and services analysis

In this section the combinations of products and services are further analyzed. The sources of data are coming from the previous chapters including inputs from the respondents as well as the prior-study of D-incert. It starts with the combinations among BII, BMS, and DGS and then it continues with the combination between smart charging and payment services. In the following paragraphs, each of them is explained as follows.

#### 7.3.1 The combinations among BII, BMS, and DGS

Since the industry cannot expect a new breakthrough battery technology will arrive in a short-time, there is a clear need to increase the efficiency of current battery technology. The combinations among BII, BMS, and DGS have the opportunities to deliver innovative solutions by delivering real-
time battery information, providing an overview of residual battery life-time, and giving an insight on the availability of charging stations.

The target markets of these combinations products are including private EV end-user and fleet owners e.g. taxi company, logistic company, and lease company. Especially for the fleet owners and Lease Company, the products can help to predict residual value of the car so that the fleet owners as well as the lease company can make a better financial overview. In the following table the functionalities of the products are given as follows:

<table>
<thead>
<tr>
<th>Product</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>BII – BMS - DGS</td>
<td>Overview battery condition</td>
</tr>
<tr>
<td></td>
<td>Overview charging point availability</td>
</tr>
<tr>
<td></td>
<td>Monitor the batter technology</td>
</tr>
<tr>
<td></td>
<td>Control the battery system</td>
</tr>
<tr>
<td></td>
<td>Real-time functionality</td>
</tr>
<tr>
<td></td>
<td>Integrated with navigation system including reservation system for the charging station, road information, weather information, map service provision</td>
</tr>
</tbody>
</table>

Table 25: The combinations among BII, BMS, and DGS

**Status of development:** innovation phase. Several challenges still exist in the current practice e.g. to move from earlier adopter to earlier majority (crossing the chasm) and to start large scale production as an export product. Current data information about charging point is not complete and it needs some extra research to integrate the data with current map service. An open development platform is required to support the possibility for integrating various applications or services in the near future.

**Status of competition:** average competitive market especially from Asian countries e.g. South Korea, Japan, and China. The new players such as Google and other Smartphone firms are also expected to develop similar product. However, the Netherlands has a strong position compare to others since the incumbents e.g. TomTom and Navteq are currently the market leader in this field. Intellectual Property (IP) plays an important role for securing the competitiveness.

**Status of resources:** Knowledge and talented labour are available in the Netherlands. A map service is seen as a key resource in this development and it is available in this country. Source of capitals are available via established company e.g. TomTom and subsidy program from the Dutch government.

**Possible actors:** Sycada, TomTom, NXP, Philips, Technolution, IBM, Siemens, ASML, Nokia/Navteq, TU/e, TUD, TNO, and SMEs.

**Functional decision**

Deduce from the above analysis, the incumbents as well as SMEs have potential to develop the products in the market by considering the following business strategy and business model.

**Potential strategy:**

A niche market strategy is seen as the most essential strategy since the products are highly related to the EV niche market and it is expected that a long period of market adoption will occur. However, for
the incumbents such as TomTom, Nokia/Navteq, and IBM a mass market strategy could be implemented since they have established distribution network, brand reputation, and financial strength. In this case, the incumbents can strengthen their competitiveness by applying first mover strategy in the EV industry.

Another important strategy is combining the volume of production with differentiation. To stay competitive the incumbents may differentiate their products and services against their competitors. For example: TomTom can add new services in its current navigation system such as street demographic, Battery Information interface (BII), and Battery Management System (BMS).

Since the BII, BMS, and DGS are still needed to develop, a collaboration strategy with various stakeholders is essential. In this strategy each actors can reduce the risks and focus on its core business. As an example: Nokia/Navteq provides a map service, Sycada builds the application for BII, TomTom delivers real live navigation service, and IBM provides system integrator which combines all applications with an open development platform. As a result, this can become an export product. This collaboration strategy is highly recommended for SMEs since they can take advantages from incumbent’s existing network and incumbent’s financial resources.

**Potential business models:**

As it is occurred in the current practice of automotive market, a viable business model can be achieved by licensing the products to the OEMs and battery manufacturers. There is also an option to sell the combination products to the automotive aftermarket or simply sell the products directly to the EV end-customer.

Another possible business model is combining product and service model. For example: instead of solely selling the navigation products, TomTom can sell new service e.g. overview of the availability charging point. In the following figure, an example of TomTom business model is given by applying the Osterwalder’s business model framework (2010).

![Figure 44: Example of TomTom business model](image)

**7.3.2 The combination between smart charging and payment service**

Charging infrastructure is an essential factor for a large scale electric vehicle introduction. The combination between smart charging and payment service provides ease of use, reliable and secure
charging process. In the following table, several functionalities of the combinations are given as follows.

<table>
<thead>
<tr>
<th>Product</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart charging and Payment services</td>
<td>Home charging, fast and slow charging status charging point, interoperability register system, , central back-office of charging station, smart charging algorithm, open charging supports infrastructures, manage and control charging point via distance, safe and reliable transaction system, operator of charging network (call centre).</td>
</tr>
</tbody>
</table>

Table 26: The combination between smart charging and payment services

From the above table, the functionalities will be delivered through a reliable ICT platform which is mostly managed, controlled, and monitored by the service provider. The platform should support the communication among charging customer or EV user, electric vehicle, and the charging point which are authenticated and authorized in a secure way. In the current practice, the platform was developed by Logica: A Charge Point Interactive Management System (CiMs) is designed to support infrastructure management, transaction processing, user card management, user environment, and other value added service interfaces. In the following figure the platform is illustrated.

From the above figure, the platform is clearly designed to supply the energy to the car, to supply the usage data to energy grid owners and suppliers for monitoring, managing and balancing the energy network, and to facilitate the transactions between charging customer or EV end-user and charging supplier.

Similar to the previous combination products, in the combination between smart charging and payment service various key stakeholders will also involve in the development. Hence, a collaboration strategy is essential for the development. As a result, one may expect to export this combination internationally.
**Status of development:** innovation phase. Several challenges are still appeared such as settlement service providers, invoicing and billing, legal barrier, financing public charging stations, and lack of standardisation fast charging. Further, on the European level there are still various issues e.g. the emergence of dominant design, interoperability, and agreement on roaming price.

**Status of competition:** a tight competition in every EV charging value chain.

**Status of resources:** Knowledge, Government support, and innovative firms are available in the Netherlands. Charging point incumbents e.g. ABB Epyon and Alfen, ICT companies e.g. Logica, and the payment incumbents e.g. visa, mastercard, travel card play an important role for the development. Source of capitals are available via subsidy program from the Dutch government.

**Possible actors:** ABB Epyon, E-Laad.nl, Alfen, The New Motion, EV-Box, Eneco, Enexis, Logica, travel card.

**Possible target market:** in the following the target market of smart charging is given as the following.

<table>
<thead>
<tr>
<th>Segment or Group</th>
<th>Motivation</th>
</tr>
</thead>
</table>
| Municipalities regional energy providers | Reduction of noise  
Promoting green city environment |
| Car manufacturers or OEMs | Promotion of car scales  
Product bundling |
| Fleet operators – transport companies (UPS, DHL, TNT Post)  
Car leasing companies – taxi fleets | Business development: integrated mobility concepts  
Access to restricted areas |
| Parking space operators (Q-Park) | Promoting green image  
Business development |
| Gas station chains | Promoting green image  
Business development |
| User group (airport, companies, restaurant) | Reduce investment  
Promoting green image  
Marketing and business development |
| E-mobility providers, operators of charging infrastructure | Business development |

**Table 27: Relevant customer segments in the smart charging and payment services**

**Functional decision**

Deduce from the above analysis, the incumbents as well as SMEs have potentials to develop various products and services in the smart charging by considering the following business strategy and business model.

**Potential strategy:** Similar to the previous combination, a niche market strategy is seen as the most essential strategy since the products are highly related to the EV market and it is expected that a long period of market adoption will occur. A collaboration strategy is needed e.g. ABB Epyon can collaborate with Logica and Travel card to have a package solution in smart charging and payment services. Further, one is recommended to focus on the mentioned customer segments.

**Potential business models:** For every EV charging value chain, there are various business opportunities and business model. For examples: charging point manufacturer has the possibility to
reap benefits by selling the charging point equipment and delivering several services e.g. installation and maintenance service. ICT Company has potentials to achieve revenue by developing various applications and licensing its products while the payment company has a viable business model by applying subscription model.

Figure 46: EV-Box, ABB Epyon, and Coulomb charging point

7.4 The role of Dutch Government
All the mentioned product and services are relying on the growing electric vehicle market and since the electric vehicle can be characterized as a niche market, the Dutch government will play a significant role to protect the current niche to develop by stimulating and facilitating the current niche development.

In this section the possible role of Dutch Government is discussed. Generally the Dutch government should maintain its current policy and regulation for supporting the introduction of electric vehicles in a large scale.

Long-term vision on EV development
As it is mentioned during the interview session, a large number of respondents stated that the Dutch government should commit for long-term vision on EV development. This is extremely important since the firms or organizations, that are active in the current EV development, need to have support from the government with favourable policies so that they can sustain their businesses.

A large number of respondents concerned about the possibility on reduction of fiscal advantage for electric vehicle. Since, the growing of electric vehicle is not as it is expected, the fiscal advantage on electric vehicle should maintain at least until the year of 2020. Here, according to the respondents, the market development of electric vehicle can be expected to grow gradually.

Facilitator and steer to the right EV development
The Dutch government should maintain its role as becomes the facilitator and steer to the right EV development. Several numbers of respondents agreed that similar program like previous HTAS program should be re-introduced in the short-time. This is needed so that the overhead cost, that firms or organizations may face, can be reduced significantly. Especially in the development of BMS and smart charging since more research and development (R&D) are still needed to improve the current technology.

User awareness
The Dutch government should promote user awareness of how to use an electric vehicle. Several respondents mentioned that the user should be more aware of what they should expect from an
electric vehicle and what the restrictions and advantages of using electric vehicle. The electric vehicle should not be perceived as being a restriction of their mobility but rather change to the positive perspective which fits in her/his current need for mobility.

**Funding and subsidy programs**

The Dutch government should focus on giving the funding or subsidy programs wisely. In this case, there is a clear need form SMEs to further develop in the mentioned potential developments. Since in the current situation there is a scarcity on available funding and less venture capitalist in the Netherlands, a large number of respondents stated that the Dutch government should have a strategic decision on giving the right funding to the right potential products or services as well as to the right innovative companies. Several suggestions were clearly stated that the Dutch government should set up an innovation fund so that the entrepreneurs will be able to invest more easily in the mentioned potential products, services and processes. Further, according to a respondent given the fact that the Dutch government is willing to shift the subsidy program to a fiscal incentive will solely make difficulties for the SMEs to maintain their innovations.

Related to the funding, a large number of respondents agreed that the government should more investing in education. This can be done by implementing a research and development budget to several universities e.g. TU/e, TUD and research institute e.g. TNO.

**Collaboration within the industry**

The Dutch government should maintain the collaboration within the industry. The collaboration between the industry, knowledge institutes and the government is the key for improving the current products or services development and improving the current EV market. According to the respondents, the Formula-E Team program should be maintained and the Dutch government should actively take an initiative for creating more innovation clusters e.g. Helmond cluster.

A smaller number of respondents suggest that it may be better if the Formula-E Team has more authority to have decision making for specific case. The main reason is because, according to a respondent, there is too much bureaucracy in the current practice and the Formula-E Team probably needs someone who has managerial experience to make a strategic decision on EV development. Moreover, the government should promote a concrete collaboration between existing pilot projects. In the current situation, the connection between each pilot projects is still missing in several cases.

**International diplomacy**

The Dutch government should promote and demonstrate the products or services that have been successfully developed in the Netherlands. A large number of respondents stated that through its international contacts, the Dutch government could attract more investors’ especially large car manufacturers or OEMs to invest in the country. Not only in European diplomacy but this should also include Asia as well as America continent. In order to facilitate the growth of SMEs, the Dutch government is expected to promote the SMEs by getting actively involved in several international trade shows or demonstration projects e.g. EV summits and KP7 programs. The Dutch government should be able to promote the SMEs to get involve in various European projects.
Development of charging stations

The Dutch government should facilitate and stimulate the process of developing charging infrastructure in the market. A fair number of respondents stated that the local government e.g. Amsterdam municipality should not solely focus on constructing charging infrastructure but it should also facilitate and stimulate the development process in the market. The respondents agreed that the government should not too much involve in the current charging market. Accordingly, the Dutch government should prevent the monopoly on the charging infrastructure, stimulate an open market, facilitate and steer it in the right direction with strategic funding.

Several respondents mentioned that the tax incentive should be given to the energy sector. This is needed because it can help the end-customer to buy a cheaper energy when they are using electric vehicle. Other respondents mentioned that the Dutch government should also facilitate the policy for open access to infrastructure and systems, guarantee energy supply and safety, and assisting the development of smart grids. The latter one is important since without a proper grid network the electric vehicle may face another problem related to the capacity of electricity in the near future.

The Dutch government should play actively in the European negotiation for standardization the current practices e.g. the plug standard and other technical standards. This is also valid for the interoperability on the European Level. Some respondents specifically discussed that the standardization of the charging infrastructure should be brought on European Level in the current development. Since the Netherlands has been actively developed in smart charging and became the market leader, a lot of respondents argued that the Netherlands can play an important role for the standardization and interoperability development.

7.5 Chapter summary

For all EV charging value chain partners, the introduction of electric vehicles offers new opportunities and perspectives. The actors need to decide in which role they like to play in developing solutions for electric vehicles. Accordingly, in this chapter various business models and business strategies were discussed.

This chapter assumed that the EV market is attractive as it was discovered by Roland Berger consultancy that the total market value of the manufacture of electric vehicles in Western Europe will be around €30 until €100 billion by 2020 based on around 4 to 5 million electric vehicles. As the number of electric vehicle is expected to grow, the development of charging infrastructure is essential for supporting the future EV demands. On the charging market industry, it is expected that by 2020 there will be more than 4.1 million EV charging stations are installed across Europe.

Based on the previous interview with various expertise a few emerging business models were investigated. First, the business model in the area of charging infrastructure solutions was designed. Second, the business model in the area of mobility solutions was made. Both business models were made by applying Osterwalder’s framework (2010). Further, this chapter tried to design the business model for two combinations of products and services: the combinations among Battery Information Interface (BII), Battery Management System (BMS), and Driver Guidance System (DGS), and the combination between smart charging and payment services. For both combinations, these are the real strengths of Dutch industry in the current EV development and it can be seen as real opportunities in a short-time.
The business model in charging infrastructure was designed for utility company or utility providers. The revenue can be achieved by delivering value proposition including building the charging points, retailing charging points, installing the infrastructure, operating the infrastructure, maintaining the infrastructure, measuring and billing services, and distributing electricity. Since it deals with high investment cost and higher degree of uncertainty, focusing on specific target market was recommended. Similar situation can be found on the mobility solutions. Good examples of this mobility solution model are Athlon car lease, Mister Green, and Elmonet which offer electric vehicle, electric scooters and e-bikes in combination with access to a public charging network for private customers. Further, it was recommended that the more one can offer a system solution the more short-time one can reach the business.

For the combinations among BII, BMS, and DGS, the possible actors that may involve in the development are including Sycada, TomTom, NXP, Philips, Technolution, IBM, Siemens, ASML, Nokia/Navteq, TU/e, TUD, and TNO. Based on the analysis, a niche market strategy is seen as the most applicable since the products are highly related to the EV niche market and it is expected that a long period of market adoption will occur. A viable business model can be achieved by licensing the products to the OEMs and battery manufacturers or by selling the end product directly to the end-customer.

With regard to the combination between smart charging and payment service, the possible actors are including ABB Epyon, E-laad.nl, Alfen, The new motion, EVBox, Eneco, Enexis, Logica, and travel card. Since the end-products will involve various firms, a collaboration strategy is the key success. Further, similar to the previous combination, it is recommended to focus on specific niche market.

Finally, this chapter suggested to the Dutch government on how to support the potential developments by considering the following aspects:

- The need for maintain long-term vision of EV development;
- The need to facilitate and steer to the right EV development;
- The need to increase the awareness of using EV in the society;
- The activity focus of stimulating:
  - Knowledge management – Collaboration project;
  - SMEs, University and Public Institute;
  - Charging infrastructure development;
  - Tax incentive on EV end-user;
- The need for promoting the successful projects internationally;
- Policy creation on:
  - Standardization;
  - Open access to infrastructure and systems;
  - Energy supply and safety.
- Uniform regulation of charging infrastructure on European Level.
8. Conclusion and recommendations
This chapter provides the final conclusion and recommendations of this research study. The conclusion is drawn by answering the main research question and giving the main findings of this research. The recommendation is given to improve the current Dutch electric vehicle innovation system as well as to sustain Dutch competitive advantage internationally.

8.1 Conclusion
Due to the global change in economy, energy security and environment, there is a renewed interest for several countries including the Netherlands to introduce a more sustainable transportation. Specifically for the Netherlands, the introduction of electric vehicles to a large scale is expected to bring a new hope for positive impacts to the Dutch national economy, to conserve the energy reserve, to contribute to global climate change by reducing the amount of CO₂ emissions, and to improve the quality of life.

Learning from the past experience, introducing the electric vehicle is not a straightforward task. It is a complex process in which various environmental forces may influence the Dutch electric vehicle innovation system. As this system needs to be improved, continuous environment scanning is a first crucial step. The objective of this research study is to analyze the current Dutch EV innovation system which can help the Dutch government to improve current innovation development inside the EV industry by mapping out the views of potential EV developments and prosperous business models. Hence, the main research question is defined as follows.

*What are the prosperous business growth potentials for the promising developments (products or services) within the Dutch electric vehicle innovation system?*

In order to answer the main research question, this study followed the funnel technique which consists of several steps including the investigation, development and shipping products. The study also used a methodology, innovation system analysis, which consists of three main analyses: the basic analysis, context analysis and variation analysis. In the investigation phase (basic and context analysis), this study started by exploring current Dutch electric vehicle innovation system, its dynamics, and the context analysis. Using the Multi Level Perspective (MLP) analytical frameworks, this thesis was able to gain a better understanding of innovation context. The results of this analysis continued to focus on specific niche development by applying the Strategic Niche Management (SNM) framework. In this development phase, the societal experiments, twelve EV pilot projects, were investigated. From the investigated pilot experiments, it was concluded that the Dutch EV niches was well developed. This could be seen as the expectation and network formation were improving gradually.

In the earlier phase, the network of actors was rather small consisting of lead user, technology suppliers, government, established firms and research institutes from automotive and energy sectors but along the time this has been increasing gradually. The experiments showed that in the last development several ICT firms were involved in various EV pilot projects. Hence, as part of a learning process, it was recognized that the Dutch ICT sector could play an important role in the forthcoming EV development. Combining the automotive sector with the ICT sector creates a “unique” identity for the Netherlands in EV development.
Through the niche development experiments, one may found that the potential developments (products or services) for the Netherlands are mostly coming from the current pilot experiments: Future power train, Battery Information Interface (BII), Battery Management System (BMS), Driver Guidance System (DGS), Smart charging, Financial services, Payment services, and Mobility services. However, after this development stage the SNM analytical framework was not able to give an answer on how to manage those mentioned potential developments to be successfully implemented in the market. One may argue that keep the experiment or the pilot project sufficiently broad in terms of network and have committed partners in the team. But those arguments are not able to answer on how one keeps their partners motivated if the experiment does not generate revenues in a short time, and there is no more funding available for their experiments? Hence, this research study brought some new insights to the actors on how to commercialize the mentioned products and services by involving technology strategy as well as business model theory into the framework.

As a part of variation analysis, the selection of promising developments (products or services) was performed by combining prior studies from D-incert with the investigated EV pilot projects from the SNM investigation. Here, the Porter’s five force model, the value net framework of Brandenburger and Nalebuff (1995), and Ortt & Delgoshaie (2007) were used. Based on those, the selection criteria were made: market size, competition, resources and integration. Those criteria are seen as essential requirements for the large-scale diffusion of electric vehicles.

An important aspect for the success and failure of new products or services depends on the support on its environment; therefore, this study performed a qualitative research to validate the findings as well as to gain some extra knowledge for finding a proper business strategy or business model. As a result, the two most reliable combinations were chosen as short-term opportunities (Less than 5 years development) for the Netherlands:

- On the vehicle interface – combinations among Battery Information Interface (BII), Battery Management System (BMS), and Driver Guidance System (DGS) - the combinations can be integrated with the routing planning and the navigation system. The aim is to reduce the range anxiety by optimizing the use of battery technology and giving the information about the availability of charging point.

- On the infrastructure – combination between smart charging and payment service - the combination provides ease of use, a reliable and secure charging point. This includes the reservation system, central back-office system and transaction system.

For both combinations, these are real strengths of the Dutch industry in the current EV development. This is supported by the fact that the Netherlands has a strong market position in those combined products and services, and has a favourable industry support e.g. high availability of knowledge as well as highly reputation firms. Further, one can expect that the Netherlands can secure its current position as an innovating country in the charging infrastructure, ICT development, and power electronics.

However, since the development will involve various stakeholders, one should take into account for the possibility of an open strategic collaboration (strategic alliances) based on a fundamental agreement towards creating a win-win situation for the EV large scale adoption. The collaboration strategies can exist among various key stakeholders including government, universities or research...
institutes and firms. In the future, one may assume that this interconnectedness of different actors can produce more business model innovations as well as new innovative products and services.

In order to develop in a sustainable way several aspects should be considered: implement niche market strategy and focus on specific market segments. The strategy is in line with the proposed strategies to commercialise breakthrough technology by Ortt (2007).

A niche market strategy is seen as the most essential strategy since the mentioned combinations products or services are expected to have a long period of market adaptation. This is even true since the mentioned combinations are relying on the growing EV market in general. Additionally, since the current EV market is not as it is expected, the entrepreneurs are advised to focus on specific target markets: Logistics and distribution, commercial mobility and commuter traffic, mass transit such as public transport, taxis, pooling cars, and company as well as government vehicles. These market segments are valid for both national as well as international.

For all EV value chain, the introduction of EV offers new opportunities and perspectives. The actors need to decide in which role they like to play in developing solutions for EV. For electricity provider, there is a challenge for a new market with potential customers, services and income. It is the same for Telco’s, travel and credit card providers, and parking operators. However, since the charging point may consume enormous amount of electric power, the grid owner or grid operator may experience the challenge on the grid load. They may need to develop an intelligence grid which can supply reliable electricity in the near future.

In order to generate profitable and a sustainable revenue streams, various business models were discussed by applying the Osterwalder’s business model framework (2010). As it was mentioned by the respondents of this research study, without a sound market perspectives and business models there will be no real innovation. Therefore, this study proposed two business model designs for charging infrastructure as well as mobility solution model.

The charging infrastructure model was designed for utility companies e.g. Nuon, Essent, and Eneco or grid companies e.g. Stedin, Alliander, and Enexis since they have their natural core strength on this field. Accordingly, possible value proposition on this charging infrastructure includes building the charging points, retailing charging points, installing the infrastructure, operating the infrastructure, maintaining the infrastructure, measuring and billing services. Further, offering the possibility to trade the electricity may create an extra value to the end-users. The revenue can be received in one way or another by applying different pricing mechanism based on prices per kWh. Using the established channels e.g. sales channels is recommended and it would be great to secure partner channels with a car manufacturer. In this case, one may approach a strategic relationship to the automotive industry. In the Netherlands, this can be done via TomTom or NXP semiconductor.

For the possibility of mobility solution model, some good examples are represented by Athlon car lease, Mister Green, and Elmonet, which offer various EV types in combination with access to a public charging network for private customers. As it was mentioned earlier, the biggest opportunities included company and government vehicle, private customers, logistics and distribution, and commercial mobility and commuter traffic. In this case, the revenue can be attained by leasing price and service charges or by retailing the sale of the electric vehicle. However, some possible alternatives can also be done by offering electric scooters and electric bikes. Since it may require
huge front initial investment cost, one is advised to have strategic alliances with car pools, car fleet companies, charging manufacturers, ICT companies, car manufacturers, services providers, and the government.

For the overall success, supports from the Dutch government are needed. The Dutch government should act as a catalyst to increase the overall performance and create a sustainable country competitive in the EV development. Some concrete actions from the Dutch government can be expected to create more cluster regions for EV industry in the Netherlands and interconnect it globally. The strong points of the Netherlands, such as highly EV knowledge and presence of large creative ICT and automotive sector, should therefore be promoted. Simultaneously, its weak points, such as the lack of venture capital or funding, can be targeted by connecting the Dutch firms with other countries and foreign venture capital firms. It is important for Dutch government to realize that the development an EV cluster can be a long process which can take nearly more than 50 years to develop.

Finally, beside various business models which were discussed in this research study, the recommendation to the entrepreneurs is advised to secure the partnerships in the early stage by actively involved in various projects. Being a first mover in this EV development may maintain the technological leadership. On contrary, late entrants may have less risk now but they also potentially miss out on strategic partnership that can be a major specialized asset in the future business models. And lastly, it is important to aware that value delivered to the customer results in a satisfied customer who will pay a reasonable price in return for the product and service. Hence to be successful, the entrepreneurs or firms must offer products or services that meet the needs and values of the customer.

**Contribution of this study**

Contribution to the existing theories can be clearly seen as the theoretical framework, that was built, makes possible to integrate the Multi Level Perspective (MLP), Strategic Niche Management (SNM), technology strategy and business model theory in the context of innovation process. In fact, in the past few years they have been developed independently each other (Markard and Truffer, 2008).

On one side, bringing the firm strategy and its innovation process into sustainable transition has yielded additional value to the existing socio-technical study. The integration may reach a maximum extend in the situation in which the actor role and actor strategies are essential for the success of innovation process (Markard and Truffer, 2008). Further, since the innovation system naturally emphasises the interconnectedness of a large number of organizations, the network was promoted as an essential integrator in the proposed model.

EV innovation system may involve various organizations which have their own interests and goals, therefore, in practice a misalignment can occur which may hold the development process. Consequently, this study also promoted the role of government as a means to align the development activities within EV value chain. Particularly, the government is important to stimulate the innovation when the classical “the chicken eggs dilemma” occurs. Hence, on the other side this study also brings a new insight to the entrepreneurship study by adjusting the existing frameworks such as Osterwalder’s framework and Ortt’s strategy, with the existence of the government role.
The contribution of this study to the current business practice is achieved by promoting the ICT sector into the current EV development. Along the process of this study, it was recognized that the integration between automotive sector and ICT sector were not visible. There is a missing link between those two sectors which according to this study may have a significant influence on the future EV development. Through an intense contact with various key stakeholders during the interview session, there is an increasing awareness of each actor for the involvement of ICT sector in EV development. Consequently, this study was also able to promote a strategic step for the Dutch government to bring the actors from both sectors.

Since this study covered various applications within electric vehicle technology, entrepreneurs may also benefit from various opportunities and business models that were discussed on this study. Accordingly, it is expected that this study encourages the entrepreneurs to further develop electric vehicle with the given applications. Finally, given the fact that the EV innovation process is a dynamic process, continuous environment scanning is considered as an important activity. Therefore, the proposed model as it was depicted on Figure 39 can be used as an alternative analysis tool on how to support the EV development.

8.2 Recommendations

Generally, the Dutch electric vehicle development shows an improvement progress since 2010. This can be seen as the numbers of EV as well as the positive growth of charging points. In the past, the supportive innovation programs e.g. HTAS and the knowledge centre e.g. D-incert have been successfully promoting the EV development in the Netherlands. However, since the incentive scheme and fiscal support might finish soon, it is thus recommended for the Dutch government to continue support the R&D and to maintain the fiscal advantage on the electric vehicle. This should be maintained at least until the year of 2020.

On the end-user level, the Dutch government should be more actively involved in the marketing campaign so that the Dutch citizen is becoming more aware about the existence and the needs of EV. The EV should not be perceived as being restriction of their mobility but rather change to positive perspective which fits in her/his current need for mobility.

From the technology perspective, it is known that the current EV is not mature yet. The focus on the technology development is needed to divide into two main parts, named the short-cycle element and long-cycle element. In the long-cycle element one can consider the development on battery development, while in the short-cycle element the ICT can play a significant role.

All kind of ICT developments within EV innovation system can help to solve the current technology barriers e.g. related to the battery barrier ICT may help by implementing a battery management system and smarter navigation systems. The short-cycle element can also give an influence to the user adoption and markets since it can bring some “surprise effect” to the user e.g. the new EV can use digital keys via mobile phone. Hence, it is recommended to maintain the collaboration between ICT and automotive sector for improving the current EV technology development.

The Dutch government should maintain its role as becoming the facilitator and steer to the right EV development. In this case as this study mentioned two possible combinations of products and services, it is thus recommended to strongly focus on these developments. This is important since it
Dutch electric vehicle innovation system

was recognized as real short-term opportunities for the Netherlands to maintain its international competitiveness as well as for the growing of electric vehicle market.

From the collaboration between key actors, one can conclude that the Netherlands has a good network and intense interaction between key actors inside the EV innovation system. But the relationship among incumbent, start-ups, government, and research institutes or universities can be improved. The financial support for the firms including start-ups seems to be the most priority since the new technology-based firms have been the centre of innovation and the success of EV large scale adoption. For example: The Dutch government or local government creates a fund that is more targeted on technology companies and other companies in the growth stage.

The Dutch government should aim at a stronger collaboration between universities and private companies through research. This collaboration could be in the form of research opportunities and internship. Students are naturally attracted to schools with a good access to practical opportunities.

The Dutch government should use its strengths, e.g. good infrastructure, advanced highly knowledge, and good ICT development to attract more OEMs or Car manufacturers. This can be done by attracting more car manufacturers from European continents but also from other continents e.g. Asia and America. Finally, it is highly recommended that the Dutch government should promote and demonstrate the products and services that have been successfully developed in the Netherlands. For example: getting involved in several international trade shows or demonstration projects e.g. EV summits and KP7 programs.

**Recommendation for monitoring activities (NL Agency)**

Since this study is done by NL agency under innovation and monitoring department, in this part some recommendations based on the researcher observations are given. In the current monitoring department, NL agency is using Functions of Innovation System (FIS) for monitoring the innovation in specific development area. The FIS is developed at Utrecht University by Hekkert et al (2006) that can be applied to some activities in innovation systems as well as to describe and to explain the dynamic of Technology Innovation System (TIS). This consists of 7 functions: entrepreneurial activities, knowledge development (learning), knowledge diffusion through networks, guidance of the search via policy goals and programs, market formation, mobilization of resources e.g. capital, human capital, and support from advocacy coalitions.

On this FIS analysis, it is true that the “functions” approach provides a framework that helps to identify the main technology-specific policy issues and to give recommendation on how the technology development can be facilitated. However, similar to the SNM framework, these two frameworks are only proven useful for ex-post analysis of success and failure factors in the introduction of specific radical innovations e.g. wind energy, biomass, and food production but there is a few details and practical on “how to do it” guidelines to other actors e.g. firms or start-ups which are also part of important stakeholders in the niche creation.

Especially in the current case of introduction electric vehicle it is hard to ensure how successful learning experiments can be brought to the market and how to manage so that it can become successful. Moreover, with the current “economic crisis” in the Netherlands it is hard for the Dutch government to totally support the innovation process with subsidy or funding program. In this case
one may argue that the actors e.g. incumbents, start-ups, university, and research institutes should be able to continue innovating without subsidy program. But then this leads to the next questions: how does one keep their partners motivated if the experiment does not generate revenues in a short time, and there is no more funding available for their experiments? So these sorts of questions cannot be directly answered by FIS and SNM framework to give a recommendation on how the technology development can be facilitated. In the following table the comparison between FIS and SNM is given.

<table>
<thead>
<tr>
<th>Functions of Innovation System (FIS)</th>
<th>Strategic Niche Management (SNM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A network or networks of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse, and utilize technology</td>
<td>A tool to understand and manage radical socio-technical innovations and facilitate their diffusion.</td>
</tr>
<tr>
<td>Development and diffusion of innovation system is via a set of functions working in coherence such Guidance, Entrepreneurship, and Market Formation</td>
<td>Diffusion of technology is via societal experiments.</td>
</tr>
<tr>
<td>FIS Level: development and implementation of an innovation can be in different countries or the same.</td>
<td>SNM Level: focus on national level (market niche), regional level (several pilots) or local level (locally connected pilots) e.g. development of innovation system and implementation is in the same country or region, etc.</td>
</tr>
<tr>
<td>Entrepreneurial activity (one of the Functions) is sign of performance of the innovation system.</td>
<td>Continuous networking between feedback and learning indicate the sign of performance of the Innovation System.</td>
</tr>
</tbody>
</table>

Table 28: Comparison between FIS and SNM

In order to answer the mentioned challenges, this study proposed a new integration model which was built. The model makes possible to integrate the Multi Level Perspective (MLP), Strategic Niche Management (SNM), technology and strategy, and business model theory in the context of innovation process as it is given in Figure 18. If one looks at the whole process, it is true that the technology strategy and business model theory contribute to improve the socio-technical study by emphasizing on the individual level or actor level. In return, the socio-technical study provides the technology strategy and business model theory to look at a broader context in which the three development levels, named macro, meso, and niche level, can play a significant influence for achieving the objective of the firms or organizations. Hence, this research study brought some new insight to the actors on how to commercialize the potential products or services by involving technology strategy and business model theory into the framework.

Finally, as it is given in earlier Figure 39, this study was able to give a new insight on how the monitoring department should look the innovation process and on how some analysis can be done to the current Dutch electric vehicle innovation system. However, since this study is only in the context of Dutch electric vehicle innovation system, some further works need to be done for validating the model.
9. Reflection, limitation and further research

In this section, the reflection, limitation, and further research are explained. First, the reflections on the current literature and theory are briefly elaborated. Second, the limitation of this study and further research are explored.

Reflection on the literature and theory

This study used a diverse range of articles to shape the scientific knowledge of this research study including Freeman (1987) and Lundvall (1992), Ortt (2007), Porter’s five force model (1998), Osterwalder (2010), Raven (2005) and Markard (2008). After having study the Dutch electric vehicle innovation system, a few things should be stressed:

Since the introduction of electric vehicles considered as a niche market, this study used articles from strategic niche management study, Raven (2005), to perform the analysis of the current Dutch EV innovation system. By applying the complementary framework, the MLP and SNM analytical framework, this study was able to successfully explore the ongoing developments around the Dutch EV industry. Nevertheless, the complementary framework was not able to answer the challenges on how to manage the successful experiments to be commercialized and how to guide the involved actors to become successful in the niche development. Therefore, this study carried out the innovation management and entrepreneurship study to answer those challenges by focusing on the strategy to commercialize the breakthrough technology and concentrating on the business practices. Articles from Ortt (2007) and Osterwalder (2010) were used to counter the mentioned challenges. Moreover, being consistent with Freeman (1987) and Lundvall (1992), this study promoted the importance of actor’s network. In the case of the Dutch electric vehicle developments, the completeness, the heterogeneity and the density of the network made significant influence to the large scale adoption of the EV.

In line with Markard and Truffer (2008), this study resulted in adding extra variation analysis to complete a common basic and context analysis from socio-technical study. Empirically illustrated by this research study, the value assessment of the potential developments had added an extra value to select the real “short-term” potential developments within Dutch electric vehicle innovation system. In this case, this study was able to apply the value net framework of Brandenburger and Nalebuff (1995), and Porter’s five force model (1998) as the criteria to evaluate the potential developments. The two mentioned articles were useful for analysing the potential developments by looking at factors necessary for a large-scale diffusion such as industry support and market force, but there was no clear extension to the institutional support. Therefore, by adding the government role, this study was able to extend the existing models. In the case of Dutch EV innovation system, the Dutch government had a significant role to align the activities in EV value chain and to spur off the innovation process.

Lastly, having to say that there is a limited academic literature which discovers the business model in the current EV development, this study added some extra value to the existing EV community by providing an insight for entrepreneurs or firms about various opportunities due to large scale EV introduction. Especially by applying the nine components of Osterwalder’s business model framework (2010), this study designed the charging infrastructure business model, mobility solution business model, and the two potential combinations of products and services business models.
Limitations and further research

A few limitations of this research study should also be stressed. First, it was related to the scope of this study, which is not including the energy sector. Through the research process, it was founded that the energy sector had a significant influence on the success of large scale EV introduction. Especially it was highly related to the potential developments that this study has discovered: smart charging and smart grid. Therefore, it is recommended for the future research to explore more details on this part of study.

Second, due to the fact that the potential developments were selected based on the twelve pilot projects and in relation with ICT developments; this study had some limitations with regards to the selection of the potential developments. As a consequence, other potential developments such as building a new car or other transportation products, and making the battery, were not fully discovered in this research study. Moreover, although this study used reliable candidates, in practice our respondents and data sources are all embedded in the current EV-ICT development and therefore subject to a natural bias in their views about the Dutch electric vehicle Innovation System. Those parties involved might have an interest in promoting the Netherlands as an EV-ICT industry.

Third, the business models in the area of electric vehicle is an extremely sensitive topic since many actors are not willing to talk about such issues especially if it is in a new business area where competition is still not defined properly. As the matter of fact, many experts that were interviewed were reluctant to disclose information. As a consequence, this study only received very limited input on the key aspects of certain business model elements. Furthermore, there is no real financial calculation on the current proposed business model. Hence, it is recommended for the future research to look at the shortcoming in the financial part of the two mentioned potential developments (products and services). In this case, it would be interesting to calculate the profitability of certain strategies.

Fourth, this research proposed an integrated model by combining four theoretical models: Multi Level Perspective (MLP), Strategic Niche Management (SNM), technology and strategy, and business model in the context of innovation process. Although this study successfully outlines a first step towards a more systematic analysis of actor strategies in sustainable transitions, some further works need to be done to validate the model. In other words, one should interpret this as a tool to support the analysis rather than a theoretical model that we would like to propose. Finally, due to the fact that collaboration among the key actors is seen as a real essential aspect for large scale adoption of the electric vehicle, evaluating the network formation and measuring the alignment of perspectives on the EV development over the time are recommended for future research.
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Appendix A – Theory description
In this part the SNM indicators are explained as follows:

**Dynamic of expectations** - User expectations are crucial for shaping a niche. They can help direct the learning processes, attract further attention to the technology and legitimise any protection or help offered to the niche (Schot and Geels, 2008). Indicators of this process include robustness, quality and specificity. The more supportive user expectations are or the more aligned, means the process and thus niche become more robust. The greater the amount of expectations gathered, from different varieties of users and stakeholders provides better quality evidence. Lastly, the more specific the expectations that are voiced, the better the focus of the niche can become (Kamp et al., 2012).

**Network formation** - An important outcome of this process is to build a social network that facilitates interactions between relevant stakeholders (Schot and Geels, 2008). There are a large number of network characteristics that can be used to analyse this process. These are including the number of actors, the type of actors, the power relations between actors, the strength of the linkages, the heterogeneity of the network, interdependency and alignment between the various actors. Indicators of this process are thus including composition and alignment (Kamp et al., 2012).

**Learning process** - For successful development of a technological niche learning must occur at multiple levels and dimensions (Raven, 2005). Experiments can be designed to learn about various aspects e.g. technological performance or economic feasibility. Ideally, this experiment will produce results and the actors can learn from the results to improve the technology development. As a result, the learning should improve the expectations (Kamp et al., 2012).

**Porter’s five force model**

According to Porter (1998) the five competitive forces, named the entry, threat of substitution, bargaining power of buyers, bargaining power of suppliers, and the rivalry among existing firms will determine the attractiveness of industry and these will directly influence the strategy of one company.

**Threat of entry**

The new potential entrants may reduce the profitability of the existing companies (incumbents). In this situation price competition can be appeared and then it may force the incumbent to take over the new entrants. Hence, the acquisition strategy might be applied for the incumbent to maintain its market position. However, the threat of entry depends on the barrier to entry that exists. If barriers are high, the threat of entry is low (Van Beers, 2011).

There are six major sources of barriers to entry including as follows (Van Beers, 2011):

**Economies of scale** – The decreasing in unit cost of a product as the volume of a product per period increases. This economic of scale prevents the entry by forcing its competitors or new entrants to accept a cost disadvantage. Thus, the new entrants are having a higher risk to entry the market.
Product differentiation – Occurs the existing firms or incumbents have been established its own brand reputation and customer loyalties. Hence, the new entrants need to spend extra capital to conquer the existing customer loyalties.

Capital requirement – The need to invest large amount of capital up-front e.g. R&D cost and inventory cost has a tendency to create barrier for the new entrants.

Switching cost – The presence of switching cost will create a barrier for the new entrants. The switching cost means one-time cost that buyer has to spend due to the switching from one supplier’s product to the others (Porter, 1998). The new entrants have to have better improvement products to compete against the current existing products or technologies.

Government or legal protection of incumbents – The government can protect the entry to the industry e.g. control the license or limits the access to the resources, and preferential subsidies to incumbent.

Steep learning curve – In some cases, the unit cost will decrease as the worker has more experience in producing a product. By gaining more experiment, the workers are becoming more familiar and more efficient with its work.

Threat from substitute products

The more substitute products available in the market, the less profits can be achieved on specific industry, especially if the price performance of the substitutes are more attractive than the existing one. Factor that affects the substitute product is industry elasticity of demand. This elasticity of demand means how responsiveness of the demand quantity of products or services regarding the change of unit price.

Bargaining power of buyers

In practice the buyer can force the price down and put the pressure to the industry. The switching cost may affect the bargaining power of buyers. In this case if buyer faces switching cost then it has less bargaining power and also if firm has differentiate product, then it has less buyer bargaining power (Van Beers, 2011).

Bargaining power of suppliers

The supplier can use its power for the industry by raising the price or reducing the quality of the products e.g. if there are less suppliers then there is more bargaining power of suppliers. Factors that affect this are the competitiveness of the supplier market, the purchase volume of the firms, and the relation with suppliers or specific investments (Van Beers, 2011).
The nine components of business model and its relations

The nine components will now be discussed briefly as follows:

**Customer segments (CS)** – This building block defines the customer segment(s) or which group(s) that an enterprise aims to reach and serve. This component strongly influences the choices made in the remaining business model components.

**Value proposition (VP)** – This component focuses on the uniqueness or the value added provided by the firms or organizations. Thus, this will give insight which value that the firms or organizations offer to its customers. This can be achieved through the elements such as newness, performance, customization, design, brand or status, price, cost reduction, risk reduction, accessibility, and convenience or usability.

**Channels (CH)** – This component shows the various ways to deliver the value proposition to the customer including communication, distribution, and sales channels. This is an important element in customer experience and thus it cannot be neglected. Firms or organizations can have their own channel or using other party’s channels.

**Customer relationship (CR)** – A firm or organization should be able to describe the type of relationship with its customer. This can vary from personal assistance to automated service or self-service and communities.

**Revenue streams (RS)** – This component is a result of the successful delivery the value propositions to the customer. Hence, this can be seen as a cash generator of a firm or organization or the cash inflow per customer segments. The factors that may affect this are resulted from fixed or dynamic price mechanisms. Fixed price is defined on static variable while the dynamic price is depending on the market conditions. The pricing strategy such as licensing, leasing, subscription fees, advertising, etc might be applied in practice.

**Key resource (KR)** – Resources such as physical, human, intellectual or financial assets which can be owned by the firms or leased from key partners are required to offer and deliver the previous mentioned elements.

**Key activities (KA)** – This component describes the most important actions that the firms or organizations must perform to gain its sustainable competitiveness. Similar with the key resources, the key activities will facilitate to achieve the desire value propositions, distribution channels,
customer relationships, and revenue streams. Examples of these activities are logistics, operations, marketing and sales, technology development, human resource management (HRM) and services.

**Key partnership (KP)** – Partners and suppliers can be considered as key partnerships especially when certain activities are occurred. The goals of this can be seen as the key process to deliver the value proposition. The reason to have key partnership are commonly because the willingness to optimize the process, gaining the economies of scale, reducing the risk and uncertainty or acquiring resources and activities.

**Cost structures (C$)** – The last component is cost structure. Hence, the whole process results in the cost structure in which revenues should exceed costs. Osterwalder (2010) divides two broad categories of cost structures, named cost driven and value driven. The cost driven can be seen as the activity to minimize the cost in every part of the business model while the value driven focuses on creating value for the selected customer segment.
## Appendix B – Stakeholder overview

In this appendix, the stakeholder overview including its interest, resources and contribution, and power position is given. The context is in the Dutch electric vehicle innovation system.

<table>
<thead>
<tr>
<th>Stakeholders</th>
<th>Interest</th>
<th>Resources &amp; Contributions</th>
<th>Power position</th>
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</thead>
<tbody>
<tr>
<td><strong>Government</strong></td>
<td>Ministry of Economic Affairs, Agriculture and Innovation</td>
<td>National government organization responsible for sustainable economic growth. Highly interested in the sustainable innovation, entrepreneurs, and international business and cooperation.</td>
<td>Support and Funding</td>
</tr>
<tr>
<td></td>
<td>Ministry of Education, Culture and Science</td>
<td>National government organization responsible for education, culture and science. Highly interested in the EV initiative and willing to increase Dutch Human capital.</td>
<td>Support and Funding</td>
</tr>
<tr>
<td></td>
<td>Ministry of Infrastructure and Environment</td>
<td>National government organization responsible for infrastructure and environment. Interested in the Introduction of EV by supporting the entire related infrastructure.</td>
<td>Support and Funding</td>
</tr>
<tr>
<td></td>
<td>Local government</td>
<td>Administrative authority of local area. Interested in promoting the EV in the city.</td>
<td>Support and Funding</td>
</tr>
<tr>
<td></td>
<td>European Union</td>
<td>European commission who is interested in implementing sustainable transportation and concerned about the environment.</td>
<td>Support and Funding</td>
</tr>
<tr>
<td><strong>Researches</strong></td>
<td>TU Delft, TU Eindhoven, TU Twente</td>
<td>Agreement to collaborate and support the introduction of EV.</td>
<td>Supply professors, professional, students, knowledge and funding</td>
</tr>
<tr>
<td></td>
<td>Research Institute e.g. TNO</td>
<td>Collaboration with university and government to focus on applied research in automotive industry.</td>
<td>Supply network, Knowledge and funding</td>
</tr>
<tr>
<td></td>
<td>Polytechnic institutions e.g. HAN University, Fontys Hogeschool, and Hogeschool Rotterdam</td>
<td>Collaboration with the Universities, and research institute to prepare Human capital in EV industry.</td>
<td>Supply professors, professional, students, knowledge and funding</td>
</tr>
<tr>
<td></td>
<td>OEMs/Integrators e.g. DAF, VDL, Spijkstaal, Innosys Delft, Gemco E-Trucks, etc</td>
<td>Companies which have interest in manufacturing electric vehicles.</td>
<td>Deliver electric vehicle in the market</td>
</tr>
<tr>
<td></td>
<td>Supplier to vehicle design e.g. Bosch Trans Tech, Akzo Nobel,</td>
<td>Companies which are interested on the design part of the electric vehicle.</td>
<td>Supply components or materials</td>
</tr>
<tr>
<td>Firm</td>
<td>Supplier to vehicle interface e.g. TomTom, NXP, Peek Traffic and Vialis, etc.</td>
<td>Companies which are interested in electronic and software and often applied to the interface of the vehicle with its environment.</td>
<td>Supply electronics and software for electric vehicle</td>
</tr>
<tr>
<td>-------</td>
<td>---------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Supplier for battery power e.g. ACTIA, MasterVolt, Philips, etc.</td>
<td>Companies which are interested in Battery performance of electric vehicles.</td>
<td>Supply battery power for electric vehicle</td>
</tr>
<tr>
<td></td>
<td>Firms such as Corus, DSM, Vredestein, SKF, and etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Service Providers</td>
<td>Insurance companies/lease agency e.g. Lease Plan, Athlon Car lease, etc</td>
<td>Organizations or Companies who are interested to deliver services for insurance of electric vehicle.</td>
<td>Service</td>
</tr>
<tr>
<td>Infrastructures Providers</td>
<td>Electricity supplier e.g. Nuon, Essent, Eneco</td>
<td>Organizations or Companies who are interested to deliver energy supply for electric vehicle.</td>
<td>Service and Supply electric power</td>
</tr>
<tr>
<td>Charge pole manufacturers e.g. Alfen, Epyon</td>
<td>Organizations or Companies who are willing to provide charging point for recharging the battery of electric vehicle.</td>
<td>Service and supply electric power</td>
<td>Production</td>
</tr>
<tr>
<td>Distribution systems operators e.g. TenneT and Enexis</td>
<td>Organizations or Companies who are able to deliver system operators for energy supply.</td>
<td>Service and information</td>
<td>Production</td>
</tr>
<tr>
<td>Lead User</td>
<td>Government, Lease agency, and taxi companies</td>
<td>Users that face needs that indicate general demand in the market place.</td>
<td>Support and delivery a valuable insight regarding a solution of the technology needs</td>
</tr>
<tr>
<td>End-User</td>
<td>Customer</td>
<td>User that is willing to use electric vehicle and services.</td>
<td>Important for the success of electric vehicle, feedback</td>
</tr>
<tr>
<td>Local community</td>
<td>Customer</td>
<td>Local people in every region or city in which is interested in the implementation of electric vehicle.</td>
<td>Support and Important success of introduction electric vehicles in large scale, feedback</td>
</tr>
<tr>
<td>NGOs</td>
<td>Greenpeace, Stichting Natuur &amp; Milieu</td>
<td>To protect the social interest and ecological. Benefit by their support.</td>
<td>Either support or block depend on the technology</td>
</tr>
</tbody>
</table>

Dutch electric vehicle innovation system
### Dutch electric vehicle innovation system

<table>
<thead>
<tr>
<th>Venture Capital</th>
<th>SET VP</th>
<th>Interest in investing money in valuable business model or companies (start-ups)</th>
<th>Support on management, network and funding</th>
<th>Diffuse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other competitors</td>
<td>Shell, BP, BMW, VW, Audi, Exxon Mobile</td>
<td>Companies who are interested in other alternative vehicles such as combustion vehicle, Hybrid, and bio fuels vehicles</td>
<td>Blocking. They need some time to accept the electric vehicle</td>
<td>Blocking</td>
</tr>
</tbody>
</table>
Appendix C – Overview of EV pilot projects

In this appendix various EV pilot projects which consist of ICT development are discussed. There are in total twelve EV pilot projects: Prestige GreenCab, Greenwheels, Amsterdam Electrics, Rotterdam Electrics, Electropool Haaglanden, CityShopper, Connected Cruise Control (CCC), 360 EVT - eVehicle Battery Monitoring en Control System, Dabox, Electrical Vehicles Intelligently Directed By E-ware Navigation Technology (EVIDENT), Innovation in the power train for EV, and Logica project. Each of them is described as follows:

1. Project Name: Prestige GreenCab

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Prestige GreenCab</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To stimulate fully electric vehicle and Plug-in Hybrid Electric Vehicle</td>
</tr>
<tr>
<td>Project Description</td>
<td>Prestige GreenCab invested in 18 electric vehicles and charging infrastructure. This project used 10 Mitsubishi i-MiEV’s and 8 Nissan LEAFs. The electric vehicles are used for hospital vehicle, Schiphol and hotel vehicles, commercial taxi, and company cars. This project was performed in Utrecht region.</td>
</tr>
<tr>
<td>Consortium</td>
<td>Prestige GreenCab, Stedin, Mitsubishi, Kyotolease, ABB/Epyon, Utecht Municipality, Renault, TNO, Essent, Tiodos Bank, Cap Gemini, Conclusion, Utrecht Bereikbaar, BP, e-laad.nl, and BYD.</td>
</tr>
<tr>
<td>Project Change</td>
<td>The result of this project was not performed as it was made at the project plan. Contrary from its original idea the Prestige GreenCab was less investing in the charging infrastructure. At the end the public charging infrastructures were invested by the Utrecht Municipality and Schiphol region. Other results of this project were successfully reducing the cost of the elective vehicle since it was successfully selling more electric vehicles and implementing a more sustainable energy e.g. using solar panel and wind in the charging infrastructures.</td>
</tr>
<tr>
<td>Bottlenecks</td>
<td>In practice the action range of the vehicles was not satisfied. This can be improved by implementing routing planning software in which ICT will play an important role. The Utrecht Municipality was not clear with the current policy for electric vehicle. Hence it resulted to the delay of the project especially with the permission to build the fast charging station. Not enough charging infrastructure can be seen as another barrier. Currently there were only around 6 fast charging stations in Utrecht region. Related to this situation not all electric vehicles can use the fast charging. This has to be improved by implementing more fast charging station in the Region.</td>
</tr>
</tbody>
</table>

2. Project Name: Greenwheels

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Collect Car (Greenwheels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To stimulate fully electric vehicle and Plug-in Hybrid Electric Vehicle in Amsterdam, Rotterdam, The Hague, and Utrecht</td>
</tr>
<tr>
<td>Project Description</td>
<td>Greenwheels invested in 25 electric vehicles and charging infrastructure. This project used Peugeot iOn’s as the testing car. Every car has its own parking places with normal charging point. The parking place is built in the public places. Every charging point can be used for two cars at the same time.</td>
</tr>
<tr>
<td>Consortium</td>
<td>Greenwheels, Peugeot, Essent and Municipalities: Amsterdam, Rotterdam, The Hague, and Utrecht</td>
</tr>
</tbody>
</table>
Bottlenecks

- In practice there is a delay in the project since not all charging point can be directly implemented.
- It remained unclear regarding the ownership charging point on the public place.
- Attaching and detaching the cable during the charging process.

3. Project Name: Amsterdam Electrics

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Amsterdam Municipality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2009</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To stimulate the introduction of EVs in Amsterdam in order to reduce the air pollution and emission.</td>
</tr>
<tr>
<td>Project Description</td>
<td>The taskforce “Amsterdam Elektrich” was founded to stimulate the introduction of EVs. The first target is to have 10,000 EVs in Amsterdam by 2015 and the second target is that 5% of the driven city kilometres is made by EVs in 2015. Amsterdam Elektrisch has relations with most of the actors in the network, since the start of the taskforce in 2009. Ties can be divided in operational ties and strategic ties. Operational ties are formed with actors like Nuon, the districts of Amsterdam and Liander, about the installation of the charge points. The strategic ties are formed with E-laad, Formule E-team and also energy companies like Nuon and Liander. The strategic ties are formed to create standards and synchronization with other EV charge infrastructures in the Netherlands. The difference between operational and strategic ties is the frequency of interaction and the level of involved personnel. Operational ties are more frequent compared to strategic ties. The last type of relationship is with the mobility service providers (MSP). These actors are helping customers with their needs concerning EV. Requests for charge points or subsidies are submitted by MSP’s. But also the municipal EV fleet is maintained by the MSP’s.</td>
</tr>
<tr>
<td>Consortium</td>
<td>Alliander, Nuon, Essent, The New Motion, Mister Green, Elmonet, EV-Box, Coulomb, RWE, ABB Epyon, Nissan, Mitsubishi, ANWB, e-laad.nl, Amsterdam Municipality, Travel Card.</td>
</tr>
</tbody>
</table>

4. Project Name: Rotterdam Electrics

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Stedin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To stimulate fully electric vehicle and Plug-in Hybrid Electric Vehicle in region Rotterdam and to gain experience in charging infrastructure including customer identification and payment system. Further, the project is also aimed to get experience in smart grid as well as to gain insight in the air quality inside the city environment.</td>
</tr>
<tr>
<td>Project Description</td>
<td>The consortium tested 75 electric vehicle and plug-in hybrid vehicle from various models and brands. 30 of these electric vehicles were funded from the testing ground project. The vehicles were used as car pools for the employees e.g. company car for technician at Eneco and Stedin and company car for delivering services at Municipality. On the charging infrastructure: there were 54 charging stations placed across the three consortium partners and it was mainly placed on their private places. The normal charging point was used and each charging point could be used for two cars at the same time.</td>
</tr>
</tbody>
</table>
### Dutch electric vehicle innovation system

|------------|--------------------------------------------------------------------------------------------------|
| Bottlenecks | • Consequences from the All Green Vehicle (AGV) bankruptcy. This had implications on the maintenance, services and monitoring on charging station.  
• Obtaining the permission on charging stations outside the Rotterdam Region. |

5. **Project Name: Electropool Haaglanden**

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Ontwikkelsmaatschappij Den Haag</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To stimulate fully electric vehicle and Plug-in Hybrid Electric Vehicle in region The Hague and to gain experience on charging infrastructure.</td>
</tr>
<tr>
<td>Project Description</td>
<td>The consortium tested 11 pool cars. The electric vehicles were coming from various models. With regard to charging point, there were in total of 12 normal charging point installed in the private place.</td>
</tr>
</tbody>
</table>
| Bottlenecks   | • Realization on public charging station was costing more time than the expectation.  
• The Hague municipality had no clear policy on electric vehicle and there were not enough charging point in the public places. |

6. **Project Name: CityShopper**

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Cornelissen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To stimulate fully electric vehicle and Plug-in Hybrid Electric Vehicle in region Nijmegen and to gain experience on charging infrastructure.</td>
</tr>
<tr>
<td>Project Description</td>
<td>In this project 7 electric vehicles were tested for distribution and logistics purposes at AlbertHeijn company within Nijmegen region. The charging points were installed in the Cornelissen distribution central in Nijmegen. Smith Newton and Renault Maxity were tested in this project</td>
</tr>
<tr>
<td>Consortium</td>
<td>AlbertHeijn, Nijmegen Municipality</td>
</tr>
</tbody>
</table>
| Bottlenecks   | • The price of electric vehicle is too expensive  
• The range and the capacity to charge were limited  
• There were some issues related to the policy category on the driver license. |

7. **Project Name: Connected Cruise Control (CCC)**

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Delft University of Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2009</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To implement the CCC application in electric vehicle and to reduce traffic congestion on the road by 30%.</td>
</tr>
<tr>
<td>Project Description</td>
<td>In this project the CCC application was developed. This application was developed within the vehicle system that can look beyond the direct predecessor of a vehicle and use the information to give advice to the driver on the speed, headway, and lane. As a result the CCC application was expected to reduce the traffic congestion delay by 30%.</td>
</tr>
<tr>
<td>Consortium</td>
<td>Delft University of Technology, Eindhoven University of Technology, University of Twente, Navteq, NXP Semiconductor, TNO, and SME’s (SAM, Technolution,</td>
</tr>
</tbody>
</table>
### Dutch Electric Vehicle Innovation System

**Clifford).**

<table>
<thead>
<tr>
<th>Project Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Architecture, interface specifications and software solutions, and connected infrastructure communication.</td>
</tr>
<tr>
<td>- Demonstration of connected cruise control that provides advice on speed, headway, and lane use.</td>
</tr>
<tr>
<td>- On-line traffic flow state estimation model.</td>
</tr>
<tr>
<td>- User interface which enables the interaction with the drivers (Human Machine Interfaces / HMI).</td>
</tr>
</tbody>
</table>

8. **Project Name: 360 EVT - eVehicle Battery Monitoring en Control System**

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Sycada</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Start</strong></td>
<td>2010</td>
</tr>
<tr>
<td><strong>Project Goal</strong></td>
<td>To develop a real time battery monitoring system and user interfaces for large scale introduction of electric vehicles.</td>
</tr>
<tr>
<td><strong>Project Description</strong></td>
<td>In order to solve the current barriers related to the range anxiety, the total innovation system has to be developed. Hence, Sycada introduced a new innovation solution, named an intelligence battery monitoring and control system. This technology innovation was expected to deliver a total concept by implementing an integrated solution among the electric vehicle innovation system. The concept is derived to accelerate the introduction of EV’s on an International scale. By being involved in various EV initiatives across Europe, this project will provide unlimited support infrastructure to all stakeholders in the EV value chain: Vehicle and Battery Manufacturers, Lease companies, Local Government and Drivers. Each party benefits from the lessons learned as well as the scale and scope pertaining from EV projects and roll-outs across Europe.</td>
</tr>
<tr>
<td><strong>Consortium</strong></td>
<td>Sycada, The New Motion, RDM Automotive, ZEM.</td>
</tr>
<tr>
<td><strong>Project Deliverables</strong></td>
<td>360°EV Platform-as-a-Service - driver support &amp; Battery Health Predictions. Sycada was providing a plug &amp; Play telematics platform for e-vehicle introduction and support. The 360°EV platform addresses two important barriers to mass-market introductions of electrical vehicles, named range anxiety of drivers and limited insight to battery health of OEM’s and lease companies.</td>
</tr>
<tr>
<td>     </td>
<td>Driver Web Portal &amp; Mobile Applications supporting:</td>
</tr>
<tr>
<td>     </td>
<td>- Charge point finder</td>
</tr>
<tr>
<td>     </td>
<td>- State-of-charge driven trip planning &amp; navigation</td>
</tr>
<tr>
<td>     </td>
<td>- Drive and charge style suggestions for extending battery life</td>
</tr>
<tr>
<td>     </td>
<td>- Mobile alerts (charging events, SoC alerts)</td>
</tr>
<tr>
<td>     </td>
<td>Vehicle &amp; Battery Monitoring supporting:</td>
</tr>
<tr>
<td>     </td>
<td>- Detailed EV usage statistics (drive &amp; charge style)</td>
</tr>
<tr>
<td>     </td>
<td>- Driver efficiency analysis (comparative)</td>
</tr>
<tr>
<td>     </td>
<td>- Battery health scorecard</td>
</tr>
</tbody>
</table>

9. **Project Name: Databox**

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>MisterGreen Holding B.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Start</strong></td>
<td>2010</td>
</tr>
<tr>
<td><strong>Project Goal</strong></td>
<td>To make electric vehicle affordable and sustainable.</td>
</tr>
<tr>
<td><strong>Project Description</strong></td>
<td>High price of electric vehicle is not attractive to the consumer. Hence in the current automotive industry, the combustion engine vehicle becomes clearly a dominant. In this project, introducing a battery management system (databox)</td>
</tr>
</tbody>
</table>
Dutch electric vehicle innovation system

can be seen as a solution to make electric vehicle affordable and sustainable by estimating real time data information, providing longer battery lifetime, improving battery lifecycle and creating a second-life battery.

Consortium
MisterGreen, Technolution, SP innovation, Wetac Motive Power, Miton, Delft University of Technology, KEMA, and TNO.

Project Deliverables
Architecture, software solutions, communication protocols, and user interfaces.

10. Project Name: Electrical Vehicles Intelligently Directed By E-aware Navigation Technology (EVIDENT)

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>TomTom International B.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To become solution of range anxiety in the current electric vehicle barrier</td>
</tr>
<tr>
<td>Project Description</td>
<td>EV is a new technology to enter the mobility world, which until recently has remained too limited in range and performance to be a viable solution. With several major automotive manufacturers are now releasing their first production cars, TomTom, TNO, e-laad.nl and Quipment are working together to ensure that the driver’s experience of an electric vehicle is simple, enjoyable, and stress free. The aim of the EVIDENT project is to promote the acceptance of electric vehicle economically and environmentally friendly manner. The project has the following specifics goals: • Minimize drivers of range anxiety in EV by introducing intelligence navigation solutions and providing feedback to the driver to ensure they reach its destination with confidence. • Improve the effective range of the EV through the combination of advanced vehicle modelling and intelligent navigation technology. • Optimize the usage of available charging stations and planning of charging infrastructure by using intelligence navigation, up-to-date information on the availability of charge points and reservations services. • Design a platform for professional public mobility in future green zones to enable the expansion of environmentally protected areas and support new business opportunities to exploit these. Target market: earlier taxi transportation (Prestige Utrecht) and OEM (Renault) Further, this project was able to boost the driver guidance and vehicle efficiency areas of the HTAS programs, and contributed to the EV technology strategic objectives.</td>
</tr>
<tr>
<td>Consortium</td>
<td>TomTom, TNO, e-laad.nl, and Quipment.</td>
</tr>
<tr>
<td>Project Deliverables</td>
<td>• Generic power consumption model for EV – Aims: to predict the amount of energy needed to travel over a certain route or to predict the remaining driving range. This model uses an adaptive strategy to constantly improve accuracy between computed data and the measurement data. • A route planner for EV, taking vehicle’s power consumption model into account. • Geographic map extensions (new parameters relevant for EV). • EV service concept (reservation, dynamic availability). • Eco coaching (To driver and vehicle component). • Field trials with earlier market users. • An open access portal to real time data of public charging points.</td>
</tr>
</tbody>
</table>
11. Project Name: Innovation in the power train for EV

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>All Green Vehicles B.V.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2010</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To create an integrated power train</td>
</tr>
</tbody>
</table>
| Project Description  | This project is related to the HTAS project under electric vehicle theme. The market of EV power train technology component will be expected to be grown in the next 10 year development. According to recent study, the market for this power train component will soon be worth around €20 to €50 billion a year in the world.

In order to gain the market position, the actors on this project are willing to invest in the power train technology project. By doing this project they expect to build the knowledge around this power train technology.

The scope of this project is including the energy management system, electro-motor, the mechanism of transmission, the network, and the charging interfaces. The end product of this project will create an integrated EV power train. Subsequently, the Netherlands can be expected to extend the supply of power train components in the EV market globally.

|-----------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Project Deliverables  | • Charging – The new fast charging solution is a priority since in the current situation there is less innovated solution in this area.  
• Design Battery pack and battery management 
• Power switches 
• Electro-motor and power electronics 
• Energy recuperation 
• Transmission technology 
• Integration within the vehicle |

12. Project Name: Logica Project

<table>
<thead>
<tr>
<th>Project Leader</th>
<th>Logica</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Start</td>
<td>2008</td>
</tr>
<tr>
<td>Project Goal</td>
<td>To develop an end-to-end solution for electric vehicle charge point infrastructure.</td>
</tr>
<tr>
<td>Project Description</td>
<td>This project focuses on the information exchange between charge points and the infrastructure management system. Specifically it emphasizes on the privacy and security – identification and authorisation, remote management and transaction processing.</td>
</tr>
<tr>
<td>Consortium</td>
<td>Logica, Enexis, E-laad.nl, and Alfen.</td>
</tr>
<tr>
<td>Project Delivery</td>
<td>This pilot project was successfully delivered. The project was resulted on a request and agreement from the foundation E-laad.nl to develop the information and communication technology (ICT) infrastructure for the roll-out of a national grid of 10,000 charge points in the Netherlands. The total concept of this pilot project was named as the Charge point interactive Management System (CiMS).</td>
</tr>
</tbody>
</table>
Appendix D – Overview of potential products or services

In this appendix, the overview of each potential products or services is given including the criteria score. Here, the prior study of D-incert and the investigated EV pilot project are used as the main inputs for evaluating each potential products or services. In the following paragraphs, each of them is discussed as follows:

1. Future power train - In the future power train lots of improvements can be developed to make the power train more compact, cleaner, lighter and cheaper. Focusing on the improvement of technology components such as integrated power train with energy management system might be beneficial for the future electric vehicle.

   - **Market size**: The market of EV power train technology component will be expected to be grown in the next 10 year development. According to recent study, the market for this power train component will soon be worth around €20 to €50 billion a year in the world. Currently there is a small amount of potential export on this technology but it may increase in the future.

   - **Competition**: In the Netherlands only small players are involving in this technology development. Drive train Innovations and NXP semiconductor are both playing an important role for this technology development. Further, development can still be expected to improve parts of power train technology components. Accordingly, there are opportunities for new entrants.

   - **Resources**: Knowledge and talented labour are available in the Netherlands. Support from the government can be seen in the form of subsidy.

   - **Integration**: Integration with other EV components is high since there is a strong synergy and collaboration with other EV components e.g. transmission technology, battery technology, and ICT.

2. Battery Information Interface (BII) - This is a product (software) or service which can give an overview of important information about the battery conditions. The technology developments within this BII can include the control and power conditioning system, the battery storage, and the range. Herein, the focus is on the human-battery interaction.

   - **Market size**: There is a large acceptance in the market for this technology development. Possible development growth as well as market growth can be expected in the near future. There is a direct relation to the other innovation development areas like connected EV, smart charging, and battery management system. Export potential is recognized by the integrators or OEMs.

   - **Competition**: There is a tight competition to maintain the top position in the market. Innovation strategy can be improved in the near future since in the current situation there is still small collaboration between industry players. However, the protection to the Intellectual Property (IP) might be difficult to be applied.
Dutch electric vehicle innovation system

- **Resources**: Knowledge and talented labour are available in the Netherlands but there are lacks of capital sources and lacks of available data information relate to the technology itself.

- **Integration**: Possibility to collaborate with different key players in semiconductor (NXP), smart charging (ABB/Epyon), navigation system (TomTom), and mobile application (Sycada).

3. **Battery Management System (BMS)** – This is a product (software and micro-electronics) or service which is integrated inside the battery cell or battery pack. This BMS provides solution for the optimization of the battery usage by estimating real time data information, providing longer battery lifetime, improving battery lifecycle and creating a second-life battery. In other words, the efficiency (range), the durability, the cost structure of an electric vehicle is directly influenced by this BMS development.

- **Market size**: There is a large acceptance in the market for this technology development. This technology is growing in the line with the growth of EV development. There is a direct relation with other innovation areas such as connected EV, smart grids, and battery management. There is a strong domestic demand on this technology and there is a huge export potential as well.

- **Competition**: Average competitive market especially from Asian countries e.g. South Korea, Japan, and China. Hence, Intellectual Property plays an important role for the developments. Possible development should be integrated with developments from outside the country.

- **Resources**: Knowledge and talented labour are available in the Netherlands. For examples: NXP semiconductor, Philips, and Technolution.

- **Integration**: An integrated solution has to be established with other key actors including universities or public research institutes and other firms.

4. **Driver Guidance System (DGS)** – This is a product (software) or service which provides necessary information about the availability of charging points including time and place. This product or service is integrated with the routing plan, navigation system, and the driving behaviour of the user. Further, this DGS can also be integrated to other services such as mobile services and infotainment.

- **Market size**: At this moment the market size is still limited since the development is still in the innovator or development phase. Relation to other innovation development areas is possible e.g. with Integrated electric mobility, connected electric vehicle, smart charging, and battery management. Potential export can be integrated with the OEMs or integrators.

- **Competition**: There is an average competition. The new player such as Google and other Smartphone firms are expected to involve in this technology innovation. However, the Netherlands still can maintain its current position since there are some innovating firms e.g. TomTom and Navteq which are still the leaders in this technology. Intellectual Property plays an important role for maintaining their position.
• **Resources:** Knowledge and talented labour are available in the Netherlands. These have a strong relation an attractive Dutch ICT sector. Source of capitals is coming directly from the established company e.g. TomTom and also from the government through its subsidy program.

• **Integration:** There is a strong collaboration with different EV components e.g. navigation system, router planning, and mobile communication network. International collaboration can also be seen as an interesting aspect for this technology development.

5. **Smart charging** – This is a product or service which can provide ease of use, reliable, and secure charging infrastructure. This smart charging can be built on the road, parking place, house, and other public places.

• **Market size:** In the current situation the market is still limited. However, the market is expected to be grown in the near future. Relation to other innovation areas can be established e.g. combination with connected EV and smart grid. There is a potential export in the future development.

• **Competition:** There is a high competition for slow charging market as well as for the fast charging market. In additional, for the battery swap there is a limited competition. Another competition can also be found in the control and maintenance services for this smart charging.

• **Resources:** Knowledge, sources of capitals for R&D and talented labour are available in the Netherlands. The government supports can be seen via subsidy programs. However, there is no viable business model yet.

• **Integration:** The collaboration with various key actors e.g. with energy suppliers, infrastructure, product or services developers are possible in this product innovation.

6. **Financial services** – This is a financial service which can support a new business model for the battery-packs investment, charging infrastructure, local smart grids, and lease mobility model.

• **Market size:** The market of this development is growing with the EV development. Financial sector is the only sector which contributes directly to this development.

• **Competition:** Tight competition can be expected in this development especially in the domestic market. The growing on the market size will depend on the future development focus (in Asian countries).

• **Resources:** Knowledge, sources of capital, talented labour, and government support are highly available in the Netherlands.

• **Integration:** There is a potential collaboration with other commercial actors from financial or ICT sector in the Netherlands.
7. **Payment service** – This is a service which is related to the transaction (payment) process at the charging station. This payment service should deliver a reliable and a simple payment process. For examples: payment to the charging station can be done by applying a subscription model or simply include the charging price inside the lease price. Further, another possibility is that this payment service can also apply for mobile payment service.

- **Market size**: The market size is huge, attractive, and still expected to growth with the EV development. There is a huge export potential in this development.

- **Competition**: There is a tight competition since various commercial or financial sectors and ICT sectors can deliver an innovated solution in this payment service. This payment service has a highly dependency on which specific development will be implemented in the future.

- **Resources**: Knowledge, sources of capital, talented labour, and government support are high available in the Netherlands.

- **Integration**: There is a potential collaboration with other commercial actor from financial or ICT sector in the Netherlands.

8. **Mobility services** - This is a service which delivers an integrated solution with other alternative transportations e.g. trams, bus, and train, and with other public places e.g. parking place, restaurant, and office building. Hence, this mobility services can provide a sustainable solution for the whole mobility demands in the future.

- **Market size**: The market size is huge, attractive and it is expected to grow as the EV market grows. Lots of possible developments can be improved in the near future. There is a huge export potential in this development.

- **Competition**: There is an average competition in the market since new entrant or start-ups can entry to the market. Commercial actor from Financial, ICT, and automotive sector are possible to provide solutions by using its own expertise and knowledge.

- **Resources**: Knowledge, sources of capital, talented labour, and government support are highly available in the Netherlands.

- **Integration**: There is a potential collaboration with other commercial actors from financial or ICT sector in the Netherlands.
Appendix E – Invitation letter and interview protocol

Sample of the Invitation Letter

Dear Mr/Mrs,

My name is Ferdian Suprata and I am a second year Management of Technology master student at TU Delft. Currently I am doing my master graduation internship at NL Agency. I have got your contact information from my colleagues at NL Agency and d-incert who recommend me to conduct interview session with you. Accordingly, within this letter I would like to invite you to participate in this research study on Dutch Electric Vehicle Innovation System.

Many technology developments within electric vehicle (EV) innovation system such as future power train, Battery Information Interface (BII), Battery Management System (BMS), Connected Cruise Control (CCC), Driver Guidance System (DGS), smart grids, smart charging, financial service, payment service, mobility service, and many more are integrated with Information and Communication Technology (ICT). This integration can be seen as the total concept of electric vehicle innovation system in which will add a synergy and become a solution to the drawback of the main barriers, named inferior battery technology, limited ranges (range anxiety), lack of market, lack of infrastructure, and affordability. Subsequently, several countries including the Netherlands are willing to discover the opportunities within this emerging market.

Nevertheless, even though the importance of ICT within EV innovation system is identified properly, several challenges are emerged: what are the immediate or short term opportunities and the potential business models. Accordingly, NL Agency on behalf of the Dutch Ministry of Economic Affairs, Agriculture, and Innovation conducts a scientific research to explore the potential success of ICT technology developments in the Dutch electric vehicle innovation system.

The research is organized as follows. Researcher invites potential candidates from various companies to participate. Participating candidates are asked to answer several interview questions within one hour. All interviews will be conducted in English and will use semi-structure interview form. Your answers to the questions are confidential and will be used for anonymous research purposes only. As a participant of this research you will receive a report with the findings.

I hope you would like to participate in this research study.

Best regards,

Ferdian Suprata
+31 642 307 003
Interview Protocol

Interview questions related to the potential success of ICT developments in the Dutch electric vehicle innovation system

Many developments within electric vehicle (EV) innovation system such as future power train, Battery Information Interface (BII), Battery Management System (BMS), Connected Cruise Control (CCC), Driver Guidance System (DGS), smart grids, smart charging, financial service, payment service, mobility service, and many more are integrated with Information and Communication Technology (ICT). This integration can be seen as the total concept of electric vehicle innovation system which will add a synergy and becomes a solution to the drawback of the main barriers, named inferior battery technology, limited ranges (range anxiety), lack of market, lack of infrastructure, and affordability. Subsequently, several countries including the Netherlands are willing to discover the opportunities within this emerging market.

Nevertheless, even though the importance of ICT within EV innovation system is identified properly, several challenges are emerged: what are the immediate or short term opportunities and the potential business models. Accordingly, NL Agency on behalf of the Dutch Ministry of Economic Affairs, Agriculture, and innovation conducts a scientific research to explore the potential success of ICT technology developments in the Dutch electric vehicle innovation system.

The research study is conducted in cooperation between Delft University of Technology and NL Agency. The main research question that has to be answered is as follows:

*What are the prosperous business growth potentials for the promising developments (products or services) within the Dutch electric vehicle innovation system?*

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<thead>
<tr>
<th>Name:</th>
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<tbody>
<tr>
<td>Function:</td>
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<tr>
<td>Actor:</td>
<td></td>
</tr>
<tr>
<td>Company:</td>
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</tbody>
</table>
General information related to the process of the Interview

The use of voice recorder

During the interview session, interviewee will be asked for the permission of using video recorder. The main reason to use this voice recorder is for reviewing the collected data during data processing and to ensure all the findings are included in the data analysis phase.

Data confidential

The answers to the questions are confidential and will be used only for research purposes. This means that the answer will not be delivered to other parties and the answer could be checked by the interviewee. As a result, the summary of each interview sessions will be added in the appendix of the final research report.

Language

All interviews will be conducted in English and will use semi-structure interview form.

Time and programs

Generally each interview sessions takes approximately one hour. The first 10 minutes will be used for the introduction, 40 minutes will be used for question and answer session (core interview), and the last 15 minutes will be used for concluding the interview session.

Questions

The questions will be constructed as follow:

A. Questions related to the visions and expectations
B. Questions related to the developments (products or services)
C. Questions related to Business Models (the selected development)

Contact Information researcher

<table>
<thead>
<tr>
<th>Name:</th>
<th>Ferdian Suprata</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major of study:</td>
<td>Delft University of Technology</td>
</tr>
<tr>
<td></td>
<td>Faculty: Technology, Policy, and Management</td>
</tr>
<tr>
<td></td>
<td>Programs: Msc. Management of Technology</td>
</tr>
<tr>
<td>Telephone number:</td>
<td>+31 642 307 003</td>
</tr>
<tr>
<td>Email address:</td>
<td><a href="mailto:Ferdiansuprata-1@student.tudelft.nl">Ferdiansuprata-1@student.tudelft.nl</a></td>
</tr>
<tr>
<td></td>
<td><a href="mailto:f.suprata@gmail.com">f.suprata@gmail.com</a></td>
</tr>
</tbody>
</table>
Dutch electric vehicle innovation system

Interview Questions

A. Questions related to the visions and expectations

In the first three questions, the focus is on exploring the expectations and visions from each companies or organizations toward the introduction of electric vehicle in the Netherlands.

1. What is your company’s or organization’s contribution to the EV innovation system?

2. What are the future perspectives of Dutch automotive industry and Dutch ICT Industry?

3. What is the role of electric vehicle for introducing sustainable transportation in the Netherlands? (Advantages of electric vehicle compare with other alternatives)

B. Questions related to the developments (products or services)

EV literatures mentioned several main barriers, named inferior technology components (limited range, long recharge time, and high cost batteries), lack of infrastructure, lack of market, and lack of services, and affordability. Here, the aims for the next questions are to explore these barriers and to find potential developments (products or services) that may become innovated solutions.

4. What kind of other barriers do you think may still appear for introducing electric vehicle in the Netherlands?

5. Can ICT provide solution to answer those barriers? If yes, how can ICT provide solutions to those barriers?

6. Currently there are many potential developments, which are integrated with ICT, within Dutch electric vehicle innovation system. Some examples are future power train, Battery Information Interface (BII), Battery Management System (BMS), Connected Cruise Control (CCC), Driver Guidance System (DGS), smart grids, smart charging, financial service, payment service, mobility service, and many more.

Related to those potential developments: do you have other ideas for other potential developments?

If yes, which development is that? (Short-term opportunities or long-term opportunities)

If no, which developments from the mentioned developments, do you think the most potential for the Netherlands? (Short-term opportunities or long-term opportunities)

C. Questions related to Business Models (the selected development)

As the potential development is selected, the following questions are relating for potential business models.

7. Which actors (companies or organizations) will have important role for the selected development?

8. How do you see the market force (acceptance, needs & demands, revenue attractiveness) for the selected development?
9. How do you see the industry force (resources, suppliers, competitors, substitutes, potential buyers) for the selected development?

10. Which competencies, that the Netherlands has, to bring the selected development be successful in the market?

11. What are the possible business models? (Strategic decision, value proposition, revenues)

12. Are there still any actors that resist to these developments?

13. How do you think the government can support?

Thank you for your participation
Appendix F – Contribution of each company or organization
In this appendix, the contribution of each company or organization to Dutch electric vehicle innovation system is given as follows.

<table>
<thead>
<tr>
<th>Category</th>
<th>Company or Organization</th>
<th>Contribution to EV Innovation system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>NL Agency</td>
<td>Part of Dutch Ministry of Economic, Innovation, and Agriculture NL Agency facilitates businesses, educational institutions and government for gathering information, getting advice, supporting financial, and networking, and regulation matters.</td>
</tr>
<tr>
<td>Automotive NL</td>
<td>Automotive NL is cluster organization for the Dutch automotive sector. This organization supports the Dutch automotive sectors by providing network, develop various projects, searching international partners, and promoting knowledge transfer.</td>
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<tr>
<td>Automotive NL</td>
<td>E-laad.nl foundation contributes to Dutch EV innovation system by implementing public charging infrastructure for electric vehicle as well as providing maintenance service around charging infrastructure.</td>
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<tr>
<td>Firm</td>
<td>ABB Epyon</td>
<td>ABB plays a vital role in the development of sustainable mobility by providing innovative and efficient technologies for EV charging infrastructure. Several innovation solutions are including: AC regular and DC fast charging stations, powerful network management software, flexible maintenance services portfolio and components.</td>
</tr>
<tr>
<td>Firm</td>
<td>Better Place</td>
<td>Better Place delivers services to enable EV adoption in the market, builds and operates the infrastructure and systems to optimize energy access and use, and works with the stakeholders to enable a compelling and integrated solution in EV.</td>
</tr>
<tr>
<td>Firm</td>
<td>Drive Train Innovations</td>
<td>The organization is committed and focused on the development and marketing of drive train innovation core technologies. For examples: multiple gears, PHEV structures, drivelines software, and integration projects.</td>
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<tr>
<td>Firm</td>
<td>EVConsult</td>
<td>The company contributes to the EV innovation system by providing a clear knowledge and network for the EV development. The main activity of the company is to give a strategic advice or project management to its clients (including SMEs and Incumbents, and Government) for organizing and implementing various EV pilot projects. Further, EV consult help its client formulating a sustainable objectives which can increase the success chance for the implementation of electric vehicle.</td>
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<tr>
<td>Firm</td>
<td>Innopay</td>
<td>Innopay is an independent consulting firm, specialized in payment and related transaction services. The company contributes to EV innovation system by providing an expert knowledge of online payment, e-invoicing, e-identity, mobile payment, cards and rules.</td>
</tr>
<tr>
<td>Firm</td>
<td>KEMA</td>
<td>KEMA is a global, leading authority in business and technical consultancy, testing, inspections and certification, risk management and verification around the energy value chain. The contribution to EV innovation system is providing a unique expertise and facilities for energy related e.g. battery technology, battery safety, grid connection, and demand and supply of the energy.</td>
</tr>
<tr>
<td>Firm</td>
<td>Logica</td>
<td>Logica is a global leader company which provides business and technology services. The company contributes to EV innovation system by developing the EV infrastructure supporting ICT systems for charge point operators like e-laad.nl with sufficient charging points across the country. In charging infrastructure developments the company has been actively developing innovated systems such as central back-office system and software system within the charging point station. Further, the company has been successfully introducing charge point interactive management system (CIMS) in the European market including the Netherlands, Belgium, Germany, and Luxemburg.</td>
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<tr>
<td>Firm</td>
<td>MisterGreen</td>
<td>MisterGreen Electric Lease is an independent leasing company specialized in electric cars. MisterGreen contributes to EV development by applying lease model to its client for any possible maintenance as well</td>
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<tr>
<td>Company</td>
<td>Description</td>
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<tr>
<td>Navteq</td>
<td>Navteq is a global leader for digital map, traffic, and location data. The companies can contribute a comprehensive digital map information for OEM or car manufacturers, portable or wireless company, internet providers, fleet companies and government agency.</td>
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<tr>
<td>NXP Semiconductor</td>
<td>NXP is an innovative company which provides an innovation solution for overall vehicle efficiency; reduce fuel consumption, CO₂ emissions and costs. Further, the company is also enabling seamless communication between internal and external systems, increasing safety, convenience and enjoyment of today’s motoring experience.</td>
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<tr>
<td>Prestige GreenCab</td>
<td>Prestige GreenCab is one of the taxi companies in the Netherlands that uses electric vehicles in the taxi market segment. The company has its contribution to EV innovation system as the lead user, investors and developing EV network.</td>
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<tr>
<td>Sycada</td>
<td>Sycada Green is a company that is entirely focused on helping the company to reduce the fuel cost and CO₂ emission. This is done in two ways: firstly the company facilitates its clients or customers for the introduction of electric vehicles and secondly the company provides the drive style analysis and feedback for its clients or customers to optimize the fuel consumption. Generally the clients are including the car manufacturer, fleet company, Lease Company, and individual EV users. The company has been actively for more than 15 years experience in the area of mobile data solution. Specifically in the EV market, Sycada has been involved in various EV projects such as battery monitoring system and driver support tools. Further within the HTAS program, the company has been successfully developed the 360-EVT platform which provides a solution among electric vehicle innovation system. Various products or services are developed in the last developments such as GPS navigation system, connected navigation, security system, and solution for EV infrastructure.</td>
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<tr>
<td>Syntens</td>
<td>Syntens encourages nascent entrepreneurs as well as incumbent entrepreneurs to introduce a sustainable company in the Netherlands. Contribution to the EV innovation can be achieved by supporting a large network of knowledge partners, research institutions, entrepreneurs, and industry.</td>
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<tr>
<td>TomTom</td>
<td>TomTom is the world’s leading supplier of in-car location and navigation products and services focused on providing all drivers with the world’s best navigation experience. Contribution to EV innovation system can be seen by delivering routing planning, reservation of charging station, providing guidance of use, and comprehensive navigation map.</td>
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<tr>
<td>Ubiqu Access</td>
<td>Ubiqu provides unique solution for safe and easy access, named qKey. This solution can be implemented to home, office, store, vehicle, and many more through an online service. Soon when the car is connected to other cars or its infrastructure, Ubiqu plays an important role for secure and easy mobile services through a mobile device e.g. mobile phone. Hence, the solution can reduce the start-up cost for charging infrastructure especially the payment service by eliminating the card cost.</td>
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</tr>
<tr>
<td>Delft University of Technology</td>
<td>Knowledge supplier and produce talented student with both a strong technical and business background. These students are prepared to become the next professional worker, professional researcher, and entrepreneurs who will undoubtedly contribute to the EV development.</td>
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</tr>
<tr>
<td>Eindhoven University of Technology</td>
<td>Knowledge supplier and produce talented student with both a strong technical and business background. These students are prepared to become the next professional worker, professional researcher, and entrepreneurs who will undoubtedly contribute to the EV development.</td>
<td></td>
</tr>
<tr>
<td>TNO</td>
<td>Knowledge supplier and consultant for the Dutch and European governments and companies in the field of sustainable mobility. The knowledge and expertise include the technology development, behavior aspects, mobility effects, environmental and sustainability aspects and innovation system.</td>
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</table>
Appendix G – The values of each business models

In this appendix, the values of each business models with regards to the potentials developments are given as follows. To be noticed: during the interview session, each of the codes was displayed in different variations and alternatives.

1. The Battery Information Interface (BII): this is a product (software or application) which can deliver important information about the battery conditions. Here, the focus is on the human-battery interaction.

![Diagram of Battery Information Interface (BII)]

**Current innovation phase:** innovation /market adaptation phase, a respondent mentioned that that the challenge is to move from earlier adopter to the earlier majority (crossing the chasm).

**Potential strategy:** a large number of respondents stated that there is high opportunity to export this product to the international market as well as to develop a collaboration strategy among two or more organizations for the improvement of this product. Further, it was suggested that this product has to focus on specific target market e.g. lease company, taxi company, electric bus and fleet company.

**Potential business models:** the respondents believed that there is a viable business model for this BII product. Several ideas were presented such as licensing or sell it to the OEMs and battery manufacturers.

2. The Battery Management System (BMS): this is a product (software or application) which is integrated inside the battery cell or battery pack. This BMS provides solution for creating electric vehicle more affordable and sustainable by estimating real time battery information, providing longer battery lifetime, improving battery lifecycle, and creating a second-life battery.
**Current innovation phase:** innovation / market adaptation phase, a respondent stated that the challenge is to start large scale off the products as an export product.

**Potential strategy:** several respondents mentioned that there is a tendency to apply a niche market strategy since this BMS product is highly related to the physical battery technology. Further, it was suggested to look at the market segment that greatly need this product e.g. taxi company, fleet company and Lease Company, and to develop a collaboration strategy with universities, public research institutes, and other firms.

**Potential business models:** a large number of respondents mentioned that there is a concrete business models for this product simply by license or sell this product to battery manufacturers or OEMs.

**3. Connected Cruise Controls (CCC):** this is an application which is developed within the vehicle system that can look beyond the direct predecessor of a vehicle and use the information to give an advice to the driver on the speed, headway, and lane.
Current innovation phase: innovation phase, the respondents stated that the challenge is on further improve the performance of the current product. Several respondents specifically discussed that this product may not be seen as a short-term opportunity but rather as a long term opportunity. The main argument was based on the fact that this product has to be integrated within the vehicle system.

Potential strategy: the respondents addressed that the Dutch government should invest in the university or public research institute (R&D) to facilitate further development of this product.

Potential business models: a large number of respondents argued that there is no feasible business model yet since this product is still in the innovation phase. However looking at the future opportunity the respondents mentioned that this product can be easily made revenue by license or sell it to the car manufacturers or OEMs.

4. Driver Guidance Systems (DGS): this is a product (software) or service which can provide necessary information about the availability of charging points including time and place and reservation system. This product or service is integrated with the routing plan, navigation system (including road overview and temperature information), real-time range estimator, and the driving behaviour of the user. Further, this can also be connected to other services such as mobile services and infotainment.

Current innovation phase: innovation phase. The availability data information is not ready.

Potential strategy: a large number of respondents suggested for applying product differentiation strategy. Nevertheless, since the EV market is still rather small, many respondents stated clearly that one has to focus on specific target market. Lastly, the majority of respondents stated that in order to successfully promote this product strategic alliance or open collaboration among various key actors is needed. Here, the risks or uncertainty for each actor can be diminished.
Potential business models: a large number of respondents mentioned that this product is highly potential for the Netherlands since there are number of innovated firms e.g. Navteq and TomTom who are still the market leaders in this field. However, several respondents are unsure about who will own the major benefits in this development field.

5. Financial services: this is a regular commercial financial service which can support the new business models such as investing in battery-packs, charging infrastructure and local grids, and lease mobility creation.

Current innovation phase: adaptation phase, the respondents stated that this service is in the market adaptation phase. Several respondents argued that this financial service can be comparable with the traditional financial services. However the respondents mentioned specifically that this is highly dependent on the growing of EV market.

Potential strategy: several respondents mentioned that the collaboration strategy and niche market strategy are both feasible for this service.

Potential business models: a large number of respondents discussed the potential business models for this financial service is by combining product and service models. In addition, other respondents stated there is a need to know the total cost of ownership which can help the investors to determine direct and indirect costs of the product or system.

6. Future power-train: this is a product, an integrated power train, which consists of the energy management system, the electro-motor, the mechanism of transmission, the network and the charging interfaces. This product is integrated within the vehicle components.
**Current innovation phase:** Innovation phase, a large number of respondents stated that this product is not seen as a short-term opportunity but rather as a long-term opportunity since this product is integrated inside the vehicle. It means that this requires a close relationship to the OEMs or car manufacturers. However, other respondents stated that this can become a breakthrough innovation for the future electric vehicle and has lots of influence to the performance of the upcoming electric vehicle.

**Potential strategy:** the respondents addressed that the Dutch government should invest in the university or public research institute research and development (R&D) to facilitate further development of this product. Further, a large number of respondents mentioned to promote collaboration strategy on this development field.

**Potential business models:** a large number of respondents argued that there is no feasible business model yet since this product is still in the innovation phase. However, looking at the future opportunity the respondents mentioned that this product can generate revenue by license or sell this product to the car manufacturers or OEMs.

**7. Payment services:** this is a service which can deliver a reliable and easier payment process. For example: this payment service can apply a smart monthly payment model which is integrated with smart-mobile applications. Further, within this payment service field, there are still lots of possibilities to develop various user applications that can support for most favourable transaction process of electric vehicle.
Current innovation phase: adaptation phase, a large number of respondents mentioned that this service is identical with the traditional payment service. Hence, only a small adjustment is needed to be implemented in the EV transaction process. In other words, this payment service can be seen thus as a direct short-term opportunity. Lastly, many respondents stated that the interoperability is the key success factor for this development service.

Potential strategy: several respondents mentioned that the collaboration strategy is needed especially with an innovated ICT firms and other commercial firms. Further, a large number of respondents mentioned that the Dutch government should promote a standard payment policy on the European level.

Potential business models: several respondents mentioned that a feasible business model can be achieved by implementing a subscription models or product and service models.

8. Re-use and recycling the battery: this is a product or service which focuses on recycling and reuses the material and component of battery.
**Current innovation phase:** innovation phase, several respondents mentioned that this product or service is seen as a long-term opportunity (at least more than 10 years). However a breakthrough development in this field is essential for the future of battery technology.

**Potential strategy:** a large amount of respondents mentioned that the Dutch government should invest on the university or public research institute (R&D) to facilitate further development on this field. Other respondents mentioned that a close international collaboration strategy among key stakeholders is needed to find a sustainable solution on this re-use and recycling battery technology.

**Potential business models:** a large number of respondents argued that there is no feasible business model yet since this product is still in the innovation phase. However, in order to generate revenue one can simply license or sell this product to the car manufacturers or battery manufacturers.

9. Smart charging: this is a product or service which can provide the ease of use, reliable, and secure charging infrastructure. This smart charging can be implemented in home, street, parking place, and other public places.

**Current innovation phase:** Innovation phase. A large number of respondents suggested that this products or services can still be improved by adding various “unique” applications or services within the charging product.

Several respondents mentioned that this smart charging can be seen as a short-term opportunity. The main reason, as it was discussed, is because they expect that the market will appear soon and the Netherlands is a potential candidate as a first-mover in this field.

**Potential strategy:** a large number of respondents mentioned collaboration strategy is a “must” for this smart charging field. Further, another respondent stated that it is necessary to look at the niche market strategy, and to orientate an international market. During the interview it was discussed that this field should be developed by the market since several respondents believed that the market can creatively develop this smart charging field.
Potential business models: several respondents mentioned that it is not straightforward to find a feasible business model on this field while others stated that the revenue model can be achieved by implementing a subscription models or product and service models. Other respondents mentioned the more one involves in service area, the more one can reap the benefits on this field.

10. Smart grids: this is a product (software) or service which can provide an innovated solution for charging and recharging process. In the emergency situation the electric vehicle battery can be expected to become a “smart” solution for the total energy infrastructure.

Current innovation phase: innovation phase, a large number of respondents stated that the smart grid is still in the innovation phase. Hence, most of them believed that this smart grid can be considered as a long-term opportunity. Further, a large number of respondents mentioned that the implementation of smart-grid will change the entire energy distribution and supply which can be occurred in the long period of time.

Potential strategy: a large number of respondents stated that there is a high possibility to promote a collaboration strategy among different parties including the energy suppliers, infrastructure manufacturers, and product or services developers. In addition, a large number of respondents discussed that it is needed to further discuss the energy distribution on the European Level.

Potential business models: the respondents argued that a feasible business model in this field cannot be achieved in the short time since it may change the current energy market in the Netherlands. However, several ideas were proposed such as implementing product and service pricing model, real-time payment model, and subscription business models. A smaller number of respondents mentioned that it is recommended to have a comparison study on the energy market which is applied for the Scandinavian countries such as Denmark and Norway.

11 Mobility services: this is a service which delivers an integrated solution with other alternative transportations e.g. trams, bus, train, etc, and with other public places e.g. parking place, restaurant, and office buildings. Hence, this can provide sustainable solution for the whole mobility demands in the future.
Current innovation phase: innovation phase, the respondents stated that this mobility service is still in the niche market. There is yet no real integration solution among public transportation, public places, and private transportation. This service will highly depend on the EV market.

Potential strategy: several respondents discussed about the collaboration strategy among several commercial firms from ICT, Financial, and transportation sector. Other respondents stated there is a possibility to start implementing this service in the city like Amsterdam or Rotterdam by integrating the public transport with car sharing program in the city centre. In additional, a large number of respondents recommended that one need to apply a niche market strategy for this service.

Potential business models: a large number of respondents mentioned about product and service business model while other respondents stated that the subscription model may be beneficial for this mobility service.

12. Combination of products or services as a testing ground country: this is a total concept which integrates the total products or services as a testing ground country. For example: a demonstration Amsterdam green city, Schiphol green airport, and Helmond green cluster.
**Current innovation phase:** innovation phase, a large number of respondents mentioned that this concept development is still in the earlier phase. There are still many tasks which need to be done. However, a small number of respondents stated that this concept can be introduced in the short-time since most of the supporting factors are in place right now.

**Potential strategy:** a large amount of respondents mentioned that the collaboration strategy is the key for this concept. Especially, according to many respondents, the Dutch government should represent and promote this concept internationally.

**Potential business models:** several respondents mentioned that this concept can become an export potential for the Netherlands. However, according to many respondents the economic benefits can be achieved in the long term.
Appendix H – Result of top discussion electric mobility (in Dutch)

Onderstaande tekst is een weergave van de hoofdpunten die zijn besproken tijdens de Topdialoog Elektrisch Rijden, georganiseerd door het ministerie van Economische Zaken, Landbouw & Innovatie (EL&I) en ICT-Office. Tijdens de topdialoog is onderzocht welke rol ICT kan spelen om de introductie van elektrisch rijden in Nederland te versnellen.

De focus in de dialoog lag op slimme dienstverlening en het zoeken van een businessmodel voor deze innovatieve ontwikkeling.

Deelnemers

Inleiding
Tot nu toe heeft ICT een belangrijke rol gespeeld in de maatschappij. Ook voor de transitie naar een duurzame energiehuishouding, waarin elektrisch vervoer (EV) een belangrijke schakel is, vervult ICT een essentiële functie. Smart grids, slimme auto’s en energiebesparing zijn enkele voorbeelden, waarbij blijkt dat ICT een bijdrage kan leveren als “enabler” voor innovatie van de producten, processen en businessmodellen. De verwachting is dat het samenwerken van verschillende partijen een stimulans is voor een succesvolle introductie van EV in de markt. In de toekomst zal ICT bijdragen aan een totaal concept voor Elektrisch Vervoer, via batterij-management-systemen, oplaadpunten, betaalsystemen, en routering- en reserveringssystemen.

Tijdens de Topdialoog is gezamenlijk onderzocht of de gepresenteerde toekomstvisie leidt tot nieuwe, innovatieve productmarkt-combinaties en interessante innovatieve businessmodellen voor de ICT en de mobiliteitdienstverleningssector.

In dit verslag zijn de hoofdpunten opgenomen die tijdens de Topdialoog aan de orde kwamen. Het eerste deel betreft de hoofdpunten uit de presentaties van KEMA en IBM. Het tweede deel is een samenvatting van de plenaire sessie, waarin de uitkomsten van de subsessies werden teruggerekoppeld.

Toekomst visie – DNV KEMA
DNV KEMA presenteert: “Electricity 2050: some reflection, forecast and ‘food for thought’”.

Kern van de boodschap is dat anders dan de traditionele auto, de elektrische auto onderdeel uitmaakt van de gehele energiehuishouding. De volgende noties komen hierbij aan de orde:

- De maatschappij ziet er in 2050 anders uit.
- De wereld moet voorbereid worden op elektrificatie. De vraag naar elektriciteit zal enorm groeien, de uitstoot van CO2 moet sterk naar beneden, consumenten worden prosumenten (gaan ook zelf elektriciteit genereren en leveren aan het net). Alle partijen op het gebied van energie zullen moeten veranderen. Demand-side management en Smart Grids zijn nodig.
In dit licht is het van belang om ook consumenten voor elektrisch rijden te motiveren. Van de wet- en regelgever wordt verwacht dat deze proactief ondersteuning verleent aan EV.

In het Nederlandse EV Innovatiesysteem moeten de verschillende partijen samen kunnen werken. Hiervoor is een dynamisch innovatiesysteem nodig. Op basis van gezamenlijke competenties van de verschillende partijen zou het huidige EV innovatiesysteem kunnen verbeteren. De grote uitdaging is dus hoe we alle verschillende partijen op een lijn kunnen brengen.

Reflectie – IBM
IBM presenteert: “Advancing Electro Mobility: The new frontier of smarter transportation”, een onderzoek dat is uitgevoerd onder een groot aantal (mondiale) partijen die directe en indirect zijn betrokken bij mobiliteit.

De uitdaging is het slechten van de paradox, het geluk dat de auto brengt voor het individu versus de stijgende problemen doordat iedereen dit geluk nastreeft. Hoe kunnen we slimmer transport in de markt introduceren. De volgende noties zijn van belang:

- Uit het onderzoek blijkt dat West-Europese landen een “greater awareness of mobility” tonen, die moet worden omgezet naar concrete acties.
- Door economische veranderingen, sociale veranderingen en het milieu is transformatie van de mobiliteit heel hard nodig.
- De gebruiker wil niet inboeten op comfort en zekerheid.
- Een reductie in de vervoerskosten is de grootste motivatie voor consumenten om de transitie naar de elektrische auto te maken.
- Andere businessmodellen op het gebied van mobiliteit zijn noodzakelijk; ICT kan en moet daar een rol in spelen.
- De grens tussen concurrenten en partners wordt minder scherp.

Thema’s voor discussie
Na de introductie volgde een korte discussie. Elektrisch rijden maakt in dit beeld onderdeel uit van verschuivingen in de energiehuishouding van de samenleving. De komende decennia zal de samenleving, mede onder druk van de CO2 – reductie, in grote mate worden geëlektrificeerd. De focus ligt op wat ICT kan toekomen op het gebied van Elektrisch Rijden. In de discussie zijn vier thema’s benoemd die in subgroepen zijn besproken:

- Samenwerking
- Het omgaan met disruptie
- Wijziging van attitude
- Gemak, genot, gewin

Thema 1: Samenwerking (TNO)
In deze subgroep is geconstateerd dat er al veel initiatieven en pilots lopen op het gebied van elektrisch rijden. De groep heeft bedacht dat het verstanding zou zijn om initiatieven (fysiek) aan elkaar te gaan knopen. Met name de mainports en (logistieke) hubs lijken hiervoor geschikt.

Voorbeelden zijn:
Dutch electric vehicle innovation system

- Rotterdam inclusief de logistieke hub in het Westland en logistieke verzamelplaatsen met veel activiteit
- Clean Tech Delta
- De verbinding van regio Rotterdam met Amsterdam, voornamelijk de Rotterdamse haven naar luchthaven Schiphol
- Locaties in en om Amsterdam
- De A15 pilot
- De verbinding tussen Groningen en Arnhem

Op en tussen deze plaatsen vindt veel verkeer plaats en er zijn veel partijen bij betrokken. Daarnaast zijn deze mainports economisch relevant, waardoor ze (meer) aandacht krijgen en waardoor investeringen eerder rendabel zullen zijn. Het koppelen zal de hoeveelheid vervoersbewegingen en daarmee de laadbehoefte stegov doen toenemen. ICT zal een belangrijke rol kunnen en moeten spelen in de planning en logistiek van het laden en het betalen. Daarnaast is ICT onontbeerlijk om de verkeersstroom te reguleren, niet alleen om congestie op de weg tegen te gaan, maar ook congestie bij de laadpalen.

Het koppelen van de mainports zal het internationaal aanzien van Nederland positief beïnvloeden, waardoor de relatieve achterstand die we hebben mogelijk in een voorsprong kan worden omgebogen.

Voor een klein land als Nederland geldt dat samenwerking beter is dan concurreren. Diverse mogelijkheden om dit te stimuleren zijn kennismigratie en – delen, patenten delen; consortium-vorming stimuleren via tendersysteem en open lab innovatie (creëren van fysieke omgeving en zodoende prikkelen tot samenwerking); de overheid kan hier een rol in spelen.

Thema 2: Het omgaan met disruptie (IBM)

In business en technologie literatuur wordt met ‘disruptive’ gedoeld op ontwikkelingen of innovaties die zeer onverwacht en ongebruikelijk zijn, ontwikkelingen die bestaande producten of diensten vervangen; niet evolutionair, maar revolutionair. In dit kader is met ‘disruptive’ bedoeld dat er zeer onconventionele wegen bewandeld moeten worden. Met het oog op het succes van ontwikkeling internettechnologie in VS, is gesuggereerd dat Nederland een vrijplaats moet worden of krijgen om elektrisch rijden te ontwikkelen en te stimuleren. De gedachten zijn om gedurende 10 jaar met 1% van het wagenpark (80.000 auto’s) te experimenteren. Hiertoe zou de laadcapaciteit verder moeten worden ontwikkeld, zou de elektriciteitswet moeten worden aangepast, zouden leasemaatschappijen andere proposities moeten maken. Hierdoor zou een nieuwe markt moeten ontstaan die na de proefperiode voldoende volwassen is om op eigen benen te staan. “Cloud Computing” en een open platform kunnen hierin toegevoegde waarden brengen. Crowd management is een methode om het publiek om input en bijsturing te vragen.

De rol van ICT is het monitoren, voorspellen en controleren van de verschillende ontwikkelingen.

Een randvoorwaarde is de bereidheid om data te delen en open standaarden te hanteren. Grote en met name kleine bedrijven kunnen op basis van de beschikbare data allerlei apps ontwikkelen die het gebruiksgemak voor de berijders, maar ook voor de beheerders, de eigenaren en de dienstverleners, vergroten.
Een belangrijke disruptie is dat concurrenten elkaar nu ook als partner zouden moeten zien. Dit is geenszins een utopie. Door samen te werken aan standaarden en open data en door elkaars infrastructuur open te stellen in plaats van af te schermen, wordt de propositie voor de gebruiker steeds aantrekkelijker. Hiervan profiteert de hele markt, waardoor een opgaande vicieuze cirkel wordt bereikt. Een voorbeeld hiervan zijn de afspraken die gemaakt zijn tussen de diverse marktpartijen over het laden en betalen van elektrisch vervoer.

**Thema 3: Wijziging van Attitude (ABB Epyon)**

*Walk the Talk & Talk the Walk (doe wat je zegt en zeg wat je doet).*

Elektrisch rijden moet je doen. Wijs niet naar anderen, wacht niet op anderen, maar doe het zelf en communiceer dit ook! Deel je successen. Iets doen is een keuze, doe het dan ook. Dit geldt zowel persoonlijk als zakelijk. Laat je niet weerhouden doordat sommige mensen of partijen niet meedoen, streef niet naar 100%.

Heb aandacht voor zowel lang-cyclische als kort-cyclische elementen. De doorontwikkeling van batterijen is een voorbeeld van een lang-cyclische ontwikkeling, de ontwikkeling van allerlei slimme ICT is kort-cyclisch. Het voorbeeld wordt genoemd van het via de mobiele telefoon op afstand openen van een auto (digitale sleutels) of services om de mensen tijdens het opladen van de batterij te kunnen laten werken (toegang tot internet). Die korte cyclus kan een “verassings” effect op de markt teweegbrengen en de verschuiving van bezit naar gebruik gemakkelijker maken. Er is behoefte aan financiële support voor de start-ups die zich richten op de korte cyclus.

Een beter investeringsklimaat kan bereikt worden door “de-risc-en” van omgevingsfactoren. Voor de lange termijn is vooral stabiele regelgeving van belang. Voorlopig vergt de introductie van elektrisch rijden veel investeringen, dat geldt niet alleen voor het concept (denk aan de hele laad- en betaalinfrastructuur) maar dat geldt ook voor het individu. Bij elektrisch rijden is de aanschaf hoger en zijn de energiekosten per verplaatste km lager. Dit vraagt om andere financieringsmodellen, die op hun beurt belang hebben bij stabiele regelgeving.

Een kans ligt in het koppelen van elektrisch rijden met het nieuwe werken. Slimme werken vereist slim reizen. ICT is hierbij onontbeerlijk.

**Thema 4: Gemak, Genot, Gewin (Innopay)**

In deze groep is de consument centraal geplaatst. Elektrisch rijden en voornamelijk de elektrische auto voldoet voor 80% van de kilometers: het probleem zijn de uitzonderingen, waarbij de caravan in de zomer als voorbeeld het meest voor de hand ligt. Hierdoor kiezen gebruikers toch vaker voor een alternatief waarbij ook de uitzonderingen afgedekt zijn.

Dit probleem is via aanpaste dienstverlening op te lossen. Door de auto minder centraal te stellen en juist de vervoersbehoefte centraal te plaatsen, kan de inzet van vervoersmiddelen (de auto, maar ook alternatieve of het openbaar vervoer) efficiënter plaatsvinden. De consument zal hierbij wel geholpen moeten worden. Hier ligt een sterkte link naar dienstverlening en ICT.

Een ander probleem dat genoemd is, zijn de verschillen tussen theoretisch haalbare verbruiks-cijfers en het gerealiseerde verbruik. Dit geldt zowel voor elektrische auto’s als ook voor benzine, diesel en hybride varianten. Oplossingen hiervoor vergen ICT-toepassingen die het gebruik meten en terugkoppelen aan de berijders en beheerders en hen ook ondersteunen bij het reduceren van het
verbruik. Hierbij kan gedacht worden aan het inzetten van financiële stimuli zoals beloningen voor de zuinigste rijder. ICT kan ook helpen bij het optimaliseren van de route door op het juiste moment via de juiste laadpaal te rijden.

Het in Nederland ontwikkelde en (bijna) geïmplementeerde marktmodel oogst internationaal veel aanzien. Dit marktmodel maakt het door de inzet van ICT mogelijk dat gebruikers de laadpalen van alle aangesloten partijen kunnen gebruiken. Door een slim systeem van authenticatie, kan de benodigde informatie worden uitgewisseld, waardoor periodiek afgerekend kan worden. Dit marktmodel is een goed voorbeeld van samenwerking. De samenwerking levert alle deelnemende partijen (ook concurrenten) voordeel op, doordat het aanbod van laadmogelijkheden wordt vergroot.

Het laatste onderwerp is de decentrale opwekking, een element dat elektrisch rijden voor de gebruiker nog aantrekkelijker maakt. De overheid wordt opgeroepen om de mogelijkheden hiertoe te vergroten. Daarvan zijn verschillende internationale voorbeelden beschikbaar. Het “verrekenen voor de meter” is in Nederland politiek echter een heikel punt. Er wordt gewerkt aan een kamerbrede motie o.b.v. internationaal onderzoek in het licht van verduurzaming.

Tot slot
De bijeenkomst heeft veel positieve energie gegenereerd. Het is zaak om deze energie vast te houden.