Utrecht University

The Green Electric Mobility Tool

The development of an ex-ante assessment tool contributing to the advancement of eMobility in urban areas in middle-income countries

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29th July 2016, Utrecht

Universiteit Utrecht

EVCONSULT
EXPERTS IN SUSTAINABLE MOBILITY

The Green Electric Mobility Tool *The development of an ex-ante assessment tool contributing to the advancement of eMobility in urban areas in middle-income countries*

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Master thesis of 30 ECs, submitted in completion of the MSc Sustainable Development, Environmental Governance
Faculty of Geosciences, Utrecht University

The research is part of an internship at EVConsult, a Dutch consultancy focused on the advancement of sustainable mobility (January 2016 – July 2016)

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Summary

Due to the increasing urgency to cut back global greenhouse gas emissions and improve local air quality related to motorized transportation, electric mobility (eMobility) is on the rise as it is seen as one of the main methods towards a more sustainable mobility system. Still, the development, introduction and diffusion of eMobility has been limited to cities in industrialized countries. Some pilot projects are being conducted in developing countries, but they are not scaled-up and do not lead to the desired structural transition towards eMobility. This is for a large part due to an unsupportive or unprepared local system, a lack of comprehensive vision and an unstructured introduction, hampering the required systematic change needed for a large-scale transition.

An enabling environment, however, is essential for a technical innovation like eMobility to be taken up as the process towards technological change includes the development of the technology itself in interaction with the local system in which it is embedded. Yet, the design of this form of governance for innovations is a key issue, which is particularly the case for developing countries which generally have less technical and institutional capabilities to develop and introduce technical innovations. Insights in the (performance of the) existing innovation system, encompassing all factors influencing the development and diffusion of eMobility, will help to map determine the optimal policy strategy and enhance the local governance of eMobility.

Therefore, this research aims to contribute to the advancement of the successful implementation of eMobility in developing countries by designing an ex-ante assessment tool which can be used to provide an overview and evaluation of the existing local innovation system before the introduction of eMobility, based on identified preconditions relevant for the introduction and diffusion of eMobility. The tool is referred to as the Green Electric Mobility (GEM-) tool and is developed for local policy makers in urban areas within middle-income countries.

For its development, a framework was first designed, including its components and delineation of its application. Based on the framework, data was gathered to form the content of the GEM-tool. Both the framework and the content are based on an extensive literature research regarding the Technical Innovation Systems (TIS-) approach, and on a comprehensive analysis of reports and articles relating to the introduction and diffusion of eMobility, taking into account the context of urban areas in middle-income countries. Furthermore, experts from the field of innovations, international development, sustainable mobility and electric mobility as well as policy makers dealing with the introduction and diffusion of eMobility, have been interviewed or asked to participate in a survey or brainstorm session. Additionally, the GEM-tool was tested via an illustrative case, which confirmed its application and usefulness, while increasing its validity. This combination of methods and data sources secures a solid base for the GEM-tool.

The findings of the framework and contents were operationalized, resulting in the online GEM-tool which can be found at *evconsult.nl/gem-tool.* It includes a questionnaire based on relevant preconditions for the successful implementation of eMobility and their operationalization through questions, answer categories and corresponding scores. The outcome of the GEM-tool consist of the evaluation of the existing local innovation system complemented by general policy implications & recommendations. The application of the GEM-tool enhances the understanding of the (performance of the) innovation system in place, which is an essential first step in determining the optimal policy strategy. These insights empower local policy makers for the structural introduction of eMobility,

taking into account the desired large scale transition. This enhances the chance for the uptake and diffusion of eMobility considerably.

This research provides an innovative first step towards the development of an ex-ante, practical assessment to advance the introduction and diffusion of eMobility in middle-income countries. It presents the first blueprint of the GEM-tool and paves the way for further (empirical) research on the development and application of the GEM-tool.

Preface & acknowledgements

During my time as a student of the research master Sustainable Development, it became clear to me that neither my interest nor strength lies in the performance of conventional, empirical research. So, when the time came to start with my thesis as part of the completion of my master program, it was evident that my thesis would not be performed this way. Luckily, I found a supervisor who encouraged me to wander off this beaten track, and an internship which was interested in my ideas.

Whilst a conventional thesis within this master program follows the construction of a theory-oriented or practice-oriented type of research using a conceptual model as starting point and empirical evidence to get reliable and valid results, this research can be interpreted as having as end goal the design of a conceptual model, namely the GEM-tool. It can therefore be seen as an unconventional thesis and should be read and interpreted as such. It presents the development of a practical ex-ante assessment tool including the establishment of its framework, its content and its operationalization which resulted in the online Green Electric Mobility tool which can be found online at *evconsult.nl/gem-tool.* However, as it is not feasible to include the online tool in the thesis document itself, the results are therefore not presented in a result section within the thesis but as annex in plain text (not including its online functionalities). As this does not do justice to the functionality of the tool, it is recommended that the online GEM-tool is kept at hand when going through this research.

All in all, I am very pleased with the end result which represents the first step of the development and application of a practical assessment tool for eMobility, based on theoretical insights combined with practical knowledge. Therefore, I would like to sincerely thank my supervisor, Frank van Laerhoven, for supporting me throughout the development of this thesis and encouraging me to do what I believed in and believing in it as well. Thanks to his enthusiasm and motivation, this thesis has become much more than I hoped for. Furthermore, I would like to thank Geert Wijnen and Roland Steinmetz of EVConsult for their support and their extensive knowledge which I could tap out of. They made me keep my eye on the practical side of things which has become a major strength of this research and its outcome. And many thanks as well to all of my other colleagues at EVConsult who have helped me both content wise as mentally to make the most out of this research. Of course a lot of praise goes to Emre Koc, who put so much of his own time and effort into translating all my ideas into an online tool which has become the backbone of this research. Thanks to Emre the Gem-tool became tangible and workable. I would also like to thank all respondents and interviewees who have helped me to conduct the necessary analyses and provided essential input to the research. Lastly, I would like to thank all my friends, roommates and family members who have put up with me during this process and motivated me to keep on going.

I hope you enjoy your reading.

Susanne van der Kooij Amsterdam, 29th July 2016

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Chapter 1 Introduction

Key messages

- eMobility can contribute to social and economic development, without many of the negative effects on the environment caused by traditional motorized road vehicles;
- The development, introduction and diffusion of eMobility is not taking place in middle-income countries due to a lack of a comprehensive vision, not making use or having knowledge about the local innovation system;
- To enable a successful transition towards eMobility in middle-income countries, an innovation system should be in place which stimulates the introduction and diffusion of eMobility starting from the local context;
- This research will design a practical ex-ante assessment tool which can be used to provide a structural overview and evaluation of the existing local innovation system before the introduction of eMobility, based on identified preconditions relevant for the introduction and diffusion of eMobility;
- The research aims to answer the following research question: '*What should an ex-ante assessment tool encompass to contribute to the advancement of electric mobility in urban areas in middle-income countries?';*
- The tool is referred to as the Green Electric Mobility (GEM-) Tool and focuses on urban areas in middle-income countries and will provide recommendations for local policy makers.

1.1 The dilemma of mobility

Mobility can be seen as one of the most fundamental characteristics of societies (Geerlings et al. 2012). On an local level, transportation is essential for the well-being of people as it has significant (indirect) positive effects, such as better accessibility to jobs, education and healthcare. On a national and global level, a positive relationship exists between the economy and transportation. Besides representing an important economic sector in its own right, transportation allows other economic sectors to function properly (Banister et al. 2011). Mobility can therefore be seen as the motor of social and economic welfare (Geerlings et al. 2012; Sperling & Salon 2002; Ebinger & Vandycke 2015).

But the current motorized transportation patterns, based primarily on automotive transport powered by fossil-fuels, also comes with adverse side-effects which can have significant negative local and global impacts on our society, its economy and environment (Hidalgo & Huizenga 2013). On a global scale, the transport sector is responsible for 14% of all greenhouse gas (GHG) emissions, 23% of all energy-related CO2 emissions and 66% of the oil combustion emissions (IEA 2015; IPCC 2014; Banister et al. 2011). Transport-related CO2 emissions are expected to rise with 57% between 2005 and 2030, mainly as a result of rapid mobilization in developing countries (Geerling et al. 2012). On a more local scale, transportation is responsible for 80% of the local air pollution in cities in developing countries, causing significant health effects. Additionally, other serious problems are associated with the current transportation system i.e. a dependency on fossil fuels, noise pollution, congestion problems and safety issues (Geerling et al. 2012; Banister et al. 2011). These problems are most pressing in cities in developing countries: population growth, rapid mobilization and urbanization,

and fast growing economies pose many difficulties for these regions and amplify the negative effects of transport (Sperling & Salon 2002). Developing countries thus face the dilemma between social and economic development fostered by transportation on the one hand, and the ambition towards a more sustainable future on the other (Nilsson et al. 2012; Geerling et al. 2012). It is therefore important to improve the link between the role of mobility and the lack of sustainability of the current transportation system (Bertolini 2012), particularly in developing countries.

1.2 eMobility as solution to the dilemma of mobility

The need for a more sustainable transport system which aims to meet society's economic, social and environmental needs is evident, especially for urban areas in developing countries, and has risen up the political and economic agenda (Vidal 2016). As part of this larger transition towards sustainable mobility, electric mobility (eMobility) represents one of the most promising pathways to reduced GHG-emissions and other pollutants and is seen as the main alternative for the traditional internal combustion engine (ICE) vehicles (IEA & EVI 2013; Andersen et al. 2009; Yong et al. 2015; COP21 2015). Electric mobility relates to the electrification of the propulsion of vehicles used for road transport and includes two, three and four wheeler as well as busses and freight delivery vehicles. There are different types of electric vehicles (EVs), including battery electric vehicles (BEVs), hybrid electric vehicles (HEVs), plug-in hybrid electric vehicles (PHEVs), and Fuel Cell Electric Vehicles (FCVs) (see Table 1) (OECD & IEA 2016; Nilsson et al. 2012). Compared to conventional vehicles, EVs have two preferable characteristics: they are more efficient and they are more flexible in their energy sources, as electricity can stem from multiple (renewable) origins (Lutsey 2015).

Type of electric vehicle	Explanation
Battery Electric Vehicles (BEVs) or Full Electric Vehicle (FEV)	BEVs/FEVs use an all-electric motor drive instead of an internal combustion engine (ICE), which is powered by a battery system and charged via the energy grid.
Hybrid Electric Vehicles (HEVs)	HEVs are powered by either battery- and electric motor components or the ICE or a combination. The battery cannot be charged via the energy grid but is charged via the ICE.
Plug-in Hybrid Electric Vehicles (PHEVs)	PHEVs have the same construction as the HEVs, but use a larger battery with a plug-in charger for grid energy, which is then stored in the on-board battery.
Fuel Cell Electric Vehicles (FCVs)	FCVs use hydrogen as their fuel source for its electric motor.

Table 1 Types of electric vehicles (from Nilsson et al. 2012 and PRC & EVConsult 2010)

So, eMobility can reduce GHG-emissions and local pollution stemming from motorized road transport, improve energy security by diversifying energy sources and reducing the dependency on fossil fuels, increase fuel efficiency and stimulate innovation and new industries (OECD & IEA 2016; Yong et al. 2015). This advances both social and economic development, without many of the negative effects on the environment caused by traditional motorized road vehicles. It provides the desired solution to the posed dilemma between economic prosperity and sustainable development (IEA & EVI 2013; Geerling et al. 2012). Although the current EV market is still small, representing less than one percent of global passenger vehicles, the outlook is encouraging (CEM 2012). Already the number of electric cars is growing exponentially: it increased from almost zero in 2010 to 1.2 million in 2015, of which 750,000 fully electric (BEVs), while the worldwide annual sales grew 79 percent in 2015. The IEA has projected that by 2020 annual global EV sales will reach almost six million vehicles or five percent of total passenger car sales (EVConsult 2016).

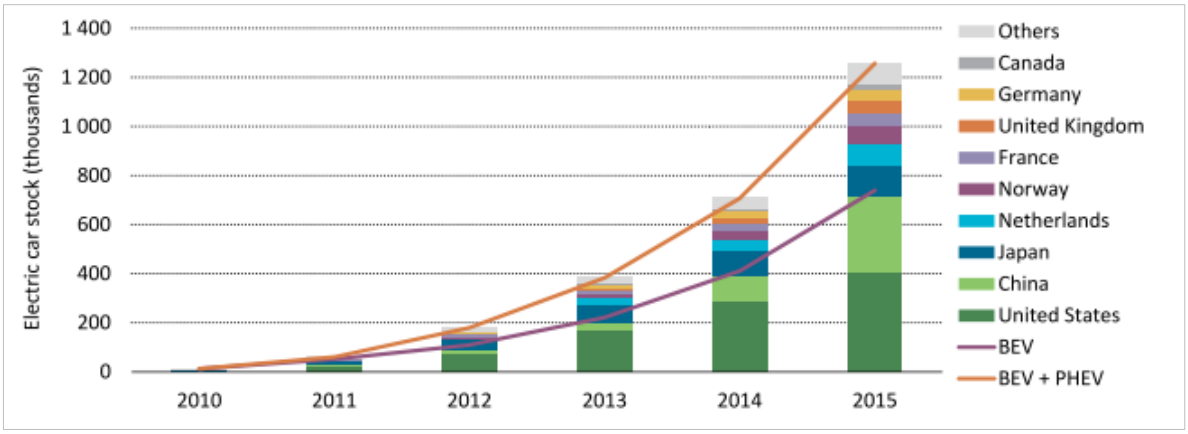

Figure 1 Evolution of the global electric car stock (from OECD/IEA 2016)

1.3 Challenges for the transition towards eMobility

The *Paris Declaration on Electro-Mobility and Climate Change & Call to Action,* launched during the UN Climate Change Conference (2015), has set the global deployment target of 100 million electric cars and 400 million electric two- and three-wheelers in 2030, as well as the aim for 30 percent of urban motorized transport to become electric by 2030. The agreement is a response to the findings of the International Energy Agency (IEA), which concluded that at least 20 percent of all road transport vehicles globally should be driven electrically by 2030 to stay below the 2°C temperature rise (COP21 2015; UEMI 2014). Meeting these targets implies substantial market growth necessary in both industrialized countries and emerging economies. Governments around the world have therefore set national goals to increase the market share of eMobility (Mock & Yang 2014; Yong et al. 2015).

Despite the ongoing developments in the EV market, there are still some challenges to overcome. The high costs of batteries and EVs, the (perceived) range limitations, the uncertainties of the life span of batteries and a lack of charging infrastructure represent existing barriers for the diffusion of EVs (Beeton 2013; OECD & IEA 2016). eMobility therefore still requires policy support to achieve its widespread adoption and diffusion. Nevertheless, frontrunner countries and early adopters have demonstrated that EVs can meet the expected practical, sustainability and affordability requirements (OECD & IEA 2016; Beeton 2013). Especially cities have proven to be well suited for EVs due to their density and short distances. The experiences of urban users and policies of local governments can help spur widespread EV uptake and accelerate the transition to clean and sustainable mobility (CEM 2012).

It is noteworthy that the development, introduction and diffusion of EVs and its related charging infrastructure have taken place in industrialized countries such as Norway, the U.S. and the Netherlands (IEA & EVI 2013). Developing countries have the opportunity to learn from the experiences of these frontrunners, including their lessons learned and best practices, and prevent mistakes of transport investments by focusing on the introduction of non-polluting modes of transportation such as eMobility (Sperling & Salon 2002; Loorbach 2010; Siyanbola et al. 2012). This is already taking place on a small scale with pilots regarding eMobility being conducted in cities in e.g. South Africa, the Philippines and Colombia (IEA 2014). It is however happening in an unstructured manner, lacking a comprehensive vision and in absence of an enabling environment (IPCC 2002; EVConsult 2016). It fails to take into account the systematic change needed for a

structural transition towards eMobility (Avnimelech & Teubal 2007). However, it is essential for the diffusion of a technological invention like eMobility that technological change is linked to a process of innovation, referring to the development of technology in interaction with the system in which the technology is embedded.

To foster the growth of an emerging technical innovation, changes are necessary in the social and political domain to stimulate the development, introduction and diffusion of the new technology (Geerlings et al. 2012; Hekkert et al. 2007; Siyanbola et al. 2012). Furthermore, there is an incentive for public policy to shape and speed up this innovation process when the prevailing technologies – i.e. traditional internal combustion engine (ICE) vehicles – produce negative side-effects that can be solved by new technologies – i.e. electric vehicles (Hekkert et al. 2007). Public policy is essential to manage the introduction of eMobility as its need to compete with the existing system (including prevailing technological, regulatory, cultural and market factors) and overcome the vested interests in traditional technologies (Sagar & Majumdar 2014; R.Mourik & Raven 2006). However, policy makers struggle to develop strategies to support such as transition towards a new technology. The design of this form of governance is a key issue in many innovation policy programs (Hekkert et al. 2007). This is particularly the case for developing countries, which generally have the least technical and institutional capabilities to develop and introduce technical innovations (Sagar & Majumdar 2014). Even if a developing country has access to a new technology, the related infrastructure, knowledge, and skills essential for its uptake and diffusion might not be present (Jacobssen & Bergek 2007). Furthermore, many cities in developing countries have limited planning expertise and inexperienced local institutions to implement plans and enforce policies. Effective policy on transportation and infrastructure development is often challenging (Sperling & Salon 2002), which can negatively affect the introduction of eMobility. Insights in the local capabilities of the existing policy system can help to identify these barriers.

Additionally, experience from the last decades of international development aid and technological transfer to developing countries shows that introducing western technologies or carrying out top-down interventions in developing countries will often lead to the failure of these initiatives (Pike et al. 2006; Crescenzi & Rodríguez-Pose 2011). Local capacity, referring to the capability to adapt, develop, deploy and operate technologies within the specific context of the (developing) country, should be recognized and developed, which often poses a challenge (Ockwell et al. 2010). Yet without proactive innovation efforts and local capacity building, a foreign technology will never turn into real technological capability and it will not become embedded in the receiving country (Sperling & Salon 2002; Pike et al. 2006; Fu et al. 2011). It is therefore essential for an innovation to become a self-propelling success within the local context. Key for a successful introduction of an innovation, especially in developing countries, is therefore a high level of understanding of the local context, which forms a starting point of its deployment (Sagar & Majumdar 2014).

1.4 Contributing to the structural diffusion of eMobility

The above mentioned findings suggest that to enable a successful transition towards eMobility in developing countries, an innovation system should be in place which stimulates the introduction and diffusion of eMobility starting from the local context. An innovation system refers to 'all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion, and use of an innovation' (Edquist 2004, p.182). As insights in the functioning of the existing innovation system is a first step in determining the optimal policy strategy

(Hekkert et al. 2007), it would appear to be of interest to have an overview of the prevailing local situation ex-ante - *before* the introduction of eMobility - and evaluating it with regard to preconditions necessary for a successful introduction and diffusion of eMobility. This provides support to local policy makers in their decision-making process as it enhances insights in the (functioning of the) existing local innovation system. This can stimulate the structural introduction of eMobility by making use of the existing system and increase the chance for eMobility to become embedded in the local context.

One of the main frameworks that puts the innovation system central in transitions is the technical innovation system (TIS) approach. This heuristic framework can be used to understand system the dynamics and performance of an innovation system focusing on a certain technology, including both the technology and the components that influence the innovation process for that technology. It was developed to replace the market failure approach as a basis for policy action and instead focuses on innovation systems (Wieczorek & Hekkert 2012; Bergek, Jacobsson, et al. 2008). However, there are multiple shortcomings to the use of the TIS approach for the above stated goal of providing an ex-ante overview and evaluation of the prevailing local situation with regard to eMobility.

Firstly, the method used for the application of the TIS approach is often based on historic event analysis or process analysis. These methods consists of retrieving as many events as possible that have taken place in the innovation system (Hekkert & Negro 2008). This means that to understand and evaluate the dynamics, back casting is applied to come to a qualitative storyline about the process of the build-up of a TIS. In other cases, the TIS approach provides the state of an existing innovation system at a defined moment in time after the introduction of the technology (Wieczorek & Hekkert 2012). Hence, it does not directly provide an approach which can be used *in advance* to understand the innovation system before the introduction of the innovation. The latter is required to solve the problem stated above, as it helps the innovation system to be recognized and used by local policy makers before the introduction of eMobility.

Secondly, the TIS approach focuses on the co-evolution of a technology and the innovation system surrounding it (Hekkert et al. 2007). However, with some innovations including eMobility, the technology has been developed (to some extent) and needs to be adapted to the local context while the technological innovation system needs to catch up on the technological developments. Innovation systems in these late-comer countries differ greatly from those of frontrunner countries, as actors within the innovation system are weak and not connected to each other, and there are no institutions or Knowledge Developments supporting the innovation. This can counter the effect of the window of opportunity for late comers to use existing technologies (Intara 2011). The TIS approach does not recognize this situation. It has mostly been applied to western countries (Edsand 2016). Some studies have analyzed this 'catching-up process', focusing on developing countries, such as Jacobssen & Bergek (2007), but they have been limited to ex-post analyses. It would therefore be useful to apply the TIS approach in a 'catching-up' phase, which has not yet been performed (Jacobssen & Bergek 2007). This calls for an adaptation of the TIS approach, including these catching-up processes in late coming countries.

Thirdly, as the TIS approach is designed to be an analytical framework, it does not provide an operationalization of the criteria essential for the evaluation of an innovation system. The TIS approach is frequently used as practical guideline in which case guiding questions are formulated (for

example Hekkert et al. 2011; Wieczorek et al. 2013), an evaluative scale is applied (for example Wieczorek & Hekkert 2012), indicators for the functioning of the system functions are provided (for example Suurs (2009), Hekkert et al. (2007) & Negro et al. 2008), a set of analytical goals are presented to assess the strengths and weaknesses of the TIS (Hellsmark et al. 2016) or the gathered data are interpret by the researchers which then forms the basis of the TIS evaluation (Eveleens et al. 2015). However, the above mentioned methods do not provide *consistent* guidelines on how to interpreted the gathered data nor do they elaborate upon how to apply this qualitative evaluation using the criteria for the functioning of the innovation system. Therefore, the operationalization of the functioning of the innovation system could complement the above mentioned (limited) evaluation methods.

Taking these limitations into account as well as the intention to provide an overview of the existing local situation beforehand with respect to conditions necessary for a successful introduction and diffusion of eMobility, the design of an ex-ante practical assessment tool is proposed. The theoretical framework of the TIS approach will serve as a guide in the development of the tool as it provides insights in the essential factors for the uptake of an innovation such as eMobility. It will, however, be adapted to fit a more practical and ex-ante application focusing on the pre-development phase of eMobility and the existing local innovation system beforehand.

1.4.1 Research objective

The research aims to contribute to the advancement of the successful implementation of eMobility in developing countries by designing an ex-ante assessment tool which can be used to provide a structural overview and evaluation of the existing local innovation system before the introduction of eMobility, based on identified preconditions relevant for the introduction and diffusion of eMobility. Its applications maps the receptivity of the prevailing innovation system in advance and enhances the understanding of the functioning of this system. These insights stimulate the structural introduction of eMobility as they provide local policy makers with the opportunity to understand and make use of the local context as a starting point for a systematic introduction of eMobility. This increase the chance of eMobility becoming embedded in the local context. Furthermore, barriers and opportunities can be identified, leading to policy recommendations which stimulate the development of a successfully functioning innovation system for eMobility.

The focus of the tool will be placed on urban areas as they are often the starting point of the introduction of eMobility due to the short distances within the city, their density and the pressing challenges regarding transportation including local air pollution (CEM 2012). Furthermore, the application of the tool will be concentrated on the advancement of eMobility in middle-income countries (MICs) as defined by the World Bank. Generally, these countries are still faced with the various challenges caused by motorized road transport but their growing economies also provide the opportunities to invest in sustainable mobility (Sperling & Salon 2002). Lastly, the outcomes of the application of the GEM-tool can be relevant for multiple stakeholders. The focus will be placed, however, on relevant outcomes for local policy makers who aim to get involved in the implementation of eMobility. The choices regarding the delineation of the tool will be elaborated upon in Chapter three.

1.4.2 Research questions

Having stated the research objective, the following research question can be formulated:

What should an ex-ante assessment tool encompass to contribute to the advancement of electric mobility in urban areas in middle-income countries?

The ex-ante assessment tool will be referred to as the Green Electric Mobility-tool, as it stimulates the change from a fossil-fuel based transport system towards a sustainable, green transport system based on electric mobility. The development of the GEM-tool requires the design of its framework, its content and the operationalization of the gathered information. Therefore, the following sub-questions will be of help in answering the main research question:

1) *How can the framework for the GEM-tool be developed using the technical innovation system approach guiding its design?*
2) *What does the content of the GEM-tool have to encompass with regard to its framework?*
3) *How can the GEM-tool be operationalized including the findings of its framework and contents?*

1.4.3 Research framework

Whilst a conventional thesis starts with a theoretical outline and key concepts to come to a conceptual model and assessment criteria which forms the research perspective to gather empirical evidence to acquire reliable and valid results relating to the research objective (Verschuren & Doorewaard 2010), this research can be interpreted as having the design of a conceptual model as final goal, namely the GEM-tool which includes assessment criteria based on identified preconditions and their operationalization. Therefore, the theoretical outline, the key concepts and the assessment criteria used to specify the research perspective are part of the results section as they form a part of the development of the GEM-tool.

The research framework as shown in Figure 2 presents a schematic representation including the necessary research steps to achieve the stated research objective (Verschuren & Doorewaard 2010). The combination of the design of a framework, the determination of content and the operationalization of the identified components and dataset leads to the development of the GEM-tool. To test the GEM-tool, it will be applied to an illustrative case. The result from this case will show the application and increase the validity of the GEM-tool. This leads to conclusions to answer the research questions and recommendations for the further development of the GEM-tool, as this research presents the blueprint of the GEM-tool, paving the way for further research.

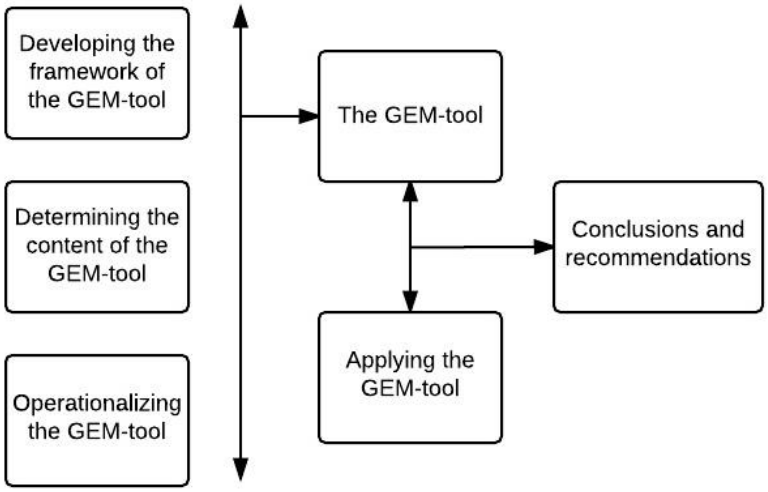

Figure 2 Research Framework

The research will be conducted in collaboration with EVConsult, a Dutch consultancy firm working on the national and international advancement of sustainable mobility and in particular electric mobility. EVConsult is interested to learn more about the complex governance side of the introduction of eMobility in developing countries as this has not yet been explored but can become an important driver in the global growth of eMobility. The experts within EVConsult will have a supporting role during this process, contributing to the content as well as the execution of the research.

1.4.4 Societal & scientific relevance

The research responds to the need to strengthen public policy regarding eMobility as an emerging technological innovation in middle-income countries. It aims to stimulate the change from a fossil-fuel based transport system towards a sustainable mobility system, by designing an ex-ante assessment tool which provides an overview and evaluation of the local innovation system based on preconditions for the successful introduction and diffusion of eMobility, which supports local policy makers in their decision making process. It therefore contributes both to the governance of sustainable development in middle-income countries as well as to decision-making regarding the introduction of sustainable innovations on a local policy level.

Furthermore, according to Suurs (2009), more case studies on sustainable energy transition should be conducted, involving technology comparisons and country comparisons. The development of the GEM-tool will enable such comparable case studies and will provide insights into a part of this energy transition, namely the transition towards eMobility. Additionally, this allows for a structural comparison between different urban areas regarding their receptivity for eMobility which contributes to the understanding of readiness for eMobility of different regions.

The contribution to the theoretical debate, however, is limited as it is a practice-oriented research aiming for a practical outcome. It does, however, contribute to the translation of scientific insights into practical applications and therefore stimulates research uptake by a broader audience. It provides a first step in the design of a practical and ex-ante assessment tool based, in part on the theoretical framework of the Technical Innovation System approach, to advance the introduction and diffusion of eMobility in middle-income countries. It will develop the first blueprint of the GEM-tool and paves the way for further (empirical) research on the development and application of such a

tool. Furthermore, the above stated relevance of the research is in line with the main objectives of the Copernicus Institute of Sustainable Development affiliated with University Utrecht. This research institute aims to resolve environmental problems through, among others, the management of technical innovations and applying its expertise and knowledge development directly to our society.

1.4.5 Structure of the research

The thesis is structured according to the various steps undertaken to develop the GEM-tool. After introducing the research (Chapter one), the main methods used to carry out the research steps and answer the research questions are presented (Chapter two). Chapter three starts with an overview of the origins, composition and application of the Technical Innovation System approach. This is followed by the conversion from the TIS approach to a framework for the practical assessment tool, based on the delineation and adaptation of the TIS approach. Chapter four then continues by determining the content of the GEM-tool, using input from innovation theories, sustainable mobility and specifically eMobility. Having identified the framework and input for the GEM-tool, the identified framework and content are operationalized to form the GEM-tool. The operationalization includes the various steps of the GEM-tool and the online design. This is presented in Chapter five. The results, consisting of the tool itself, can be found at *evconsult.nl/gem-tool*. As it is not feasible to include the online tool in the written thesis itself, the online tool should be seen as the result section of the research. Additionally, the tool is displayed in plain text in Annex I, not including its online functions. It therefore does not do justice to the functionality of the tool and it is recommended that the online GEM-tool is kept at hand when going through this research. After the development of the GEM-tool, it is applied to an illustrative case of which the results are presented in Chapter six. Chapter seven will proceed with the main conclusions of the research and will answer the posed research questions. As this is the first version of the GEM-tool, there is room for improvement and further research which will be elaborated upon in the discussion (Chapter nine).

Chapter 2 Methodology

Key messages

- The research steps to develop the GEM-tool include the design of its framework, the identification of is content and the operationalization of the gathered information;
- Combining a literature study and semi-structured interviews, the framework of the tool is designed consisting of components and the delineation of the GEM-tool;
- The content of the GEM-tool is identified by the combination of a literature study, semi-structured interviews, a brainstorm session with experts from EVConsult and an online survey;
- The GEM-tool is operationalized through the identification of the steps within the tool, based on the gathered input and an additional literature study, and the design of its online functionalities;
- The GEM-tool is tested to an illustrative cases to increase its validity and confirm its applicability.

This chapter provides an overview of the research steps with their corresponding qualitative methods used during the research to develop, validate and test the GEM-tool. Using the combination of methods as illustrated in Figure 3 will result in a research strategy which supports the triangulation of methods. Additionally, various types of data sources will be used - e.g. experts views, policy documents, reports and scientific articles - increasing the data source triangulation. Both the triangulation of methods as data sources will enhance the reliability of this research.

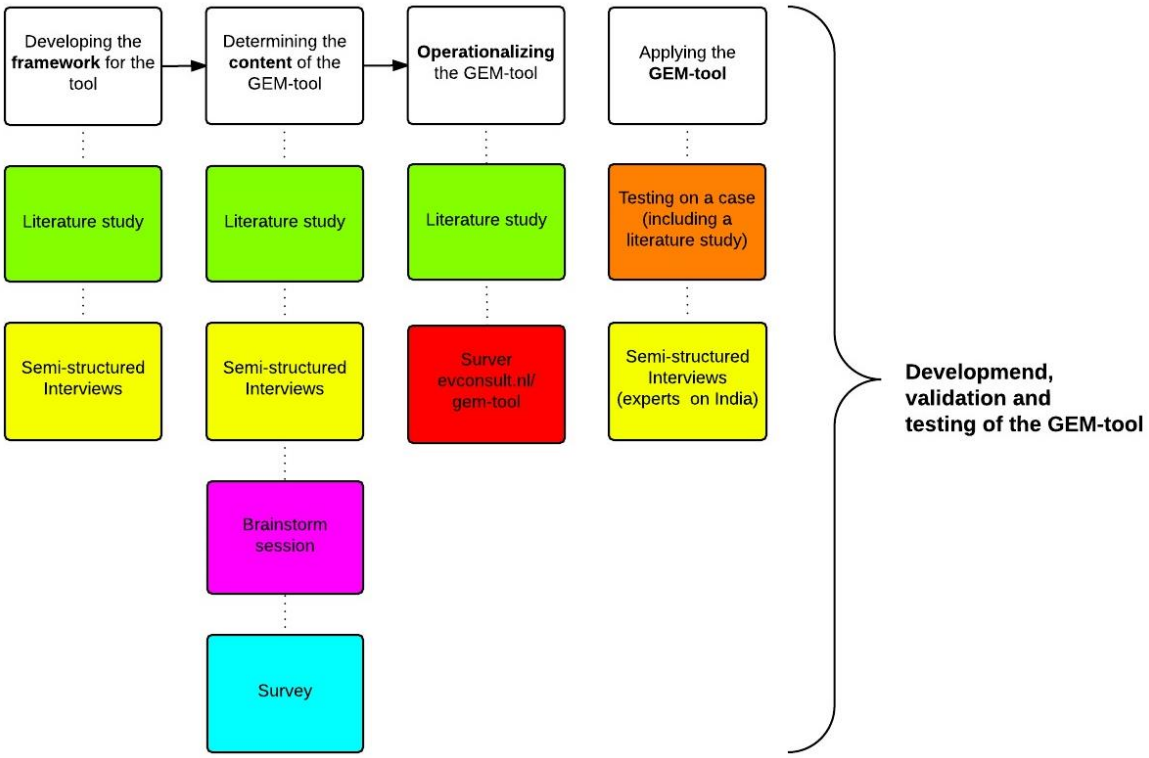

Figure 3 Overview research steps towards the GEM-Tool

Furthermore, the research is practice-oriented as it aims to contribute to a practical problem since there is a difference between the desired and actual situation (Verschuren & Doorewaard 2010). Moreover, the research includes both evaluative as prescriptive knowledge as it aims to design an ex-ante assessment tool to evaluate the innovation system regarding eMobility, as well as to give brief policy recommendations on the necessary changes to get to an improved innovation system for eMobility. It should be underlined however that the emphasizes will be placed on the evaluative aspect of the GEM-tool to give a structural overview of the prevailing situation with regard to identified preconditions for the successful implementation of eMobility.

2.1 Developing the framework of the GEM-tool

Before gathering and analyzing information which could be of use for the content of the GEM-tool, it is important to know what kind of data should be obtained. Therefore, a framework including the components and delineation of the GEM-tool is the first step in its development. The components should at least include a set of preconditions and corresponding questions, an evaluation of this set of preconditions and corresponding policy implications & recommendations as these are part of the research objective described in Chapter one. To gather this input, a literature study is performed analyzing the Technical Innovation System approach which forms the theoretical foundation of GEM-tool which increases the validity of the GEM-tool. Based on this analysis, the TIS approach is converted to be of use for the objectives and functionalities of the GEM-tool. Additionally, a first analysis of literature on eMobility is performed to complement the theoretical approach in designing the framework, focusing on the concept of eMobility in an urban context, in MICs and with regard to the role of local policy makers as in line with the research objective.

Additionally, semi-structured interviews are held with experts on innovation theory approach, on the introduction of innovations in developing countries and with experts from the field of eMobility. These are conducted in a semi-structured way as they generate as much input from the respondents as possible, combining the benefits of unexpected responses from the respondents with the structure on content analysis (Bernard 2006). This first set of interviews is used for the development and validation of the framework of the GEM-Tool. The method of interviews will be explained in more detail in section 2.2. The combination of the presented literature study and interviews will result in the components and the delineation of the GEM-tool, which together make up the framework of the GEM-tool.

2.2 Determining the content of the GEM-tool

After having identified the framework, the content of the GEM-tool should be specified. To do so, a combination of literature of the TIS approach as well as literature eMobility is analyzed. This means some overlap with the previous step (see subsection 2.1) but applies a different focus namely the identification and operationalization of the content of the components. This includes the analysis of best practices and lessons learned, as well as barriers and opportunities and policy recommendations for the introduction and diffusion of eMobility based on the TIS approach in the context of eMobility.

Furthermore, interviews are held with experts from the field of eMobility. These interviews become more structured and narrowed down with the advancement of the GEM- tool, as the tool encompasses a questionnaire which can (partially) be used during the interviews. The interviewees consist of experts from a range of professions such as academics, members of (international and national) transport boards and associations, policy makers, advisory firms etc. The type of

information resulting from the interviews depends on the background and profession of the interviewee. Therefore, experts from various backgrounds and professions are approached. Academia with a background regarding innovations and emerging technologies are asked about the underlying theoretical aspects applied to the GEM-tool (as described in section 2.1). Policy makers and experts from (inter) national institutes and partnerships focusing eMobility are consulted based on their perspective on the introduction and diffusion of eMobility, resulting in best practices and lessons learned. Interviews with experts stemming from the eMobility industry are focused on the performance of the eMobility market and the barriers and opportunities which can be identified. The interviews are held in person if possible and otherwise are carried out through skype- or telephone calls. The interviews are recorded (with the respondent's consent), transcribed and checked by the respondent. Afterwards, the interviews are coded with the help of NVIVO, a qualitative data analysis software. The interviews are coded according the identified framework of the GEM-tool. Afterwards, the identified information is used to develop the content of the GEM-tool.

Additionally, a brainstorm-session is organized. This is a relevant starting point for the identification of inducing and blocking mechanisms and enables the use of the available experience and knowledge within EVConsult (Andersson-Sköld et al. 2014). During this session, the (ten) consultants of EVConsult are asked about the development and rise of electric mobility for the Netherlands and other countries. The first step of the session consists of recording all the inducing and blocking factors that have influenced this development. In a second step, the consultants are asked to cluster the identify factors according to the seven system functions. The outcomes of the brainstorm-session can be used for the identification and validation of the content of the GEM-tool.

Moreover, not every identified precondition is assumed to be of the same importance. To give an individual weight to the preconditions, a survey is held amongst experts in the field of innovations and in the field of eMobility. The survey is performed via an online survey software named surveygizmo (www.surveygizmo.com). The experts stem from both front-runner countries as MICs as this combines knowledge on what has been done with knowledge within the context of MICs. The experts are asked to participate in the online survey, during which they are requested to order the preconditions per system function from highest priority to lowest priority. This results in a specific weight for each precondition The results are taken into account in the scoring system of the individual preconditions and innovation system. Furthermore, room for general comments is given within the survey which is used as input for the GEM-tool.

2.3 Operationalizing the GEM-tool

Having identified the framework and input for the GEM-tool, this information is translated into a practical tool. This includes the various steps which together form the tool, as well as designing this tool online. This combination is referred to as the operationalization of the GEM-tool. The steps of the GEM-tool are based on the previously identified information (see section 2.1 and 2.2). This is complemented with a literature study when necessary to complement this information (e.g. defining the key concepts used during the application of the GEM-tool).

The results of the above mentioned methods are stored in an Excel file which forms the input of the online tool. The web-based tool is built at *evconsult.nl/gem-tool.* Due to the size of the Excel file and the functionalities of the online tool, it is not possible to integrate the tool in the thesis itself. The thesis should therefore be seen as supportive to the results. The GEM-tool is incorporated in the

thesis as plain text in Annex I which displays the content but not the functionality of the tool. Furthermore, the GEM-tool consists of two parts: an online questionnaire and a PDF as outcome of the online questionnaire.

2.4 Applying the GEM-tool

Lastly, after the development of the GEM-tool, it is tested by applying it to an illustrative case. The application on a real-world case helps to understand the functioning of the tool, to identify gaps or over-use of components in the tool, to test its applicability and to increase its validity. As the GEM-tool aims to be generically applicable for all MICs, the tool should be applied to a set of representative cases for its (empirical) validation from a methodological point of view. However, due to practical reasons, in particular time- and resource constraints, only one case is analyzed to test the GEM-tool. Furthermore, the application to a case should not be regarded as full-fledged empirical case study, but should be interpreted as a illustrative test as it is set-up to present a brief overview of the applicability of the GEM-tool. The development of the tool is seen as a *'work in progress'* and the result of the thesis should be interpreted as the first step in an ongoing process towards a more validated and specified tool. Nevertheless, as the tool is based on a solid interpretation of literature, it is assumed to still be generically applicable, which is shown in the illustrative case. A literature study will be performed on the local situation regarding eMobility, using the data collection component indicated within the GEM-tool. This information is complemented and validated through semi-structured interviews with experts with extensive knowledge on the case study.

For the selection of the case, a number of criteria are applied. Firstly, the case should be an urban area located in a middle-income country as this is where the focus of the GEM-tool lies. Secondly, eMobility should be on the political agenda and a start of the implementation should be made. Having a case which is expected to score well shows the relevance of the identified preconditions and the potential gaps or excessive use of elements within the tool. Furthermore, it shows whether a country scores well using the GEM-tool when it is considered to perform well in general. A case study which does not have any eMobility development shows how the region scores which does not lead to conclusions about the performance of the GEM-tool. Thirdly, forming a more pragmatic criteria, the case should be feasible, accessible and be able to be researched by means of desktop research and interviews carried out via skype in English or Dutch. The case is therefore chosen in consultation with EVConsult, who for a large part can provide the contacts necessary to conduct the case study. Furthermore, as expert in the field of sustainable mobility, EVConsult has the experience to choose a case which fits the aim of the application of the GEM-Tool.

With the above mentioned criteria in mind, Delhi (the capital of India), a major urban region in a MIC, was chosen as illustrative case. India as a whole has high ambitions regarding eMobility and has an extensive national plan to carry out its ambition. Furthermore, India is the frontrunner of MICs when it comes to eMobility (OECD & IEA 2016). Lastly, the problems regarding air pollution and emission in Delhi are very pressing. It is one of the most polluting cities in the world according to the World Health Organization, with the main source of pollution (70%) in Delhi being emissions from vehicles (WHO 2016; IUT India 2009). eMobility can play an important role in tackling this issue.

Chapter 3 Developing the framework of the GEM-tool

Key messages

- The Technical Innovation System approach forms the foundation of the framework of the GEM-tool and is adapted to fit the ex-ante practical assessment tool;
- The TIS approach can be applied to understand the dynamics and performance of a system focused on a specific technology, including both the technology and the components that influence the innovation process of that technology;
- The TIS approach includes the following steps: delineation of the TIS, the identification of structural factors, a system function analysis including the motors of innovations, and a functional-structural analysis leading to systemic instrument goals;
- The delineation of the GEM-tool resulted in a focus on the pre-development phase of the introduction of eMobility in urban areas in middle-income countries and the aim to support the decision making process of local policy makers;
- The framework of the GEM-tool includes the following components: system functions, preconditions, the operationalization of the preconditions including a question, answer categories and a scoring system, their corresponding scale, weight and structural factor, possible answers and data collection strategies, and policy implications & recommendations. Furthermore, an evaluation of the overarching system functions is included also leading to policy implications & recommendations which together evaluate the existing innovation system.

This chapter starts with an overview of the origins, content and application of the TIS approach. It will briefly introduce the concept of sustainable transitions from a socio-technical system perspective and will touch upon the system of innovation perspective. Next, the focus will be placed on the Technical Innovation System approach which can be applied to understand the performance of a specific system focused on technology. This forms the basis of the application of the TIS approach to the GEM-tool. The chapter continues with the delineation of the GEM-tool and the adaptation of the TIS approach within the GEM-tool. The chapter concludes with the identification of components which will make up the framework of the GEM-tool.

3.1 The origin, composition and application of the TIS approach

3.1.1 Sustainable transitions

The issue how to govern a transition towards a more sustainable society has received increasing attention in social science research (Suurs 2009; Markard et al. 2012). One of the main theoretical perspectives on sustainable transitions resulting from this emerging research is the socio-technical system perspective. This approach conceptualizes sectors as socio-technical systems consisting of actors, institutions, artefacts and knowledge. These elements are interrelated and dependent on each other, forming the dynamics within a system. A set of processes leading to the fundamental shift in a socio-technical system is referred to as a socio-technical transition. When this takes place, both technological and institutional structures change as the transition encompasses a series of complementary technical and non-technical innovations. From this perspective, sustainable transitions can be defined as “long-term, multi-dimensional and fundamental transformation

processes through which established socio-technical systems shift to more sustainable modes of production and consumption" (Markard et al. 2012, p.2).

Research on socio-technical transitions and sustainable technologies, aiming to enhance the understanding of sustainable transitions, has resulted in various frameworks of which four adopt a systemic view of the transformation processes (Markard et al. 2012): transition management (Loorbach 2010; Rotmans et al. 2001), strategic niche management (Raven et al. 2010; Hoogma et al. 2005; Kemp et al. 2011), the multi-level perspective framework (Geels 2012) and the system of innovation approach (Bergek, Jacobsson, et al. 2008; Hekkert et al. 2007; Wieczorek & Hekkert 2012; Negro 2007). The latter differs from other research on sustainable transitions as it incorporates a system perspective and is derived from the idea that (technical) innovation lies at the core of the transition process (Suurs 2009). It uses the concept of innovation systems to analyze all subsystems, actors and institutions contributing to the emergence of an innovation (Hekkert et al. 2007). It furthermore offers abstract patterns for theoretical generalization while said to be concrete enough for practitioners (Suurs 2009; Arocena & Sutz 2002). As this is in line with the aim of this research to develop a practical assessment tool to support decision makers in the introduction of eMobility, the SI approach is used as theoretical lens for this research.

3.1.2 System of innovation approach

Innovation can be seen as the development and adoption of new and improved ways of addressing social, environmental and economic needs and wants, which can have social, economic or technological characteristics. Since the 1980s, both innovation researchers and certain policy makers have adopted a system perspective on innovation (Kuhlmann et al. 2010). This can be seen as a reaction to the shortcomings of neoclassical attempts to explain innovation (Wieczorek & Hekkert 2012), in which the concept of market failures is put forward as reason for a lack of innovation and policy interventions (Kuhlmann et al. 2010; S.O. Negro et al. 2011). Instead, the system perspective on innovations incorporates the broader concept of system thinking and associated systemic problems as basis of policy action (Markard et al. 2012; Bergek, Jacobsson, et al. 2008). It recognizes that the development and diffusion of innovations is an iterative process which is associated with uncertainty. This innovation process takes place within a co-evolution of technology and society as it depends on the co-development of new socio-technical systems, new market structures, new actors and new institutional settings in both public and private sectors (Markard & Truffer 2008; Hekkert et al. 2007; Smits et al. 2010). The system innovation (SI-) approach incorporates this systems perspective on innovations. It provides insight in the conditions that foster the growth of an emerging innovation system in such a way that it becomes part of the existing system, which can help to intentionally shape innovation processes (Hekkert et al. 2007). This has led to the application of the concept of innovation systems or "the networks of organizations and institutions that develop, diffuse and use innovations" (Edquist 2004, p.182). The innovation system does not yet have to exist but can be emerging during which it goes through different phases of development (see Figure 4) (Hekkert & Ossebaard 2010; Coenen & López 2008; Alkemade & Hekkert 2009):

1. *The exploratory phase*: this is the first phase in the build-up of an innovation system. A new innovation system arises through the introduction of a new technology, stimulated by

science, entrepreneurs and diversifying activities of existing market players. The aim of this phase is Knowledge Development and the start of Entrepreneurial Activities.

2. *The take-off phase*: in this phase the focus lies on the commercial application of the technology and the technology is introduced to the market. It is characterized by a small but increasing demand for the new technology and an increase in Entrepreneurial Activities.
3. *The acceleration phase*: this phase is characterized by a strong growth in diffusion of the technology in question through an increase in market outlets. Market creation, competition on price and process innovation are key in this phase.
4. *The stabilization phase*: this phase is characterized by the stabilization of the demand or the technology. Furthermore, it will see a decrease in number of individual companies related to the innovation and an increase in business size. The innovation system can turn into a stabilized product system.

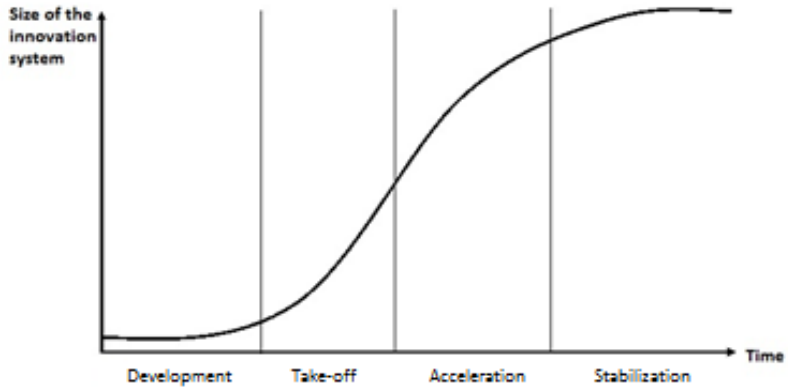

Figure 4 The build-up of an innovation system (the s-curve indicates the market diffusion of technology)

A number of different innovation system concepts have been defined for different purposes of analysis, including the national SI, regional SI, sectoral systems SI and the technical SI (Bergek, Jacobsson, et al. 2008; Markard & Truffer 2008). For this research, the Technological or Technical Innovation System approach will be applied, which refers to innovation systems focused on a specific technological innovation, in this case electric mobility.

3.1.3 Technical Innovation System approach

The TIS approach can be applied to understand the dynamics and performance of a system focused on a specific technology, including both the technology and the components that influence the innovation process of that technology (Wieczorek & Hekkert 2012; Bergek, Jacobsson, et al. 2008). It provides a method to determine the various factors influencing the innovation and diffusion of the technologies and has been developed for the use by policy makers who intent to support an emerging technology (Bening et al. 2015; Planko et al. 2014). Its application can identify systemic weaknesses and strengths within the TIS (Markard & Truffer 2008). Furthermore, technological change is not only determined by competition between existing technologies, but mostly by competition between various (developed and emerging) systems. Therefore, the TIS approach provide insights in the relation between the predominant technology and the emerging technology (Hekkert et al. 2007).

Markard and Truffer (2008) examined the diversity of interpretations of key terms used in the TIS literature and on the basis of this analysis propose an inclusive definition combining the innovation

function of the system (following (Edquist 2004) and the technology perspective (Bergek, Jacobsson, et al. 2008; Hekkert et al. 2007) while restricting the system to actors, institutions, infrastructure and networks that are supportive to the innovation process. They define a technical innovation system as: "*A set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product*" (Markard & Truffer 2008, p. 611). The focus lies on endogenous system factors that policy makers can alter as exogenous factors are often outside the immediate influence of policy makers, even though they can influence the functioning of a TIS (Wieczorek & Hekkert 2012).

Studies focusing on the development or application of the TIS approach have adopted different focuses, resulting in a variety of identified and applied steps included in the approach, beginning from different starting points of the analysis and using various structural factors and system functions (see Annex II for an overview of the identified differences). Within this research, the following identified steps are combined to form a comprehensive TIS approach which are applied to form the GEM-tool (see section 3.2): firstly, the TIS needs to be delineated according to the desired focus (Bergek, Jacobsson, et al. 2008). Secondly, the structural factors should be mapped. Thirdly, the system functions, representing the dynamics within the TIS, should be identified including their motors of innovation depending on the phase of development of the TIS (Hekkert et al. 2007; Suurs 2009). Fourthly, a functional-structural analysis can be performed to identify structural problems and corresponding systematic instruments goals (Wieczorek & Hekkert 2012). The steps are explained in more detail below.

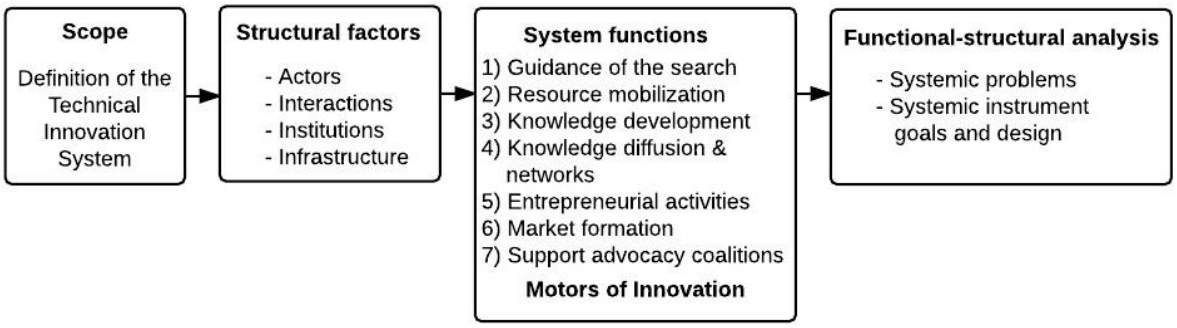

Figure 5 Overview of the steps incorporated in the TIS approach

3.1.3.1 Delineating the TIS

It is simple to say that a TIS consists of anything relevant for the development of a particular technology, but this delineation is rather impractical. It is necessary to make deliberate choices about the determination of the TIS as the outcomes influence its structure and functions. Delineation can be seen as a process in which the starting point is a particular set of core structures related to a particular (societal) problem (Suurs 2009). Three main types of choices need to be considered: Firstly, the focus of attention may be either a knowledge field (which can be applied to products) or a product (group). Secondly, a choice needs to be made between breadth and depth, following from the level of aggregation and the range of applications within the study. Thirdly, the spatial domain needs to be mapped. While TISs are generally global, there may be reasons to focus on a spatially limited part of a particular system in order to capture other aspects within a national or regional context. Depending on the above mentioned choices, different sets of structural factors are be incorporated in the TIS (Bergek et al. 2008). Furthermore, for each phase of development a specific

set of functions and interactions is important (Suurs & Hekkert 2009). Consequently, when performing an innovation system analysis, it is important to know which phase the technology has reached as this influences the criteria for its evaluation (Hekkert et al. 2007; Hekkert et al. 2011).

3.1.3.2 Identifying structural factors

Within the TIS literature, four structural dimensions[1] can be identified which make up the static components of the TIS framework: (1) actors (2), institutions, (3) interactions and (4) infrastructure:

Actors
An actor can be any organization contributing to the emerging technology, either directly as a developer or adopter of technology, or indirectly as a regulator, financer, etc. The development of a TIS depends on the presence, skills and willingness of these actors to take action (Suurs 2009). The actors can be categorized based on their role in the economic activity: civil society, government, non-governmental organizations, companies, knowledge institutes, and other parties (Wieczorek & Hekkert 2012).

Institutions
Institutions can be considered the 'rules of the game in a society', which can be both formal and informal (Suurs 2009). They are determined by their spatial, socio-cultural and historical specificity and are different from organizations, which are considered as a type of actor in this research, (following Wieczorek & Hekkert 2012). They include policy programs, as well as the responsibility and expectations of certain actor groups. Institutions are important as they are the target of government policies (Suurs 2009).

Interactions
Interactions are essential as they facilitate the exchange and diffusion of knowledge (Suurs 2009). They are an important driver for learning and the formation of coalitions that can strengthen the position of the TIS (Bergek, Jacobsson, et al. 2008). Interactions are not restricted to occurring in networks, but focus on the relationships between actors and can be analyzed at the level of networks or individual contacts (Wieczorek & Hekkert 2012).

Infrastructure
The infrastructure is divided into three categories: material (e.g. roads), financial (e.g. grants), and knowledge (e.g. expertise) factors (Wieczorek & Hekkert 2012). Including this element within the structural factors ensures that the feedback mechanism between technological and institutional change is taken into account (Suurs 2009).

3.1.3.3 Determining the systemic functions and their dynamics

In order to understand and capture the dynamics of the TIS, the activities that take place within the TIS are mapped since the process of change results from many (interrelated) activities (Hekkert et al. 2007; Anon 2012). These activities are called system functions which can be defined as "a contribution of a component or a set of components to a system's performance" (Hekkert & Negro 2008, p.8). As it is not feasible to map all the activities that take place in an innovation system, only the relevant activities within the TIS are mapped. Activities are considered relevant when they

[1] *The structural functions differ slightly in name and use in the TIS literature (see Annex II). In this research, the definitions of structural factors is based on the work of Suurs (2009) and Wieczorek & Hekkert (2012).*

influence the development, application or diffusion of new technological knowledge. This functional analysis complements the static structural analysis as it shows the way in which a TIS is organized (Wieczorek & Hekkert 2012). The list of functions can be seen as a checklist of key activities that need to be present in a TIS in order for it to develop (Suurs 2009), used to identify blocking mechanisms and serving as a framework to identify policy issues (Bergek, Hekkert, et al. 2008). There are multiple variants of the list of functions within a TIS. The set of system functions employed in this research is based on the work of Bergek & Jacobssen and on the work of Hekkert et al. (2007), as many empirical studies have been performed to validate these functions, concluding that the functions correspond well to the actual process relevant in the field of sustainable innovation (Suurs 2009). It encompasses the following system functions (see Chapter four for a more detailed description of the system functions):

1) *Guidance of the Search*: this system function refers to those activities that shape the needs, requirements and expectations of actors with respect to their support of the emerging technology (Suurs 2009). Furthermore, it represents the selection of technical designs in transformation processes (Wesseling & Vooren 2016)
2) *Resource Mobilization*: this system function refers to the allocation of human, financial and material capital used for the technology to develop and diffuse (Negro 2007).
3) *Knowledge Development*: Learning mechanisms are at the core of the innovation process. Research & Development (R&D) and Knowledge Development encompassing learning by doing and learn by searching, are prerequisites within a TIS (Suurs 2009; Hekkert et al. 2007; Alkemade & Hekkert 2009).
4) *Knowledge Diffusion & Networks*: Networks represent an important organization structure of a TIS. Its primary function is the facilitation of knowledge between all the actors involved, as an innovation only happens when heterogeneous actors of different backgrounds interact. It includes learning by using and learning by interacting (Suurs 2009; Hekkert et al. 2007).
5) *Entrepreneurial Activities*: Entrepreneurs are essential for the well-being of a TIS. Their role is to translate knowledge into actions and business opportunities (Suurs 2009; Hekkert et al. 2007; Alkemade & Hekkert 2009).
6) *Market Formation*: The Market Formation function involves activities that contribute to the creation of a demand for the new technology, for example using financial incentives. This is especially important in the field of sustainable energy technologies, since there is often a strong normative legitimation for the intervention in market dynamics (Suurs 2009).
7) *Creation of Legitimacy*: In order for a technology to develop, it has to either become part of an incumbent regime or overthrow it. Advocacy coalitions can serve as catalysts by putting the new technology on the agenda and by lobbying for resources and favorable (financial) measures. In doing so, they create legitimacy for a new TIS (Hekkert & Ossebaard 2010; Alkemade & Hekkert 2009).

The interactions between these system functions can result in positive- and negative feedback loops, thereby creating either virtuous or vicious circles that influence the diffusion of the technology. In order to develop an understanding of the TIS, it is important to know under which conditions these virtuous or vicious cycles occur. This provides a system-level explanation of why a TIS is developing as it is which can have important implications for intervention strategies (Suurs 2009). However, as the emerging technology will pass through different phases, various processes are important in the different phases. Suurs (2009) translated these dynamics into trajectories called '*motors of*

innovation' [2], focusing on emerging sustainable energy technology systems. Each of the motors is characterized by particular interactions between the system functions. The motors of innovation can be used complementary to the structural factors and system functions analysis as they help to point out which system function and interactions are important in the different phases of development of a TIS (*as introduced in 3.1.2).* Four different motors of sustainable innovation have been identified by Suurs (2009) and adapted by Hekkert et. al (2011) to fit the different phases of a TIS:

1. Science and technology push (S&TP) motor (exploration phase): the STP motor emerges when there is a new technology which holds a solution to societal problems and is dominated by the system functions Knowledge Development, Knowledge Diffusion & Networks, Guidance of the Search and Resource Mobilization.
2. Entrepreneurial motor (take-off phase): The Entrepreneurial Motor is partly similar to the STP Motor but there is an important role for the Creation of Legitimacy and Entrepreneurial Activities. New actors enter the TIS and initiate projects as they see opportunities for the commercialization of the technology. It is strengthened by the formation of markets.
3. System building motor (acceleration phase): In the System Building Motor the set of dominant system functions is similar to those of the Entrepreneurial Motor but it includes a more important role of Market Formation. System building attempts includes the strengthening of networks aiming to develop a mass market through the lobby for resources and strong institutions for the new technology
4. Market motor (stabilization phase): All system functions are strongly fulfilled and a market environment has been created as the result of formal regulations.

3.1.3.4 Performing a functional-structural analysis

The performance of the TIS can be evaluated in terms of how well the system functions are carried out (Hekkert et al. 2007). Both the individual fulfilment of each system function and the interaction between them are of importance to the development of the system. Once the functional pattern has been established, each function can be examined through the perspective of the structural factors. This is part of the functional-structural analysis as developed by Wieczorek & Hekkert (2012). It relates the structural factors to explanatory reasons why a certain system function is weak or absent, as the function performance is strongly related to its structural factors and cannot be altered without changing a structural factor (Wieczorek & Hekkert 2012). This relationship leads to the identification of system problems, which can be classified according to the four structural factors. System problems are defined as problems that arrive at the innovation system level which hinder the development and functioning of the innovation process either through a problem with one of the structural factors or with the relation between them. Both the presence and the quality of the structural factors can lead to systemic problems. This offers a systematic mapping of all possible blocking mechanisms that may occur in a TIS and allows for an understanding of the drivers and barriers to the innovation (Wieczorek & Hekkert 2012). By altering the structural elements through policy, the system functions can be strengthened (Wieczorek et al. 2011).

[2] *Within this research. the Motors of Innovation approach is seen as part of the system functions analysis and is therefore not included as separate step.*

System function	Structural element	Systemic problem	(Type of) systemic problem	Systemic instrument goals
F1: entrepreneurial activities	Actors	Actors problems	Presence?	Stimulate and organise the participation of relevant actors (1)
			Capabilities?	Create space for actors capability development (2)
	Interactions	Interaction problems	Presence?	Stimulate occurrence of interactions (3)
			Capacity?	Prevent too strong and too weak ties (4)
	Institutions	Institutional problems	Presence?	Secure presence of hard and soft institutions (5)
			Intensity?	Prevent too weak and too stringent institutions (6)
	Infrastructure	Infrastructural problems	Presence?	Stimulate physical, financial and knowledge infrastructure (7)
			Quality?	Ensure adequate quality of infrastructure (8)
F2: knowledge development etc.	Actors	Actors problems	Presence?	Stimulate and organise participation of relevant actors (1)
			Capabilities?	Create space for actors capability development (2)
	Interactions	Interaction problems	Presence?	Stimulate occurrence of interactions (3)
			Intensity?	Prevent too strong and too weak ties (4)
	Institutions	Institutional problems	Presence?	Secure presence of hard and soft institutions (5)
			Capacity?	Prevent too weak and too stringent institutions (6)
	Infrastructure	Infrastructural problems	Presence?	Stimulate physical, financial and knowledge infrastructure (7)
			Quality?	Ensure adequate quality of infrastructure (8)

Table 2 The systemic innovation policy framework developed by Wieczorek et al. (2012)

Within the innovation literature, a number of frequently occurring structural barriers have been identified which hinder the functioning of a TIS. These include: uncertainty about the future market of the innovation, lack of legitimacy, lack of policy to protect and support the innovation, ambiguous behavior of incumbent industry, poor organization of networks, lack of knowledge and competences, strong lock-in of existing technology and lack of a long term vision of the government (Hekkert & Ossebaard 2010). Based on these structural barriers and combining them with the categorization of systemic problems, Wieczorek & Hekkert (2012) distinguished eight systemic instrument goals which should be addressed to improve the functioning of a TIS (see Table 2). In summary, analyzing the system functions on the basis of structural factors, leading to the identification of (types of) systemic problems and linking them to systemic instrument goals, gives a systemic policy framework to analyze and stimulate technological innovation.

3.2 Applying the TIS approach to GEM-Tool

Building upon the theoretical outline and steps within the Tis approach as presented in section 3.1, this section will elaborate upon the application of the TIS approach for the GEM-tool. Before going through the steps of the TIS approach, it is important to introduce the definition of a TIS as used for the GEM-tool.

As introduced in section 3.1, a technical innovation system can be defined as: “A set of networks of actors and institutions that jointly interact in a specific technological field and contribute to the generation, diffusion and utilization of variants of a new technology and/or a new product” (Markard & Truffer 2008, p. 611). This definition does not include factors negatively influencing the TIS. However, as insights in the internal endogenous dynamics provides learning opportunities (Suurs 2009), endogenous opposing factors and (institutional) barriers within the TIS that negatively influence its development need to be included in its definition. This provides the opportunity to shape the innovation process by identifying and solving systemic problems within a TIS related to these barriers. Furthermore, the concept of ‘infrastructure’ as influential factor within a TIS is recognized by various authors within the TIS literature (e.g. Bergek et al. 2015; Wieczorek & Hekkert 2012; Suurs 2009) and is therefore included within this research. Lastly, the structural factor ‘interaction’ is included instead of the concept of networks, as this includes both networks and

individual relations (see also section 3.2.3) (Wieczorek & Hekkert 2012). Thus, the following definition for technical innovation systems is proposed for this research, adapted from the definition as proposed by Markard & Truffer (2008): “a set of actors, interactions, institutions and infrastructure that jointly interact in a specific technological field and influence the generation, diffusion and utilization of variants of a new technology and/or a new product”.

3.2.1 Delineating the GEM-Tool

The technical innovation system is the unit of analysis used within the GEM-tool. Still, deliberate choices should be made about the focus of the tool which should be communicated to the recipients of the analysis including the kind of focus, the breadth or depth, and the spatial domain (Bergek et al. 2008). These choices are elaborated upon in the various paragraphs below, showing how the TIS approach has been adapted to fit the aim of this research, namely to develop an ex-ante, practical assessment tool to support the decision making process of local policy makers in the introduction of eMobility.

3.2.1.1 The phase of development

As explained in section 3.1, the phase of development of the TIS influences the processes within the TIS as well as its evaluation criteria. The GEM-tool aims to map the existing policy beforehand with respect to preconditions necessary for the successful implementation of eMobility. Therefore, the focus will lie on the pre-development phase as basis for the tool. In this phase, the TIS is just emerging through the introduction of a new technology. There is a high level of uncertainty for entrepreneurial actors, investors and policy makers in terms of technologies, markets and regulations (Bergek, Hekkert, et al. 2008). Markets are not existing or very small, the number of firms involved in the technology is very limited, the advocacy coalition and legitimacy for the technology is weak and the demand is poorly articulated. This has implications for the functioning of the system functions and the motors of innovation driving this, which is taken into account during the development of the GEM-tool (see also section 3.2.3).

3.2.1.2 The concept of eMobility

Electric mobility relates to the electrification of the propulsion of vehicles used for road transport. There are different types of EVs, including battery- electric vehicles (BEVs), hybrid- electric vehicles (HEVs), plug- in hybrid vehicles (PHEVs), and Fuel Cell Electric Vehicles (FCVs) (see also Table 1). Hybrid-electric vehicles – partly driven by an electric motor – are part of the eMobility movement as they are proposed as the most promising in short and mid-term perspective (Hekkert et al. 2005). FCVs are not included in the concept of eMobility applied within this research and the GEM-tool as they represent an underdeveloped technology and need a different infrastructure and therefore a different policy approach (Dijk et al. 2013). Furthermore, two, three, four and four+ wheelers are taken into account, including personal transport, taxi’s, busses and the government fleet. To ensure the general application of the GEM-tool, it will not distinguish between the types of vehicles, modes of transport or the range of applications of eMobility as it is not known beforehand which type of vehicle or vehicle usage is suitable for electrification in the local context. It therefore focuses on the information to support local policy makers in their decision making process.

Additionally, eMobility requires a radical shift from traditional fueling techniques towards an electric charging infrastructure. There are different types of charging techniques including the use of

charging points, inductive charging, in motion charging and charging via a pantograph (IEA 2014). However, charging points are currently the main technique applied, which consist of charging points connected to the energy grid. They can be private (privately owned, installed at one's own terrain), semi-private (placed in on a privately owned terrain for public use e.g. at public indoor parking) or public (publically accessible and located in the public space) (PRC & EVConsult 2010).

3.2.1.3 Application of the GEM-tool in a developing context

The TIS approach has been adopted in the innovation policies of many European countries in (Chaminade & Edquist 2010). Within developing countries, an innovation system still needs to be created and an enabling environment for innovations is often missing (Arocena & Sutz 2002). This is partly due to the fact that technology development and innovation system build-up normally co-evolve. This is less so in developing countries as the technology related to eMobility has already been developed for a large part in frontrunner countries. The maturity of the technology is ahead of the development of the system functions within developing countries. On the one hand, developing countries can take advantage of the existing knowledge, still taking into account the adaption of the technology to the local context. On the other hand, however, uncertainties and lack of resources negatively influencing the development of a system of innovation may be compounded by failures in governance within rapidly developing countries (Berkhout et al. 2010). The capacity of policy makers to create institutions to combat uncertainties is critical to the innovation and diffusion process (Loorbach 2010; Sperling & Salon 2002). However, due to international influences and a lack of focus on local capacity building, the system before the introduction of an innovation might not be known to local policy makers (Arocena & Sutz 2002). The GEM-tool therefore has an important role to play especially in developing countries, as it aims to provide an overview of the existing situation beforehand and can therefore support the decision making process with regard to eMobility.

For the GEM-tool, the focus is placed on middle-income countries within the general concept of developing countries. MICs are countries with a Gross National Income per capita between $1,046 and $12,735 US dollars as calculated by the World Bank (World Bank 2016). Generally, these countries are still faced with the various challenges caused by the transport sector but their growing economies also provide the opportunities to invest in sustainable mobility (Sperling & Salon 2002). Furthermore, MICs have made the most reference to eMobility as means towards reducing their transport emissions (Turrentine 2016). The incentive and willingness of MIC are therefore assumed to be present. Low income countries are not taken into account as they are assumed to have other priorities regarding i.e. their infrastructure and energy sector.

3.2.1.4 Use of the GEM-tool in an urban context

A TIS analysis can be applied at international, national and regional level and can cut across different industrial sectors (Coenen & López 2008). Within this research, TIS will be applied in a local context, namely an urban area in middle-income countries. An urban area or region is defined in this research as a city and its surrounding peri-urban areas. The GEM-tool focuses on urban areas as these are favorable regions to deploy an innovation. This is especially true for eMobility as EVs are currently mostly used in urban areas due to the limited range of the battery and the relative ease of experimentation and demonstrations within a city (Nilsson et al. 2012). Secondly, urban areas experience the worst direct effects of traditional transport in the form of local air pollution, which can reach up to much higher levels than considered safe by the World Health Organization (WHO

2014). Currently, more than half the world's population lives in urban areas, mostly in developing countries. As this proportion is expected to grow while urban lifestyles are increasingly dependent on mobility, pollution levels are expected to grow as well (Bertolini 2012). Therefore, it is necessary to improve the link between the role of mobility in enhancing cities' well-being and the lack of sustainability of present urban mobility practices (Bertolini 2012). This could be an important role for eMobility.

Furthermore, local and global linkages are fundamental to the accumulation and development of technologies and capabilities (Berkhout et al. 2010). A TIS must therefore take into account international flows of resources, making the system of innovation a framework to link multiple levels of activities (Iizuka 2013; Berkhout et al. 2010). The urban region chosen as focus within the GEM-tool is also influenced by international and national developments. Hence, within the GEM-tool, the various kinds of scales are taken into account.

3.2.1.5 Role of local public policy makers

For a sustainable innovation to develop, changes are necessary in the social and political domain to stimulate the development, introduction and diffusion of a new technology (Geerlings et al. 2012; Hekkert et al. 2007; Siyanbola et al. 2012). As innovations involve a high degree of uncertainty and risk, public policy should safeguard the variety, the stimulation of formation of 'prime movers' and the formation of networks to coordinate the diffusion of the technology and corresponding knowledge by bringing a variety of actors together (Bergek et al. 2010). A sustainable innovation is especially difficult to implement as part of the gains can be seen as environmental externalities. The market price of traditional, unsustainable products does not take into account the negative externalities which results in a distorted comparison in costs with the sustainable innovation. Furthermore, the benefits derived from sustainable technology are important for the whole community but are not felt directly by the individual consumer. A sustainable innovation therefore often depends more on government intervention to enable its diffusion (Hekkert & Ossebaard 2010; Rietveld & Stough 2006). The design of this form of governance, however, is a key issue in many innovation policy programs (Hekkert et al. 2007): policy makers struggle to develop policies and strategies to support the transition towards the application of a new technology, especially since emerging technologies are characterized by uncertainty. This is particularly the case for developing countries, which generally have the least technical and institutional capabilities to develop and introduce technical innovations (Sagar & Majumdar 2014). Furthermore, policy should focus on specific activities, as policy can be seen as a process to uncover areas where policy interventions are most likely to make a difference. Policy makers should be able to identify activities and areas that are crucial for the development of TIS (Bergek et al. 2010). Lastly, the TIS approach focuses on the use by policy makers who intent to support an emerging technology (Wieczorek & Hekkert 2012). Therefore, the GEM-tool is developed for (local) policy makers who are or aim to get involved in the implementation of eMobility to support them in their decision-making by showing the baseline situation with regard to the introduction of the innovation.

3.2.2 The structural factors within the GEM-tool

The structural factors included in the GEM-tool consist of actors, institutions, interactions and infrastructure. In an emerging TIS, many of the structural components are shared with other innovation systems. For example, institutional change intended for CO2 reduction can also influence the supply of (renewable) energy. This is especially true for eMobility, as its cuts across different

sectors namely the automotive, ICT and energy sector (Ernst & Young 2012). Therefore, as the TIS of eMobility is still in a very early phase but can be linked to other systems, the *potential* structural factors are taken into account within the GEM-tool. Furthermore, the structural factor 'interaction' is included instead of the concept of networks as this includes both networks and (informal) relations (Wieczorek & Hekkert 2012) and therefore is more applicable to the practical GEM-tool, as well as to middle-income countries where (formal) networks are less apparent (Arocena & Sutz 2002).

3.2.3 The system functions and their dynamics within the GEM-tool

The system functions and their dynamics, as defined which have been introduced in section 3.1.3 (see Table 3), play an important role in the GEM-tool as they provide the overarching activities. Furthermore, the dynamics between the system functions can be used complementary to the structural factors and system functions analysis as they help to point out which system function are important in the different phases of development of a TIS (as introduced in 3.1.2). This approach provides a heuristic basis for the evaluation of TIS dynamics within the system that characterizes the formative phase of an innovation system and are therefore included in the GEM-tool.

The motor of innovation for the GEM-tool, the GEM-motor, is designed using the Science & Technology Push (STP-) motor and the Entrepreneurial motor as developed by Suurs (2009). Both the STP-motor and Entrepreneurial motor have been identified as first motors of innovations to appear within a TIS. Combining them gives a full picture of the dynamics in the first phases of an innovation system. Furthermore, as all system functions are relevant to the innovation system, as was concluded through extended empirical research in studies by e.g. Negro, Suurs, Alkemade and Van Alphen (Alkemade et al. 2007; Negro 2007; Simona O Negro et al. 2011; van Alphen et al. 2008), all system functions are included in the GEM-motor. Additionally, as the eMobility technology has already been developed and tested in frontrunner countries, Knowledge Development regarding the technology of the innovation plays a smaller role in middle-income countries, which is one of the key system functions in the pre-development phase (Hekkert et al. 2011). It is still important to improve the technology and adapt it to the local context, but Market Formation and Entrepreneurial Activities can already play a role as the basic technology is available. Therefore, they are also included as part of the GEM-motor, consisting of various feedback loops and mutual interactions explained below. It should be noted, however, that the system functions are numbered according to the steps indicated in the GEM-motor. This differentiates from the consisting numbering used in the TIS literature. No reason has been found for this particular numbering, therefore it was altered to fit the GEM-tool, taking into account the motors of innovation applied.

System function	Abbreviation
Guidance of the Search	F1
Resource Mobilization	F2
Knowledge Development	F3
Knowledge Diffusion & Networks	F4
Entrepreneurial Activities	F5
Market Formation	F6
Creation of Legitimacy	F7

Table 3 The system functions within the GEM-tool

An important driver in this first phase of the build-up of a TIS is an emerging technology offering a solution to societal problem(s) and the growing sense of urgency among a group of policy makers with regard to these societal problems. But, as the TIS is still in its start-up phase, there is only a small group of actors interested in the innovation, mostly stemming from the government and the supply side of the TIS. There is a weak involvement on the demand side of the TIS and there are no launching customers willing to invest. But governments are willing to stimulate the innovation with project specific subsidies and by serving as launching customers. The role of local governments is especially important when national government support is absent. Therefore, the GEM-motor tool starts with *Guidance of the Search* (F1) during which societal problems are identified, government goals and national plans are developed in reaction to these problems and expectations are formed about the technology (Suurs 2009). This influences *Resource Mobilization* (F2): funds are made available to finance projects, the necessary material resources are gathered to make the innovation possible and skills and capabilities of experts are developed. This gives a boost to the scientific activities represented in the system function *Knowledge Development* (F3), during which the technology developed, adapted to fit the local context and tested in R&D projects and feasibility studies. This is directly related to *Knowledge Diffusion & Networks* (F4), which main aim is to stimulate the diffusion of the knowledge and technology via the interaction between actors. According to Suurs (2009), *Knowledge Development* and *Knowledge Diffusion & Networks* are very much interlinked and are therefore displayed as such (Figure 6). These four functions are the dominant functions necessary for the start of the emerging eMobility system and their interaction make up one of the feedback loops in the GEM-motor. They are illustrated with the green dots in Figure 6 below. If the system functions are carried out well, it will lead to the rise of a shared vision that provides direction to the field, turning a radical idea into a widely shared concept amongst policy makers. It will also affect the knowledge structure and supply-side of TIS as the number of actors and their relation increases. Furthermore, it will create formal institutions to support of the emerging technology (Suurs 2009; Hekkert et al. 2011).

Furthermore, an essential part of the formation of an innovation system is the presence of *Entrepreneurial Activities* (F5). Within this system function, (incumbent) firms and entrepreneurs enter the TIS and initiate experimental projects to bring the technology to the market. Resources are necessary for Entrepreneurial Activities to develop due to the pre-commercial status of the innovation. This is done through the *Creation of Legitimacy* (F7), which includes the lobby for (resources for) the innovation and the widespread acceptation (legitimation) of the technology. When resources are mobilized, new projects can be started which feeds back in the dynamics of the motor itself as it provides incentives for other actors to initiate projects. These interactions form the second feedback loop within the GEM-motor. Additionally, these dynamics are strengthened by the existence of the incentives which can form (niche) through the function *Market Formation* (F6), influencing *Guidance of the Search* and strengthening the overall dynamics of the GEM-motor. These market activities are also influenced by the *Guidance of the Search* function themselves, as the latter determines Market Formation measures. Additionally, the mutual interaction between *Entrepreneurial Activities* and *Guidance of the Search* exists as the development of the former influences the interest of public and private to take up or drive the technology (the latter). The mutual interaction with *Knowledge Diffusion & Networks* and *Entrepreneurial Activities* consist of demonstration projects and experiments, stimulating learning-by-doing and improving the innovation. At the same time collaboration increases between heterogeneous and homogenous

actors within the innovation system and the technology becomes more embedded in formal institutions. Lastly, the demand side of the TIS can be formed carefully, connecting to the supply side and the knowledge structure through positive outcomes of demonstrations and experiments (Suurs 2009; Hekkert et al. 2011).

To conclude, the above mentioned system functions and their mutual interactions form the GEM-motor of innovation.

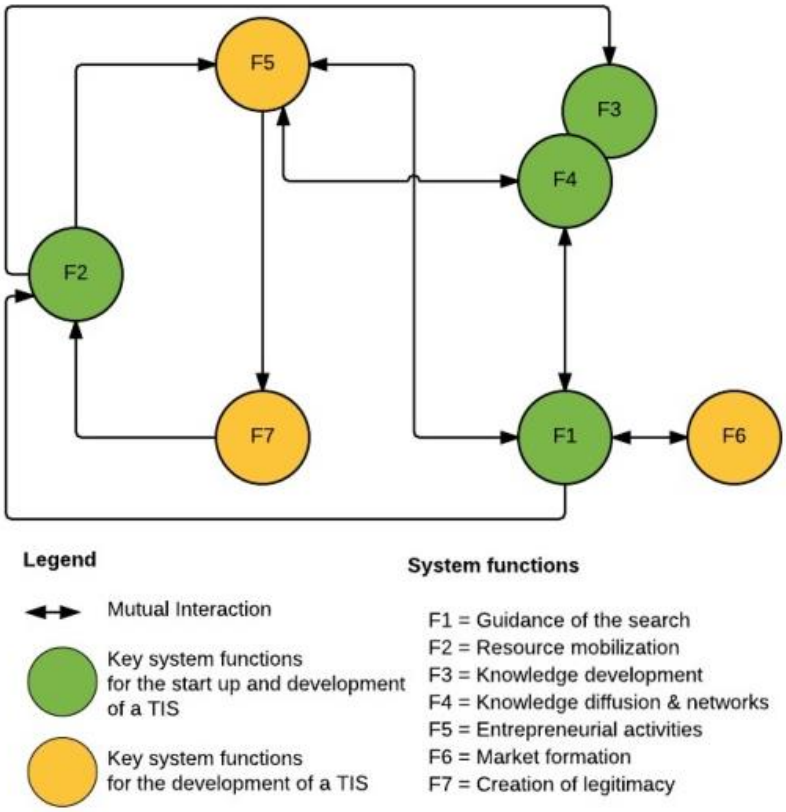

Figure 6 GEM-motor of innovation

3.2.4 Functional-structural analysis within the GEM-tool

For the GEM-tool, the system function level is chosen as unit of analysis as this focuses on the assessment of the functioning of the TIS (Eveleens et al. 2015; Hekkert et al. 2007). However, this analysis is dependent on the structural factors within the TIS. Mapping the system functions (what is happening) without referring at all to structural factors (who/what is driving it) gives an incomplete image and separates mutually dependent elements as each system function may be influenced by different structural components and each structural component may influence several functions (Bergek, Hekkert, et al. 2008). Within the GEM-tool, the structural analysis has become part of the system function analysis as the structural factors are immediately linked to the system functions instead of this being two separate steps within the research as proposed by Wieczorek & Hekkert (2012). The preconditions used for the identification of system functions are thus directly linked to structural factors making the functional-structural analysis possible, while combating the duplication of efforts and information. This will circumvent the problem of trying to identify all structural factors beforehand and then trying to give them a place in the system functions (which seems like an arduous and cumbersome exercise as various structural functions have a place in different system

functions). Using the functional-structural analysis of Wieczorek & Hekkert (2012), systemic problems can be identified related to the preconditions and their structural factors. These are complemented with systemic instrument goals to adapt the problems to the EV context (see Table 4).

System function	Structural factor	Precondition	Scoring system	Systemic instrument goals
F1 Guidance of the Search	Actor			
	- Presence	Precondition	-1, 0, +1, +2	Stimulate & organize the participation of relevant actors
	- Capability	Precondition	-1, 0, +1, +2	Create space for actors capability development
	Interaction			
	- Presence	Precondition	-1, 0, +1, +2	Stimulate occurrence of interactions
	- Quality	Precondition	-1, 0, +1, +2	Prevent too strong and too weak ties
	Institution			
	- Presence	Precondition	-1, 0, +1, +2	Secure presence of hard and soft institutions
	- Quality	Precondition	-1, 0, +1, +2	Prevent too weak and too stringent institutions
	Infrastructure			
	- Presence	Precondition	-1, 0, +1, +2	Stimulate physical, financial and knowledge infrastructure
	- Quality	Precondition	-1, 0, +1, +2	Ensure adequate quality of infrastructure

Table 4 Adapted from the systemic innovation policy framework of Wieczorek & Hekkert (2012), applied to one system function (F1 Guidance of the Search)

3.3 Creating components of the GEM-tool

The analysis above results in the identification of system functions and their dynamics, the structural factors, the scale of analysis and systematic instruments goals which can be used for policy recommendations as components for the framework of the GEM-tool. However, the aim of this research is to design an ex-ante, practical assessment tool for eMobility and therefore the following additional components are included in the GEM-tool. Firstly, the core component is the set of preconditions, partly based on TIS literature and partly based on the best practices and lessons learned of frontrunner countries (which will be elaborated upon in Chapter four). The preconditions are converted into questions which form the questionnaire of the GEM-tool and are used to gather the necessary input for the evaluation of the innovation system under study. Additionally, the GEM-tool includes the operationalization of the preconditions encompassing both a scoring system as answer categories. Due to the amount of gathered information, it is not feasible to elaborate upon the individual preconditions and their operationalization in this thesis. Therefore, to enhance the understanding of the preconditions and the operationalization, a clarification of these components is given within the GEM-tool. Furthermore, as not all preconditions are of the same importance, a weight is given to each precondition (see annex V). Additionally, to give guidance in the use of the GEM-tool, and to use the identified information on eMobility in an urban context in MICs, potential answer are given as well as data collection possibilities. Lastly, an evaluation scheme of the innovation system based on the individual preconditions and the overarching system functions is applied. The various components are explained in Table 5 and will also be elaborated upon in Chapter five as they are part of the steps of the GEM-tool.

Components of GEM-tool	Explanation of the components of the GEM-tool
System function	The system functions within this tool consist of: Guidance of the Search, Resource Mobilization, Knowledge Development, Knowledge Diffusion & Networks, Entrepreneurial Activities, Market Formation and Creation of Legitimacy.
Precondition	The preconditions represent the conditions that should be present within the innovation system. They range from essential prerequisites for the development of the innovation system to indications for relevant information beforehand to stimulate the development of the innovation system. To differentiate between the importance of the preconditions, an individual weight is given (see 'weight').
Clarification precondition	Providing an explanation per precondition regarding its importance and interpretation.
Weight of the preconditions	A specific weight is allocated to the individual preconditions. As there is a different amount of preconditions per system function, there is a difference in the total range of weights to be appointed per system function: the more preconditions are included in a system function, the more variation in possible weight per precondition (see also Annex V).
Structural factor	The structural factors include actors, institutions, interactions and infrastructure. The structural factors point towards the direction of the goal of the systemic instrument and policy recommendation, as they are often connected to the problem behind the non-functioning of a system function. Each precondition is therefore linked to a corresponding structural factor according to definition given in section 3.3.2.
Scale	The tool will be developed for local policy makers. However, these actors work in a national and international context, with various factors influencing their decision making possibilities. Therefore, the tool will include both local, national as international oriented preconditions.
Questions	Stemming from the identified preconditions, a list of questions has been developed to score and evaluate the preconditions.
Operationalization of the preconditions (including the scoring system and answer categories)	Per precondition, four answers are presented. These answers categories are scored using a consistent scoring system (unless indicated otherwise): -1 = a negative score forming a barrier 0 = a neutral score forming an area of focus +1 = a positive score forming an opportunity in need of additional focus +2 = an excellent score forming an opportunity
Reasoning operationalization	A brief explanation of the choices made during the operationalization of the precondition is included. Due to time and resource constraints, it is not possible to identify quantitative input to operationalize each precondition. In some cases normative answers and -indicators are used to obtain and to score the necessary information.
Potential answers	Potential answers have been identified to steer the question in a certain direction, while still keeping the generic applicability of the tool in mind.
Data collection	A variety of sources is necessary to gather the essential information

	for the GEM-tool. The identification of sources is an iterative process with new sources identified during the entire process of data gathering for the GEM-tool. Individual sources can be used for various answers, while individual questions should be answered using multiple sources to verify the identified information. Therefore, it is recommended that multiple questions are addressed in one interview and that the score of one question is based on multiple sources. An indication of data collection possibilities is included in the GEM-tool.
Evaluation system function	The performance of the system function is derived from the scoring of the individual preconditions times their corresponding weight, calculated in percentages to show the differences between the system functions. Based on the four scores (-1,0,+1,+2), the following evaluation is proposed : <33% = a weak system function 33-66% = an intermediate system function >66% = a strong system function
Policy implications & policy recommendations	The identified policy implications & recommendations will be presented according to the individual preconditions and the overarching system functions. Per system function, an indication is given of its influence on other system functions as identified in the GEM-motor. For the policy recommendations of the preconditions, the corresponding structural factor of the individual precondition is connected to the systemic instrument goals and policy instruments in the context of eMobility.

Table 5 Components of the GEM-tool explained

Chapter 4 Determining the content of the GEM-Tool

Key messages

- The combination of TIS literature with the context of eMobility and urban areas in MICs led to the determination of the content of the GEM-tool, according to its previously designed framework.
- The content is presented according to the overarching system functions, including a brief explanation of the functions and the choices regarding the included preconditions, as well as an overview of the main data and a cluster of the main overarching policy measures identified.
- The content analysis resulted in 49 preconditions and their corresponding components, which can be found online at evconsult.nl/gem-tool.

After the development of the framework of the GEM-tool, the content of the framework is identified. The content relates to the determined components in Chapter three and is referred to as the (set of) elements of the GEM-tool. The completion of the content of the GEM-tool has been an iterative process, during which decisions were revised and the preconditions and their corresponding components where added, deleted, combined, adapted and rephrased. This process resulted in 49 preconditions with their complementary components that sketch, score and evaluate the prevailing situation before the introduction of eMobility, making up the GEM-tool (see *evconsult.nl/gem-tool* and Annex I). Due to the amount of identified elements in the tool, it is not feasible to go over each precondition with its corresponding components. Therefore, each system function incorporating the identified elements will be elaborated upon to show the choices and sources used to come to the elements included within the GEM-tool. Before the system functions will be explained (4.3), the (use of the) main TIS literature (4.1) and literature on eMobility (4.2) will be presented.

4.1 The context of the TIS approach

TIS literature has been the main source for the identification of factors influencing the introduction of technical innovations, as the description of the system functions within the TIS literature indicates the necessary conditions for the system function to develop. It therefore forms the foundation of the identified preconditions and part of their operationalization, evaluation and the corresponding policy implications & recommendations. Most of these conditions could be translated to the specific context of eMobility without much difficulty. Some conditions, however, focused on more advanced phases of a TIS and were therefore left out or adapted to fit the pre-development phase of the GEM-tool. For example, entrepreneurs leaving the system is used as diagnostic question by Wieczorek & Hekkert (2012) but is not included in the GEM-tool. Furthermore, as the tool will be used as a practical assessment, it does not require the extensive timeframe of a full evaluation using the TIS approach. This led to the omission or adoption of conditions that are difficult to measure in a short period of time. For example, the expectations of the different stakeholders has not been included in the GEM-tool. However, if the condition was seen as highly valuable for the tool, it was nevertheless included as precondition with an operationalization based on descriptive, subjective and/or normative answers of key actors. For example, the collaboration of actors is not based on a network analysis but on input and views from key interviewees and the judgement of the researcher. Lastly,

practical choices were made with regard to overlapping preconditions in different system functions or different structural factors to increase the usability of the tool as the incorporation of all elements of the TIS approach is not feasible for a practical tool. For example, the level of political willingness is incorporated in other preconditions within the system function. These choices will be elaborated upon in sections 5.3-5.8.

As each article from the literature study of TIS used for the input of the tool incorporates the seven system functions, no distinction could be made between the TIS literature and the individual system functions. An overview of the main sources (29 articles) used for all system functions is therefore given in Table 6.

	Main TIS literature used for the content of the GEM-tool
General development and empirical evidence of the TIS approach	Negro 2007; Hekkert et al. 2007; Bergek, Hekkert, et al. 2008; Bergek et al. 2010; Hekkert & Ossenbaard 2010; Wieczorek et al. 2010; Negro et al. 2011; Wieczorek & Hekkert 2012; Wieczorek 2012; Hekkert et al. 2011; Alkemade et al. 2009; Suurs 2009; Hellsmark et al. 2016; van Alphen 2011; Hekkert & Negro 2009.
Innovations systems in a developing country context	Jacobsson & Bergek 2007; Intarakumnerd 2011; Iizuka 2013; Baković 2010; Varblane et al. 2007; Arocena & Sutz 2002; Edsand 2016; van Alphen et al. 2008.; Ockwell et al. 2010.
Application of TIS to sustainable energy transitions including low carbon innovations and eMobility	Eveleens et al. 2015; Wieczorek et al. 2013; van Alphen et al. 2008; Negro et al. 2008; Hekkert & Negro 2009; Bergek, Hekkert, et al. 2008; Negro et al. 2011.

Table 6 Main sources of the TIS literature used for the development of the GEM-tool

It includes research on the general development of the TIS approach as well as the application of the TIS approach on sustainable energy transitions and electric vehicles. The latter includes the identification of barriers, e.g. tax burdens and subsidies on fossil fuels, lack of awareness and communication, scarce stakeholders communication, lack of (technical) knowledge, and opportunities, e.g. room for demonstration projects, encouragement of public-private partnerships and positive expectations of the technology, which are used for the GEM-tool. Furthermore, articles on the practical application of the TIS approach give examples of indicators (e.g. Bergek et al. 2008; Suurs 2009), guiding questions (e.g. Wieczorek et al. 2013; Hekkert et al. 2011), data types (e.g. Bergek et al. 2008), evaluative questions (e.g. Wieczorek & Hekkert 2012), analytical goals to assess the strengths and weaknesses (e.g. Helssmark et al. 2016) and inducement and blocking mechanisms for the dynamics within and between system functions (e.g. Bergek et al. 2008; Suurs 2009; Bergek et al. 2010). This information was used as input for the various components within the GEM-tool. Articles on the dynamics between the system functions have also been included to complement the GEM-motor, in particular for the policy implications on a system function level (e.g. Negro 2007; Hekkert & Negro 2008; Suurs 2009; Alkemade et al. 2009; Hekkert & Ossenbaard 2010; Hekkert et al. 2011). Additionally, studies on the application of technical innovation system studies in emerging economies are included (van Alphen et al. 2008; Jacobbson & Bergek 2007). It emphasizes the 'catching-up processes' of developing countries on the technology and the formation of capabilities in an early phase of the TIS. As the TIS approach has mainly been applied in western countries

(Edsand 2016), studies on innovation systems in general in the context of emerging economies have been included as well. The main conclusions of these articles are the important role for the government, the build-up of capacities to receive a new technology, the creation of an innovation culture, the existence of non-formal networks, the awareness of existing policy measures and a strategic long-term oriented approach to the innovation system building. This has been taken into account in the GEM-tool. Yet, it appears to be an underrepresented part of the TIS literature, both in general as in this research.

4.2 The context of electric mobility

The input of the TIS literature on the advancement of innovations in general has been combined with the input of eMobility literature. In total, 33 reports and articles, relating to sustainable mobility, electric mobility and urban transportation (in developing countries), have been analyzed for their input in the GEM-tool. These articles include studies on barriers & opportunities, best practices & lessons learned and national and local policy measures and incentives regarding the advancement of eMobility in urban areas. This also includes policy measures of more than 70 cities regarding eMobility, stemming from the EV City Casebook and the EV 50 Big Ideas report (CEM 2012; IEA 2014). Furthermore, reports of international institutions that keep track of the developments relating to sustainable transport and electric vehicles have been included in the research e.g. the International Energy Agency (IEA), the Clean Energy Ministerial (CEM), the International Council on Clean Transportation (ICCT) and the Electric Vehicle Initiative (EVI).

There is considerable overlap between the input provided by the different sources on eMobility. Furthermore, relevant information presented per source covers multiple preconditions and components. Therefore, the mains sources of literature will be presented according to the system functions (see Chapter four). Moreover, sources of literature regarding eMobility and related subjects do not translate directly to the identified preconditions and other components. This was amplified by the fact that policy measures focus on the diffusion of eMobility during more advanced phases of the innovation system, while the GEM-tool focuses mainly on the predevelopment phase. Often a conversion, carried out by the author in consultation with experts from EVConsult, was therefore necessary between the identified policy measures, lessons learned and best practices stemming from the literature and the identification of components for the GEM-tool.

All preconditions and related components where identified using the gathered information introduced above. This information was clustered according to overarching subjects to come to general policy measures, which are presented per system function in section 4.3. In total, 21 clusters of information have been identified in the eMobility literature with regard to the system functions and their corresponding preconditions (see Figure 6). Furthermore, input from semi-structured interviews with experts on innovations and electric mobility has been used as input for and validation of the GEM-tool. This has resulted in 77 statements regarding the system functions (see Figure 7). The main interviewees are also presented per cluster in the system functions in section 4.3. Lastly, the result of the brainstorm session with experts from EVConsult consists of 65 statements on blocking and inducing factors regarding the introduction of eMobility which have been used as input for the GEM-tool (see Figure 8). However, as the outcomes of the brainstorm session are a result of collaboration between ten experts, it is not possible to present the input per system function within section 5.3 as all system functions have been identified during the session. Lastly, the comments made in the survey have been used in the development of the tool but are not included in the list of

sources per system function as the comments have been made anonymous. The complete set of data stemming from these methods is presented in Annex III, Annex IV and Annex V.

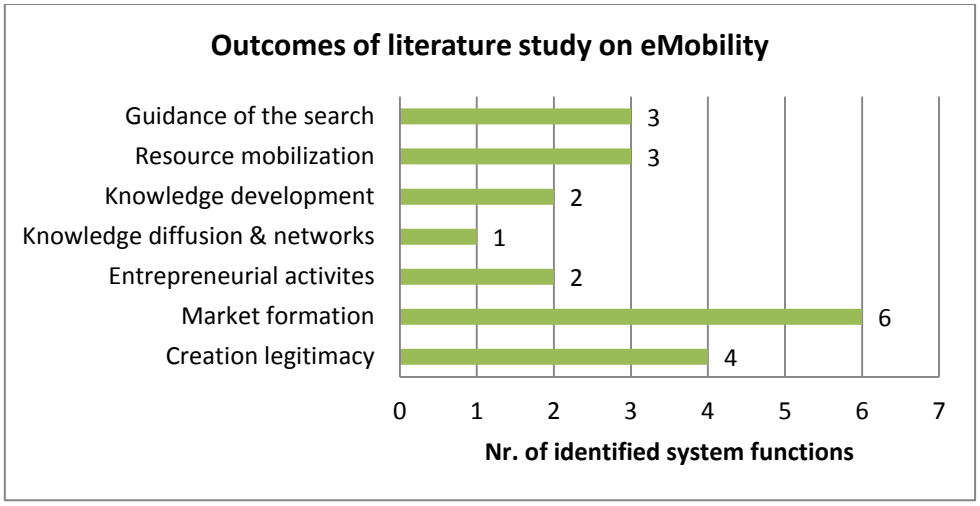

Figure 7 Outcome of the clusters of policy measures found literature study on eMobility

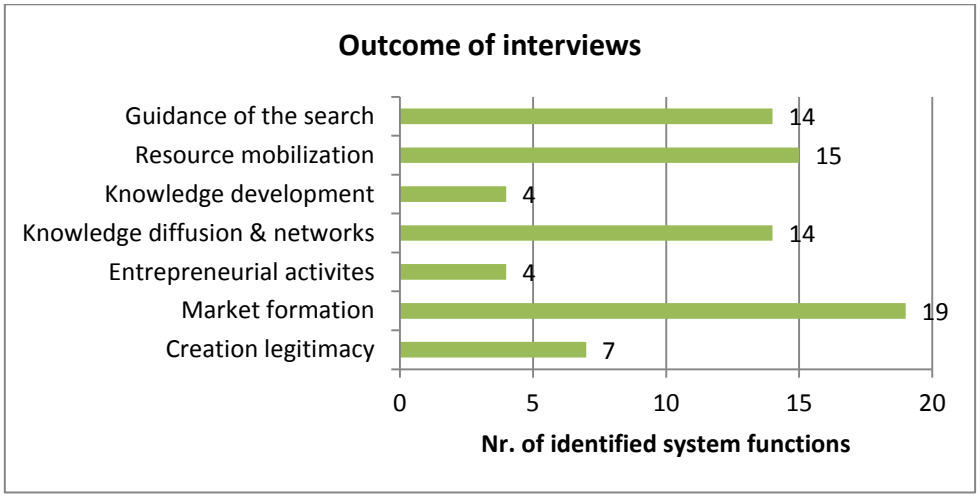

Figure 8 Outcome of the semi-structured interviews

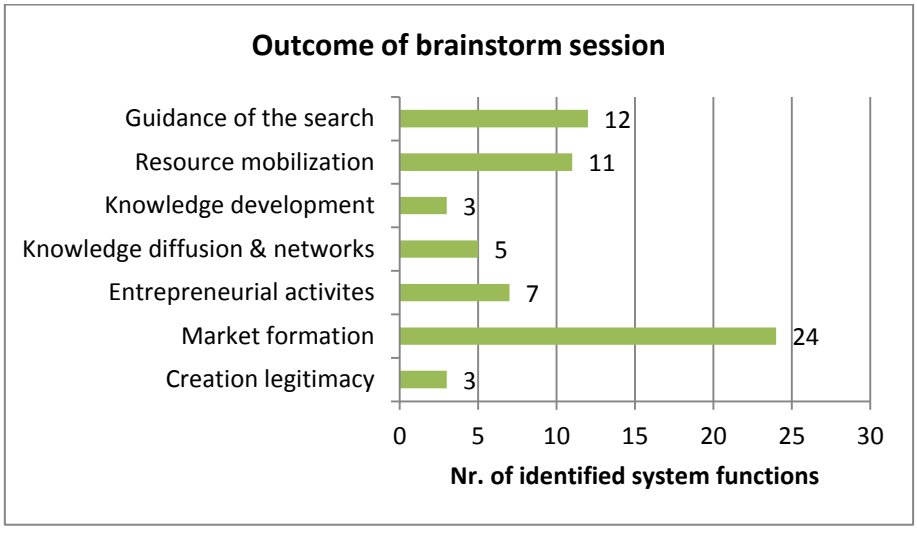

Figure 9 Outcome of the brainstorm session with experts from EVConsult

4.3 The content of the GEM-tool framework

This input on eMobility is presented per system function. First of all, a short introduction of the system function is given. This also touches upon the identified preconditions within the system function. Next, a brief outline of the main input stemming from eMobility literature and interviews is presented (see Tables 7-13). This input has been clustered to form an overview based on main overarching policy measures, including lessons learned and best practices, which is linked to the corresponding preconditions. As the operationalization, possible answers and policy implications & recommendations are based on the same literature as used for the identification of the preconditions, no distinction is made regarding this literature. Furthermore, the structural factor, the scale, the weight, the data collection and part of the operationalization per precondition are explained in Chapter three and within the online GEM-tool and will therefore not be discussed in this chapter.

4.2.1 Guidance of the Search

The function Guidance of the Search refers to all activities that shape the needs and requirements for the support of an emerging technology. It encompasses both hard (e.g. policy targets or programs) as soft (e.g. ambitions or willingness) institutions and covers positive and negative signals in a particular direction of technology development (Suurs 2009). Guidance of the Search can contribute to the level of legitimacy, mobilize resources and motivate entrepreneurs for the new technology. It therefore stands at the base of many developments and is crucial for the development and deployment of a technical innovation (Hekkert & Negro 2009). It furthermore represents the selection process of the available technological options. A selection is essential for the development of a TIS as it helps to translate broad (sustainable) visions into more concrete options connected to the emerging technology. As resources are limited, a focus on a specific innovation is helpful. The state of the technology and its fit with existing structures will influence this process (Alkemade & Hekkert 2009). During the development of the tool, the main question for this system function has been: '*What kind of guidance is given to the introduction of eMobility?*'

Firstly, the focus has been placed on hard institutions such as policy targets, (national and local) plans and the presence of actors which can diffuse the technology. It will show the driving force behind the introduction as well as the focus on eMobility (as sustainable mobility is also taken into account during the operationalization) on various policy levels. The presence of actors 'guiding the search' on a governmental level has been included. Insight in the various actors working on subjects related to eMobility can enhance the local policy makers understanding of the local actor base within the national and local government departments, and where they can find support and opposition. Furthermore, the willingness to change on the consumer side and market side has been included. eMobility is an innovation which enhances the greater good of society, but is thought to hamper the individual consumer, making them less willing to change their personal behavior (IA-HEV 2013). The willingness of consumers and market actors are therefore included as preconditions within the GEM-tool.

The level of expectations, the level of urgency and the willingness to change on the political side have not been explicitly included. Even though this makes up a large part of Guidance of the Search according to the TIS approach, it was not found to be of added value for the tool as it is indirectly measured by the other preconditions incorporated in this system function. This is supported by Negro et al. (2008), who argue that expectations are expressed in the guidance of the technology.

Furthermore, even though the direct articulation of demand can influence the introduction of the innovation this has been left out. Literature on electric mobility shows government led initiatives to stimulate eMobility. This is even more so the case for developing countries, where sustainable (personal) transport is not seen as priority by or in reach for many consumers of transportation (S. Rohilla, personal communication, 1st July 2016). Excluding the above mentioned preconditions during the iterative process of designing the tool has helped to improve the presence of input- (e.g. expectations) and output (e.g. a local plan) variables within the tool, as was suggested during the survey (see Annex V).

Cluster of identified policy measures	Related precondition	Source
Have a vision (long term and short term), have a clear (national and/or local), flexible plan including targets, monitoring & evaluation scheme as well as a the introduction and dismantling of incentives. In the form of: roadmap for the out role of electric vehicles (including charging infrastructure), national action plan for electric vehicles, urban development plan including sustainable mobility and energy supply, local joint strategy for electric vehicles, a mandate or strategy for zero emission vehicles, a local or national eMobility strategy with eMobility targets.	Precondition 1 (sustainable ambition); Precondition 2 (national plan); Precondition 3 (local plan)	(NL Enterprise Agency 2013; Bott 2014; Ernst & Young 2012; van Mil et al. 2016; International Energy Agency 2014; Mock & Yang 2014; Lutsey 2015; Anderton & Fergusson 2015; Municipality of Amsterdam 2015; Munnix et al. 2015; Clean Energy Ministerial 2012) Personal communication (between January and June 2016[3]): C. Huizinga, J. Williams-Jacobse, R. Mur, P. Cazola
Have someone to stimulate the development of EV with the right network and power to make change happen	Precondition 4 (national government); Precondition 5 (local government); Precondition 6 (driving actor)	(RMI 2009; NL Enterprise Agency 2013) Personal communication (between January and June 2016): D. Beeton, J. William-Jacobse
Raise awareness for eMobility (using a communication plan) and provide information on incentives & technology through e.g. public awareness activities (campaigns), introduction of signage, public events (EV parade; ride-and-drive with public officials), use of websites, advertisement, cost-evaluation tools, labeling, and show case projects. Include public engagement addressing different segments of population (from early adaptors to mass). Be aware of the triggers that will convince people to switch to EV	Precondition 7 (willingness potential EV value chain); Precondition 8 (willingness consumers); precondition 12 (awareness financial funds); Precondition 49 (certainty)	(NL Enterprise Agency 2013; Bott 2014; Ernst & Young 2012; van Mil et al. 2016; IEA 2014; Lutsey 2015; Anderton & Fergusson 2015; Tietge et al. 2016; IA-HEV 2013; RMI 2009; PRC & EVConsult 2010) Personal communication (22nd and 24th March 2016): J. Williams-Jacobse

Table 7 Cluster of input and corresponding preconditions and literature for Guidance of the Search

[3] See for the exact dates of the interviews Annex III

4.2.2 Resource Mobilization

Financial, human and material resources are necessary as basic input for all activities regarding the development and diffusion of an innovation system. Financial resources consist of financial funds, grands and programs. Skills, capabilities and knowledge fall under human resources. Material resources encompass all physical means related to the innovation such as infrastructure, instruments, roads and natural assets (Suurs 2009; Hekkert & Negro 2009). The main question used for this system function is: '*What kind of resources are mobilized for the introduction of eMobility?'.*

Within the GEM-tool, the focus lies on material and financial resources as most actors are identified at the functions *Entrepreneurial Activities, Knowledge Development* and *Guidance of the Search.* One precondition is taken into account regarding human resources: the presence of experts with practical knowledge, skills and capabilities relating to the technical innovation. Furthermore, (overarching) financial funds are included as a precondition which are identified in programs and can stem from various public or private actors and multiple governance levels (local, national, international). These funds can be used for the creation of financial incentives identified at the *Market Formation* function and for the stimulation of *Entrepreneurial Activities,* as public finance can help cover the risks of experimentation with a new technology which relates to a public goal (for example improvement of local air pollution) (Mur, personal communication, 12th April 2016). There should also be a level of awareness for these funds, as well as access to funds via loans, which are therefore both included as precondition. Furthermore, there should be insights in the ability to fit in the local conditions of the new technology as this influences the kind of resources which should be made available. This includes knowledge on the level of adaptation needed for EVs and the skills of experts, the funds that should be made available and the kind of EVs and supporting infrastructure (e.g. charging points, energy supply, components of EVs).

Cluster of identified policy measures	Related precondition	Source
Financial funds should be made available including funds for R&D, seed funds, grants for infrastructure development and electric vehicles (components) or sustainable mobility, funds for demonstration projects, experiments and pilots, air quality grants and stimulation of loans for innovations like eMobility (loan guarantee or low interest loans). Can be international, national or local.	Precondition 9 (international funds); Precondition 10 (national funds); precondition 11 (loans); Precondition 12 (awareness)	(Lutsey 2015; Anderton & Fergusson 2015; Tietge et al. 2016; OECD & IEA 2016; CEM 2012; Ernst & Young 2012; Agentschap NL 2013b; IA-HEV 2013; RMI 2009; Steen et al. 2015; PRC & EVConsult 2010) Personal communication (between January and June 2016): C. Huizenga, J. Williams-Jacobse
There should be physical resources made available for the introduction of eMobility including vehicles, infrastructure development and relating technologies. Infrastructure development should be included as of the start of the EV process e.g. through the supply of (public) charging stations (i.e. at public buildings) working	Precondition 13 (modal split); Precondition 14 (availability); Precondition 15 (technology); Precondition 16 (energy supply); Precondition 17	(van Mil et al. 2016; International Energy agency 2016; Clean Energy Ministerial 2012; Tietge et al. 2016; Lutsey 2015; RMI 2009; Lieven 2015; Steinhilber et al. 2013; Mersky et al. 2016; Steen et al. 2015; NL Enterprise Agency 2013; Ernst & Young 2012)

towards integrated infrastructural networks. This should be complemented with additional technology such as lithium batteries, intelligent monitoring systems and metering systems etc. Additionally, electricity related technology should be invested such as consistent and accessible energy supply, making sure that EV does not compete with important energy users, renewable energy, and in the future also investing in BI directional charging, smart grids, smart metering. EVs and related technology should be adapted to the local context. Physical resources should be adapted to the local context.	(renewable energy); Precondition 18 (environment); Precondition 42 (automotive); Precondition 43 (regulation energy); Precondition 44 (import)	Personal communication (between January and June 2016): J. Williams-Jacobse, C. Huizenga
Education on sustainable mobility and eMobility (technical aspects such as skills and capacity building) to increase expert base regarding the innovation.	Precondition 19 (experts) Precondition 20 (knowledge);	(OECD & IEA 2016; Filho & Kotter 2015; CEM 2012; RMI 2009; PRC & EVConsult 2010) Personal communication (22nd and 24th March 2016: J. Williams-Jacobse

Table 8 Cluster of input and corresponding preconditions and literature for Resource Mobilization

4.2.3 Knowledge Development

Knowledge Development is the foundation of any innovation process. R&D is therefore a prerequisites within an innovation system. It includes learning by doing – i.e. R&D activities in basic science - as well as learning by searching – i.e. learning in a more practical context. Its activities differ per phase of the innovation system and are dependent on the advancement of the technology. For example, if the technology has for a large part already been developed, as is the case for eMobility, the R&D can focus on its application to the local context through for example feasibility studies or technical adaptation programs (Negro et al. 2008). The main question for this system function is '*What is the level of existing knowledge and where can it be identified?'.*

The basis of the technology used for eMobility has already been developed, but improvements are still being made as the electric vehicles and charging infrastructure are adapted to their specific usages. As it is assumed that knowledge development within the local context is still low, the focus of the precondition lies on the identification of *potential* actors with knowledge on (subjects related to) eMobility, who have been involved in eMobility in other regions or who have been involved in small pilot projects. The focus lies on the development of knowledge, not on entrepreneurial knowledge development which is included in the system function *Entrepreneurial Activities*.

Cluster of identified policy measures	Related precondition	Source
R&D should be in place including Knowledge Development of technology relating to eMobility and its infrastructure (i.e. recharging options, inductive charging,	Precondition 13 (local context); Precondition 18 (environment);	(OECD & IEA 2016; NL Enterprise Agency 2013; CEM 2012; Lutsey 2015; Steinhilber et al. 2013; Steen

developing proto-types, performance of batteries, range extension, intelligent mobility, electric car safety equipment) as well as learning activities around the marketing, use and users, networks etc. R&D should be used for the adaption of eMobility to the local context (extreme weather, interoperability; vehicle use and vehicle models;). R&D can be carried out by public and private actors or a collaboration between the two.	Precondition 20 (knowledge); Precondition 21 (R&D institutes); Precondition 22 (automotive sector); Precondition 23 (ICT-sector); Precondition 24 (energy sector)	et al. 2015; PRC & EVConsult 2010)
The deployment of demonstration projects, pilot projects and experiments (using a living lab approach for example fixed route operation demonstrations). Pilots can include busses, electric taxies, private use of EVs, focus on the adaption to the local context, testing new products. This is also related to niche market creation e.g. government procurement - electrification of public busses, airport fleets, garbage-collection fleets, and other municipal vehicles, functioning as a large-scale demonstration program. Pilots are also to increase capabilities and skills of experts.	Precondition 22 (automotive sector); Precondition 23 (ICT-sector); Precondition 24 (energy sector); Precondition 25 (knowledge exchange) Precondition 33 (innovation); Precondition 35 (niche market)	(International Energy agency 2016; Municipality of Amsterdam 2015; van Mil et al. 2016; Clean Energy Ministerial 2012; International Energy Agency 2014; NL Enterprise Agency 2013; Lutsey 2015; Anderton & Fergusson 2015; RMI 2009) Personal communication (between January and June 2016): D. Beeton, R. Mur

Table 9 Cluster of input and corresponding preconditions and literature for Knowledge Development

4.2.4 Knowledge Diffusion & Networks

The essential function of networks is to exchange knowledge (Hekkert & Negro 2009). Knowledge diffusion activities involve partnerships and collaboration between actors, as well as the created opportunities for knowledge exchange (Suurs 2009). As eMobility cuts across different sectors - automotive and mobility, ICT and energy sector - it is important that actors from these different backgrounds interact (S. Munnix, personal communication, 19th April 2016). This system function therefore focuses on 'learning by interacting'. The key question used for this system function is: '*What (f)actors enable the diffusion of knowledge?'.*

Usually, innovation system studies use the diffusion of a technology as the performance indicator of the innovation system (Negro et al. 2008). However, in the case of eMobility in MICs, no diffusion has taken place yet, thus other performance indicators are needed. All relevant stakeholders must be involved in the deployment of a new vehicle technology, otherwise there will be a large chance of failure. In front runner countries, national governments, industry, and research institutes are increasingly collaborating to advance e-mobility (IA-HEV 2013). Therefore, within the GEM-tool the presence and access to knowledge has been taken into account, as well as collaboration between various public and private actors. The collaboration between government departments at the local level, as well as the collaboration between national and local government has been included within the set of preconditions, as government stakeholders are often unaware of related projects undertaken by other ministries, which frequently results in reinventing the wheel (van Alphen et al. 2008). Furthermore, in some cases the generated knowledge is not openly available as companies

want to keep hold of their competitive advantage. Access to knowledge, however, is essential for the uptake and diffusion of eMobility and is therefore included as precondition. Moreover, knowledge diffusion can occur through projects done together, platforms and the occurrence of meetings, conferences etc. which can be measured and forms a precondition (Alkemade et al. 2007). However, the actual process of knowledge development is difficult to measure this way (Hekkert & Negro 2009). Therefore, the operationalization of this system function should be based for an important part on interviews with key actors and their views on the diffusion of knowledge taking place.

Cluster of identified policy measures	Related precondition	Source
Collaboration and partnerships should be set up regarding eMobility on different levels as well as between sectors. Examples include cross-sectoral partnerships between ICT, mobility and energy players, (public-private) procurement consortia, collaboration between different governmental departments within the local & national government, international collaboration, public-private cost sharing programs, an active dialogue between private and public parties e.g. through public-private partnerships or platforms.	Precondition 25 (knowledge exchange); Precondition 26 (access); Precondition 27 (EV actors); Precondition 28 (EV actors + local government); Precondition 29 (EV actors and R&D institutes); Precondition 30 (local government and R&D institutes); Precondition 31 (local government); Precondition 32 (local and national government)	(van Mil et al. 2016; Municipality of Amsterdam 2013; International Energy agency 2016; Municipality of Amsterdam 2015; Clean Energy Ministerial 2012; NL Enterprise Agency 2013; Ernst & Young 2012; International Energy Agency 2014; IA-HEV 2013; RMI 2009; Steen et al. 2015) Personal communication (between January and June 2016): D. Beeton, S. Munnix, R. Mur

Table 10 Cluster of input and corresponding preconditions and literature for Knowledge diffusion

4.2.5 Entrepreneurial Activities

Innovation could not take place without entrepreneurs. Entrepreneurs can be new entrants that realize the business opportunity the innovation offers, or incumbent companies diversifying their business industry of the private or public sector (Hekkert et al. 2007). In MICs the latter often have the capital to bare the risks of a new innovation and therefore play a leading role (Ockwell et al. 2010). Entrepreneurs play an important role in converting the potential of knowledge into business opportunities, and in overcoming uncertainties present in the early phase of development of a new technology. Potential actors from the ICT, energy and automotive sector are identified, as well as the general degree of entrepreneurship in the country as indication for the rate of uptake of eMobility. Also included is the level of innovation, as entrepreneurial activities do not necessarily mean a high level of innovation. Furthermore, this system function includes projects and experiments aimed to prove the usefulness of the emerging technology in a practical and/or commercial environment. The latter can be seen as niche markets which are (temporary) protected spaces for the new technology so that it can develop (Hekkert & Negro 2009; Suurs 2009). However, as it is still early days for eMobility in MICs, it is assumed that these entrepreneurial activities do not yet exist. Therefore, the focus has been placed on the presence of potential actors who could make this translation possible. For this system function, the following question has been used as indication during the identification of preconditions: '*Which potential actors can be identified that can perform the essential entrepreneurial activities regarding eMobility?'.*

Cluster of identified policy measures	Related precondition	Source
Stimulate and create opportunities for entrepreneurs by i.e. funds to set up new business (relating to eMobility e.g. environmental Investment rebate, air quality improvement), public-private partnerships, business start-up support services (e.g. sharing information, increasing ease of registration) and include eMobility in tender and procurement procedures.	Precondition 33 (innovation); Precondition 34 (entrepreneur-ship); precondition 35 (niche market); precondition 36 (automotive); precondition 37 (ICT-sector); Precondition 38 (energy sector)	(CEM 2012; IEA 2014; OECD & IEA 2016; Ernst & Young 2012) Personal communication (between January and June 2016): D. Beeton, J. Williams-Jacobs
Stimulate R&D development and pilot projects carried out by entrepreneurs by incentives (e.g. subsidy for pilots on eMobility, focus areas - see F6) and regulations (e.g. easing regulation on import of components - see F6)	Precondition 33 (innovation); Precondition 34 (entrepreneur-ship); precondition 35 (niche market); precondition 36 (automotive); precondition 37 (ICT-sector); Precondition 38 (energy sector)	(OECD & IEA 2016; Municipality of Amsterdam 2015; van Mil et al. 2016; CEM 2012; IEA 2014; NL Enterprise Agency 2013; Lutsey 2015; Steinhilber et al. 2013; Steen et al. 2015; PRC & EVConsult 2010) Personal communication (12th April 2016): R. Mur

Table 11 Cluster of input and corresponding preconditions and literature for Entrepreneurial Activities

4.2.6 Market Formation

The Market Formation function involves activities that contribute to the creation of demand and supply for the emerging technology. It can be a challenge for an innovation such as eMobility to compete with existing markets and technologies. Emerging eMobility initiatives should therefore be assisted by market support policies, which stimulate the creation of niche markets for the innovation, in which new technologies compete for a market share within the existing market or complement it. This concept was already mentioned at the system function Entrepreneurial Activities, as niche markets are essential for entrepreneurs to enter the market. The Market Formation function, however, focuses on creating the enabling environment for these niche markets to develop. Therefore, the following question has been used during the development of this system function: '*What kind of Market Formation policies are present which influence the development of a market for eMobility?'.*

The regulation, legislation and incentives which support the creation of a niche market have been identified during the literature study and interviews on eMobility. However, as the GEM-tool focuses on the pre-development phase, it is assumed that there are no specific market support policies in place for eMobility. Therefore, regulation, legislation and incentives already in place regarding the transport and energy sector which are (directly or indirectly) influencing the development of eMobility are therefore taken into account[4]. It includes both financial and non-financial incentives, as

[4] Regulation/legislation regarding the ICT sector has not been taken into account as this has not been identified in the literature study.

an optimal strategy includes financial incentives complemented by non-financial measures taking away any barriers for the technology (Ernst & Young 2012). Furthermore, the competitiveness of eMobility is taken into account as this influences the performance of Market Formation. As it is not feasible to design a Total Costs of Ownership (TCO), as multiple vehicles and use of vehicles are taken into account within the tool, only the energy price and average purchasing price are included to say something about the competitiveness of EVs in comparison with traditional vehicles.

Cluster of identified policy measures	Related precondition	Source
Introduce financial incentives related to subsidy schemes and other kinds of funding (direct and indirect): subsidies for corporate EVs (taxies, lorries, delivery and lease companies), subsidies for the production and placement of charging infrastructure and components (customers; manufacturers), public-private partnerships and programs, and subsidies for the purchasing and use of environmental friendly (electric) vehicles such as subsidy on the vehicle, subsidy on charging infrastructure, vehicle purchase rebate, free recharging for EV, free parking for EV, discount or exemption on tolls and congestion, depreciation arrangements, discount on taxi fees, lease fees or public transport fees, discount or exemption on carbon pricing schemes and environmental investment rebates. Can be used in a bonus-malus system (subsidy payed from tax). Electricity related measures i.e. investments energy access and supply, stimulate renewable energy, subsidies for alternative fuels, customized electricity pricing.	Precondition 15 (complementary technology); Precondition 16 (energy supply); Precondition 17 (renewable energy); Precondition 40 (competitiveness); Precondition 41 (subsidies); Precondition 39 (fuel price); Precondition 45 (regulation energy);	(NL Enterprise Agency 2013; Municipality of Amsterdam 2013; Municipality of Amsterdam 2015; Agentschap NL 2013a; van Mil et al. 2016; Agentschap NL 2013b; Bradley 2013; OECD & IEA 2016; Mock & Yang 2014; Lutsey 2015; Anderton & Fergusson 2015; Tietge et al. 2016; RMI 2009; Steen et al. 2015; Langbroek et al. 2016; Lieven 2015; IEA 2014; PRC & EVConsult 2010; OECD 2015) Personal communication (between January and June 2016): C. Huizenga, J. Williams-Jacobse, P. Cazola, B. Truffer
Introduce financial incentives relating to tax measures for example exemption or discount on registration tax, ownership tax, road tax, VAT, annual circulation tax, license fees, company electric vehicles (lease), energy tax alternative fuels tax; introduction of tax credit (e.g. R&D), tax deductible investments; also, tax on conventional fuel and -vehicles can be increased. Know in advance where the tax pressures are put.	Precondition 40; Precondition 42 (tax);	(van Mil et al. 2016; NL Enterprise Agency 2013; Agentschap NL 2013a; Ernst & Young 2012; Clean Energy Ministerial 2012; International Energy Agency 2014; Bradley 2013; Mock & Yang 2014; Lutsey 2015; OECD 2015; Tietge et al. 2016; RMI 2009; Lieven 2015; Mersky et al. 2016; Steen et al. 2015) Personal communication (between January and June 2016): J. Williams-Jacobse, R. Mur

Development of stimulating regulation and legislation: adapt building codes (energy; charging points), energy (electricity) standards, fuel & vehicle standards and requirements (efficiency; emissions; safety) introduction of (low) emission standards, design protocols, standards and codes of practice for charging infrastructure (see also F2), oblige the placement of vehicles in company, rental, public transport, government and/or car-sharing fleet.	Precondition 43 (regulation automotive); Precondition 44 (regulation import); Precondition 45 (regulation energy);	(Baljon 2015; Ernst & Young 2012; International Energy agency 2016; Clean Energy Ministerial 2012; van Mil et al. 2016; Urban foresight 2013; Lutsey 2015; Steinhilber et al. 2013; International Energy agency 2014)
Introduce non - financial incentives such as parking spots (permits; reduced waiting time for permits), use of restricted lanes (creating an EV corridor/avenue), exemption from vehicle emission inspection programs, expedited permitting/installation of EV (charging) infrastructure, transferable license plates, flexible taxi license caps, dedicated taxi ranks	Precondition 40 (competitiveness); Precondition 43 (regulation automotive); Precondition 49 (confidence)	(Agentschap NL 2013a; Ernst & Young 2012; CEM 2012; Beeton 2015; Bradley 2013; Lutsey 2015; Anderton & Fergusson 2015; Tietge et al. 2016; Mersky et al. 2016; Langbroek et al. 2016; Steen et al. 2015; Innovation & Action 2015; IEA 2014; PRC & EVConsult 2010) Personal communication (22nd of and 24th March 2016): J. Williams-Jacobse
Use focus areas for the gradual introduction of EVs including promising market segments & leading customers i.e. tourism industry, cities or governments as launching customers (electrifying the government fleet), emission free public transport, cooperate (taxi; delivery; lorries; lease) and (create) business cases (depending on local context & the position of the country regarding mobility, automotive production sector, energy and ICT sector). Be aware of business cases of different market segments. Consider EVs in tender procedures & public procurements (i.e. government fleet, public transport) and increase the time frame of the tenders/procurements (for EV to win back the investment). Also include the time frame of the build-up and dismantling of incentives.	Precondition 7 (willingness EV actors); Precondition 39 (fuel price); Precondition 40 (cost); Precondition 43 (regulation automotive); Precondition 48 (companies);	(CEM 2012; van Mil et al. 2016; Bott 2014; Ernst & Young 2012; Anderton & Fergusson 2015; Municipality of Amsterdam 2015; Beeton 2013; Lutsey 2015; Tietge et al. 2016; RMI 2009; Steinhilber et al. 2013) Personal communication (between January and June 2016): J. Williams-Jacobs, R. Mur

Table 12 Cluster of input and corresponding preconditions and literature for Market Formation

4.2.7 Creation of Legitimacy

In order to develop, an innovation has to become part of the existing system, or even overthrow it. Parties with vested interest in the incumbent regime will oppose of this process. Actors working

together in advocacy coalitions in favor of the emerging technology should therefore counteract this resistance to change. Advocacy coalitions can work as catalyst by improving other system function (e.g. putting it on the political agenda, lobbying for resources and favorable incentives). In doing so they create legitimacy for the technology (Hekkert et al. 2007). Therefore, this system function has much overlap with the above mentioned system functions, as without legitimacy there would not be incentives to start with eMobility. A lack of legitimacy for low carbon technologies coupled with *Market Formation* problems due to the lock-in of the incumbent technology, implies uncertainty and low expectations. The *Creation of Legitimacy* is therefore especially linked to *Guidance of the Search*, as without legitimacy no guidance will be given to the technology. The main difference between the two functions is that actors lack power to change the status quo directly – therefore they use the power of persuasion, convincing other actors to take part in particular actions that they cannot conduct themselves. However, actors in an emerging innovation system do not easily pack together to form a tight network with a clear and strong standpoint, while the interests of the incumbent innovation system are put forward by incumbent advocacy coalitions with enormous lobby power (Hekkert & Negro 2008; Suurs 2009). Therefore the GEM-tool takes into account both the presence and the power of lobbies advocating for or against eMobility, as well as the incumbent companies, who can be either frontrunners in the change or resisting the change, and the certainty and confidence on the consumer side. The legitimacy on the government side has already been identified at system function Guidance of the Search, and is strengthened by the fact that the local government has expressed the willingness to change (and to use this tool to do so). The main question for this system function is: *'What kind of support for and resistance to eMobility can be identified and by whom, which can influence the development of eMobility?'.*

Cluster of identified policy measures	Related precondition	Source
Promote formation of advocacy coalitions (*indirectly influencing lobby against eMobility)* through e.g. platforms, stimulation of partnerships, industry associations, NGO support	Precondition 46 (lobby for EVs); Precondition 47 (lobby against EVs)	(IEA 2014; CEM 2012; NL Enterprise Agency 2013)
Create support through the commitment of leading companies as ambassadors in eMobility (e.g. through financial support for this company; awareness campaigns)	Precondition 48 (companies);	(NL Enterprise Agency 2013; Bott 2014; International Energy agency 2016; International Energy agency 2014; Clean Energy Ministerial 2012; Agentschap NL 2013a; RMI 2009) Personal communication (22nd and 24th March 2016): J. Williams-Jacobse
Take away uncertainties at the industry side. It should be known where losses will be made in the traditional industry.	Precondition 48 (companies); Precondition 7 (willingness potential EV value chain);	(CEM 2012; van Mil et al. 2016; Bott 2014; Ernst & Young 2012; Anderton & Fergusson 2015; Municipality of Amsterdam 2015; Steinhilber et al. 2013) Personal communication (22nd

		and 24th March 2016): J. Williams-Jacobse
Take away uncertainties at consumer side e.g. trial lease programs, show-case pilots, cost-evaluation tools and labeling schemes (see also F1)	Precondition 49 (uncertainties); Precondition 8 (willingness consumers)	(NL Enterprise Agency 2013; Bott 2014; Ernst & Young 2012; van Mil et al. 2016; nternational Energy Agency 2014; Lutsey 2015; Anderton & Fergusson 2015; Tietge et al. 2016; IA-HEV 2013)

Table 13 Cluster of input and corresponding preconditions and literature for Creation of Legitimacy

Chapter 5 Operationalizing the GEM-tool

Key messages

- The first part of the GEM-tool is the performance of a background sketch, including the local issues and drivers regarding eMobility;
- The second part consists of filling in the questionnaire by an appointed, independent advisor with expertise regarding eMobility;
- The third part is very much related to the second part, as it includes scoring the individual preconditions, based on their corresponding weight and given answers. The preconditions receive a score of -1 (negative), 0 (neutral), +1 (positive) or +2 (excellent);
- Filling in the questionnaire results in the individual scores of the preconditions, as well as the scores and evaluation of the overarching system functions which consists of the fourth part of the GEM-tool;
- The evaluation of the existing innovation system is based on the following classification: a score from <33% is seen as a weak innovation system, a score of 33-66% is seen as intermediate innovation system and score of >66% is seen as strong innovation system;
- The last parts of the GEM-tool consists of policy implications & recommendations of both the individual preconditions as the overarching system functions. It includes the GEM-motor, or in other words the dynamics of the innovation system, and brief policy advice for local policy makers.

In the previous chapters, the background, delineation, the framework and content of the GEM-tool have been elaborated upon. This chapter will explain the functioning and usage of the online GEM-tool with reference to the various steps that are taken before and during the use of the GEM-tool.

5.1 The steps of the GEM-tool

The following steps represent the subsequent parts of the GEM-tool. They do not necessarily represent the steps that should actively be taken when applying the GEM-tool, as some are automatically performed, but rather identify the parts of the online GEM-tool with reference to the framework as described in chapter three.

5.1.1 Step I Introducing the local context

Before applying the GEM-tool, a brief background sketch of the local context should be performed, including the local issues and drivers regarding the introduction of eMobility, for example lowering local emission levels, improving air quality or stimulating the local economy. This allows for the monitoring & evaluation of the progress regarding the drivers, as well as the allocation of a variety in funds and the Creation of Legitimacy for the technology regarding the drives of its introduction. Furthermore, the ambition and main questions of local policy makers wishing to introduce eMobility should be translated to the application of the GEM-tool.

5.1.2 Step II Filling in the questionnaire

The core of the GEM-tool consists of an online questionnaire, based on the questions related to the identified preconditions for a successful eMobility implementation. As the principal customers are local policy makers, it is recommended that the actual user of the tool will be an external,

independent advisor, with an interest and expertise in (urban) electric mobility and policy. The questionnaire is then performed by the appointed advisor, who will base the answers on the sources identified in section 5.1.2.1 and additional sources identified during the application of the questionnaire. Multiple sources can be used for one questions, and multiple questions can be answered via one source. An indication of the main data sources is given per precondition within the GEM-tool. Within the GEM-tool, the preconditions and corresponding questions are categorized per system function (see Figure 10).

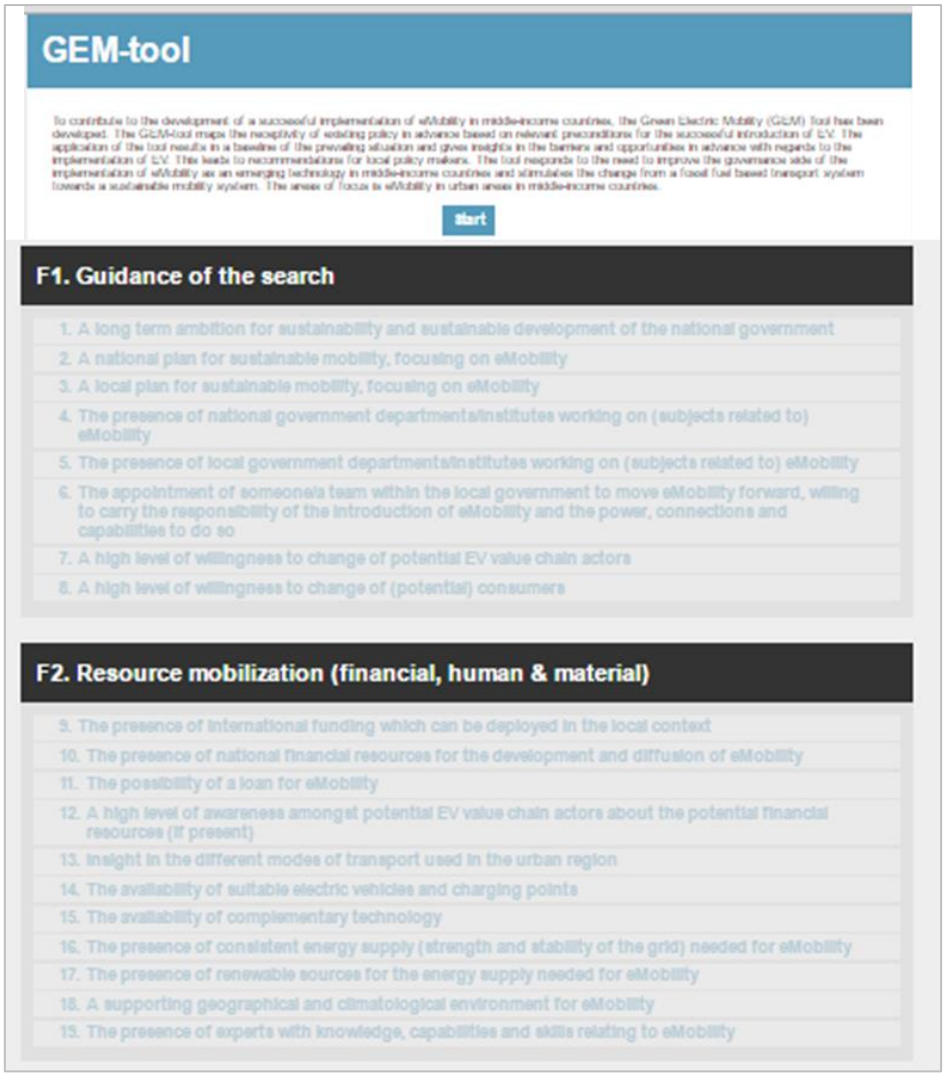

Figure 10 The display of a part of the online GEM-tool

Furthermore, a clarification of the precondition is given as well as the scale, the weight of the precondition, the related structural factor, the identification of possible answers, the data collection and the operationalization of the precondition – consisting of the reasoning behind the scoring system and three to four answer options (see step IV). An example of a precondition within the online tool is shown in Figure 11. Filling in the questionnaire will result in scores for both the individual preconditions as a score of the system functions (in percentages), as well as corresponding policy implications & policy recommendations. A complete overview of the online GEM-tool and the outcomes of the tool are presented in Annex 1.

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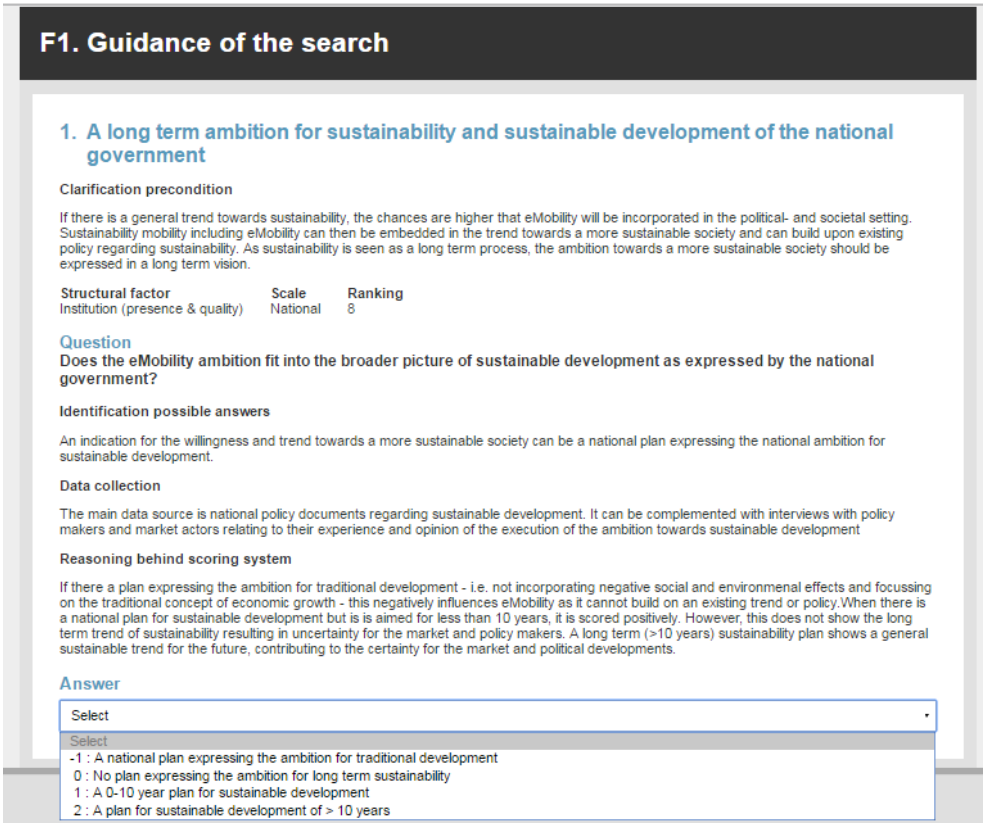

Figure 11 Example of a precondition shown in the online GEM-tool

5.1.2.1 Definition key concepts

The main overarching concepts related to the GEM-tool have been explained during the delineation of the tool in Chapter four, including MICs, urban areas and eMobility. Some concepts however, are part of the use of the GEM-tool itself and are important to know and understand when filling in the questionnaire of the GEM-tool. These concepts are briefly described in the online GEM-tool but will be elaborated upon below:

Sustainable mobility

The World Business Council for Sustainable Development defines sustainable mobility as "*the ability to meet the needs of society to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values today or in the future*" (Pantzar 2011, p.13). It includes the need for both technological and institutional changes and requires a new paradigm which favors access rather than mobility, focuses on efficient modes of transport and promotes clean vehicles. The latter can be achieved with the following actions: *avoid* and reduce motorized travel, *shift* to more efficient and environmentally friendly modes of transportation and *improve* the technologies and fuels of remaining traditional vehicles (Hidalgo & Huizenga 2013; Eichhorst 2009). Within this context, eMobility is regarded as a shift towards a cleaner and efficient zero emission vehicle.

Subjects related to eMobility

As the GEM-tool focuses on the predevelopment phase of eMobility, the assumption is made that many of the essential structural factors – i.e. the actors, institutions, interaction and infrastructure – are not yet available. However, there might be structural factors which can be associated with

subjects related to eMobility. Identifying these structural factors can help local policy makers to make use of the existing local system. Therefore, within the GEM-tool, the concept 'subjects related to eMobility' is used to identify these structural factors. They refer to energy related subjects – e.g. batteries, electricity supply and distribution – ICT related subjects – e.g. intelligent mobility systems, information management of vehicle use – and automotive subjects – e.g. public transport services, safety requirements – and lastly subjects related to the drivers of eMobility such as local air pollution and emissions from transport. The structural factor 'actor' is elaborated upon below.

Potential EV value chain actors

The EV-sector cuts across three different sectors: the energy sector (e.g. charging & batteries for the vehicles), the ICT sector (e.g. smart information systems regarding electricity use within the car and the grid) and the mobility sector (including transport & infrastructure). It therefore requires both commitment and collaboration of these different sectors (Ernst & Young 2012) which are embedded in the value chain. When referring to the automotive sector, all designers, Original Equipment Manufacturers (OEMs), vehicle manufacturers, dealerships and maintenance shops for two, three, four and +four wheelers are included (Humphrey & Memedovic 2003). The energy sector encompasses all energy producing, (component) supplying, distributing (operation & maintenance) and installation actors (Bertoldi et al. 2006). The Information and Communication Technologies (ICT) – sector includes all actors working on the advancement and deployment of computer based technologies and digital communication technologies, including ICT manufacturing, trade and service companies (Carbonara 2005). It covers the hardware (e.g. smart charging, high tech systems for EV components) and software (e.g. information services, operating systems) (Lycklama & Lange 2011) used for the advancement of eMobility. Relevant examples of the various actor groups are provided within the GEM-tool. The above mentioned definitions of the three sectors have been kept broad, so as not to exclude certain actors within the GEM-tool aim for a general application for MICs.

Additionally, as EVs are intrinsically linked to their charging infrastructure, the EV value chain actually consists of two value chains as illustrated in Figure 12. Actors from the EV value chain are: producers of raw materials, producers of components & power techniques, vehicle manufacturers, assemblers & converters, vehicle importers & dealers, (electric) vehicle users (private, business/lease, taxi companies & fleet owners), actors ensuring the maintenance of EVs, actors ensuring the second life of EVs (and components) and actors responsible for the recycling of EVs (and components) (Eveleens et al. 2015; EVConsult 2015). Furthermore, the second value chain includes producers and installers of charging equipment, energy producers and suppliers, suppliers of charging infrastructure, users of charging points, actors ensuring maintenance of charging infrastructure and actors responsible for the recycling of charging infrastructure (Eveleens et al. 2015; EVConsult 2015). When referring to the EV value chain during this research and within the GEM-tool, both value chains are considered which include actors from the sectors elaborated upon above.

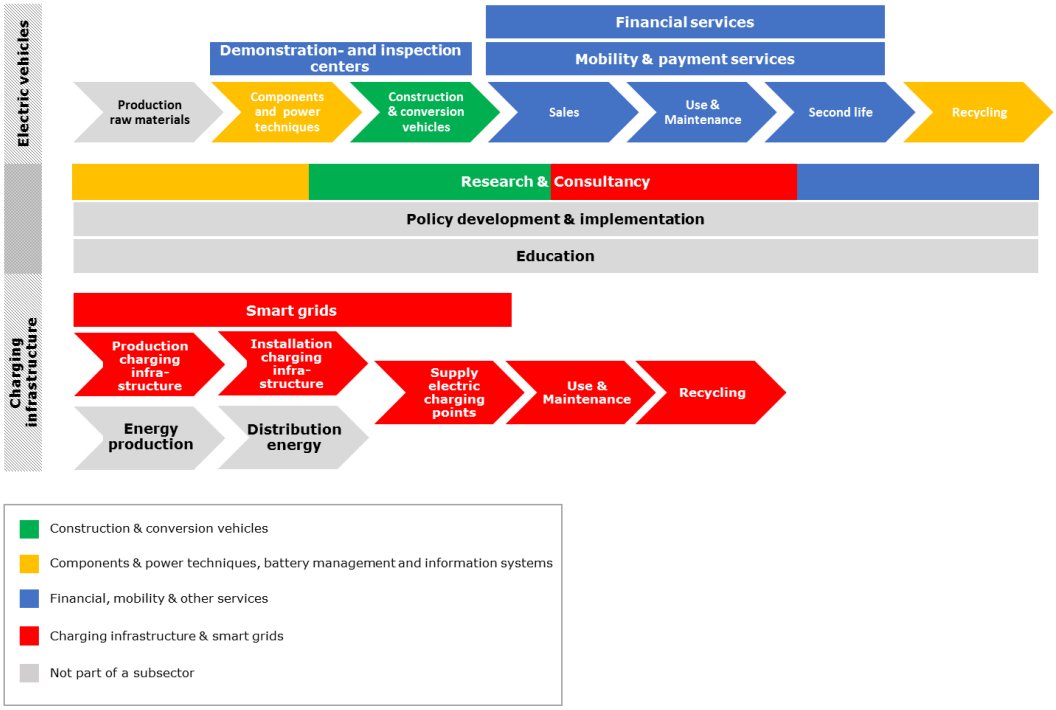

Figure 12 EV value chain of EVs and charging infrastrucutre as adapted from Munnix et al. (2015).

As the GEM-tool focuses on the pre-development phase of eMobility, it is assumed that most of the EV actors do not exist yet or do not have eMobility related knowledge. However, in frontrunner countries such as the Netherlands, for the majority of the companies involved in electric mobility EVs are only part of their business model as they have other (main) products (Eveleens et al. 2015). These actors can be identified in advance as they already exist and possibly have an interest in EV as expansion of their business. Therefore, within the tool, they are referred to as 'potential actors of the EV value chain'. Examples of potential EV value chain players are energy producers & suppliers, manufacturers of vehicles, importers, fleet owners, lease- and transport companies, IT-service providers and battery producers (Ernst & Young 2012; NL Enterprise Agency 2013). Furthermore, even though second life and recycling are part of the final phase of the value chain and the use of eMobility, they play a small role in the pre-development phase and are therefore not taken into account. Even in frontrunner countries, this is still an underdeveloped part of the supply chain (Eveleens et al. 2015). Moreover, policy makers, research institutes, consultancies and educational institutes are not part of the value chain, but have a supportive role. This also goes for the financial and mobility services, e.g. banks, venture capital providers, branch- and network organizations, as well as the demonstration and inspection centers. They are not part of the EV value chain actors of the GEM-tool. Lastly, consumers and users are not taken into account in the EV value chain as they have a subsequent different function (demand) than market players (supply) and are therefore included as a separate actor group.

5.1.3 Step III Scoring and evaluating the preconditions

Based on the gathered information and derived answers within the questionnaire, the preconditions receive a score of -1 (negative), 0 (neutral), +1 (positive) or +2 (excellent). The scoring system takes into account the pre-development phase of the system within the context of MICs. A negative score signifies a precondition which is negatively influencing the development and diffusion of eMobility in the local context. The negative score is also based on blocking mechanisms from the literature, for

example a lack of standards. A neutral score indicates that the precondition is not met, therefore indirectly impacting the successful implementation of EV, as it implies that improvement is necessary. A positive score of +1 means that the precondition is partly met and that it could form an opportunity when it is given attention. An excellent score of +2 indicates that the precondition has been met, which forms an opportunity for eMobility as it positively influences the development and diffusion of eMobility. Both the positive and excellent scores are also based on inducement mechanisms, for example a leading frontrunner in eMobility. In some cases, a -1 or a +2 is not applicable to the answer options of the precondition. The term N.A. (not applicable) is used to indicate the lack of this option.

Scoring preconditions is carried out in a partly objective and partly subjective way. Preconditions can be assigned a score objectively when the answers and operationalization of the precondition is quantifiable. For example, the presence of a long term EV plan. Other preconditions, such as the level of collaboration, are difficult to quantify or measure objectively in a short period of time. The scores are then based on the interpretation of the advisor of the identified information and the views of the main interviewees, especially when it is a yes-no construction using No (0), Some (+1) or Yes (+2) as indication. This is explained in more detail at each precondition. As the GEM-tool can be applied to a range of MICs, the operationalization of the preconditions (the scoring system and the formulation of answer categories) has been kept broad. The scoring system should be interpreted as indication. Therefore, it is up to the researcher or advisor to decide on the final score based on the identified information within the local context.

5.1.4 Step IV Scoring and evaluating the systems functions

As elaborated upon in Chapter three, the system functions are interconnected, which is shown in the GEM-motor (see section 3.2.3). Therefore, when one system function does not function well, this has implications for the other system functions and therefore on the preconditions they encompass. Consequently, it is of importance to have an understanding of the performance of system functions as a whole, complementary to the functioning of the preconditions.

The system functions are scored based on the total score of their preconditions and their weight within the system function. As the system functions vary in the amount of preconditions embedded in their function, and therefore in the total amount of points that it can score, an absolute number as score will not show the position of the individual system function relative to the other system functions. Therefore, the percentage of the total score is calculated per system function. This shows how relatively good or bad a system function scores based on the total amount of points that it can get. Furthermore, as the preconditions are ranked according to their weight in the system function, this should be embedded in the formula for the final score of the system function as well. The following formula was therefore used to calculate the system functions' overall score in percentages, including the score and weight of the individual preconditions:

$$\text{Score system function (\%)} = \frac{\sum_{1}^{rp=N}((S_p - S_{mi})/(S_{ma} - S_{mi}) * R_p)}{\sum_{1}^{rp=N} R_p} * 100$$

Sp = score of precondition
Smi = minimal score precondition
Sma = maximal score precondition

Rp= weight of precondition

rp=1 for the precondition with the lowest weight

rp = N for the precondition with the highest weight (differs per system function)

When all the preconditions score within a system function score negatively (-1), the system function as a whole will score 0%. When they preconditions score neutral (0), the system function will score 33%. When all precondition score positively (+1), the system function scores 66%. And it will score 100% when all the precondition score excellently (+2). Therefore, a score of <33% is seen as a weak system function, a score of 33-66% is seen as intermediate system function and score of >66% is seen as strong system function.

5.1.5 Step V Scoring and evaluating the local innovation system

The total score of the GEM-tool shows the performance of the innovation system in the predevelopment phase of eMobility in the local context. It is calculated based on the scores of all preconditions. All scores of the preconditions are multiplied with their corresponding weight, and divided by the sum of all weights of the individual preconditions (which amounts to 209 for the 49 preconditions). The same formula is used for the scoring of the total GEM-tool as for the system functions (see section 5.1.4). Therefore, the same evaluation method is used for the total score of the GEM-tool: a score from <33% is seen as a weak innovation system, a score of 33-66% is seen as intermediate innovation system and score of >66% is seen as strong innovation system, taking into account the predevelopment phase of the system. No policy implication or recommendation has been developed for the performance of the innovation system as a whole, as this is based on the performance and dynamics of the system functions and preconditions which are explained per system function.

5.1.6 Step VI Policy recommendations for the preconditions

For every precondition a brief policy recommendation is presented to get to the optimal situation (see Figure 13).

Figure 13 Example of the outcome of the GEM-tool for one precondition

The policy recommendation is partly based on the operationalization and identified positive scores of the precondition, as the highest possible score represents the optimal situation in the predevelopment phase. How the precondition should evolve from a negatively to a positively or even excellent scored precondition is not elaborated upon in detail as this is very context specific.

Therefore the policy advice is focused on a general improvement of the situation. As there is some overlap between the individual preconditions and the identified EV policy measures, overarching policy advice is given at the system function level (see section 5.1.7). Furthermore, each precondition is coupled to a (type of) structural factor (see Chapter four). Each precondition is therefore linked to the systemic problems and systemic instruments (goals), using the functional-structural analysis developed by Wieczorek & Hekkert (2012) (see Figure 14). The goal of the systemic instrument formed the basis of the policy advice which was adapted to the context of eMobility.

Goals of systemic instrument
Stimulate and organise participation of relevant actors (1)
Create space for actors capability development (2)
Stimulate occurrence of interactions (3)
Prevent too strong and too weak ties (4)
Secure presence of hard and soft institutions (5)
Prevent too weak and too stringent institutions (6)
Stimulate physical, financial and knowledge infrastructure (7)
Ensure adequate quality of infrastructure (8)

Figure 14 Goals of the systemic instruments develop by Wieczorek & Hekkert (2012)

In some cases, especially when the precondition is of a national or international scale, the precondition is not (directly) in the hands of the local policy makers to change. Still, insights in the performance of the precondition, including the stimulating and opposing forces, give local policy makers an understanding of the situation in which they will introduce eMobility, as it influences the chance of success of the innovation.

5.1.7 Step VII Policy recommendations for the system functions

The policy advice per system function provides an overarching overview of the policy implications & recommendations (see Annex I). They are based on the clusters of information identified in Chapter four, the general descriptions of well-functioning system function of the TIS literature and of the policy advice identified per precondition. Additionally, the dynamics and interaction between the system functions are part of the policy implications, as the malfunctioning of one system function has implications for the functioning of connected system functions. This also implies that improvements of a specific system function can stem from policy recommendations and measures of different system functions. The dynamics are part of the GEM-tool motor and are included in the outcome of the GEM-tool (see also section 3.2.3). Furthermore, even though studies on the effectiveness and best practices of policy measures were used, all found policy measures were assumed to be equally important as the policy measure depends on the local context, the timing and timeframe of the implementation as well as on the chosen set of measures (IA-HEV 2013). It is not part of the tool to include the right (set of) policy measures but to give examples of the methods on how to deal with the found policy implications.

5.2 Designing the online GEM-tool

All the input has been gathered in an Excel file with the seven system functions and individual components as structure of the tool (see for an example Figure 15).

	System functions	Structural factor	Precondition	Clarification precondition	Ranking	Scale	Question	Identification possible answers	Data collection	Operationalization	Reasoning behind indicator	Policy implication & recommendation
2	F1. Guidance of the search	[redacted]	[redacted]	[redacted]	[redacted]	National	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
3		[redacted]	[redacted]	[redacted]	[redacted]	National	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
4		[redacted]	[redacted]	[redacted]	[redacted]	Local	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
5		[redacted]	[redacted]	[redacted]	[redacted]	National	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
6		[redacted]	[redacted]	[redacted]	[redacted]	Local	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7		[redacted]	[redacted]	[redacted]	[redacted]	Local	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8		[redacted]	[redacted]	[redacted]	[redacted]	National	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Figure 15 Insight in the build-up of the Excel file used as framework encompassing all content of the GEM-tool

The online GEM-tool consists of two interlinked parts: the front-end and back-end. The front-end is what is shown to the user of the online tool. It has been designed using HTML (structure), CSS (styling) and JavaScript (animations and management of data). The back-end part is where the database is stored, the Excel document is imported and where the PDF of the GEM-tool is generated. It has been designed using the PHP framework Laravel. With an internal Excel reader, all system functions, preconditions and corresponding components included in the excel file are imported, stored within the database and shown in the front-end part to the user. During the application of the tool, the user is provided with the option to choose between four answers per precondition. Javascript saves the answers until the user submits them in the front-end. This generates a form encompassing the total set of answers which is sent to the back-end part of the tool. This converts the form into a specific score per precondition and system function, and results in a PDF including these scores forming the outcome of the GEM-tool (Emre Koc, personal communication, 26th July 2016).

Chapter 6 Applying the GEM-Tool in Delhi

Key messages

- To test and validate the GEM-tool, it is applied to Delhi, a major urban region in a middle-income country (India) and interested in the uptake of eMobility;
- Overall, the local innovation system regarding eMobility of Delhi scored 65% in the GEM-tool, making it an intermediate innovation system;
- The illustrative case provides an excellent example of how an innovation system in its predevelopment phase can make use of the GEM-tool to give an overview of existing barriers and opportunities and to help to make use of existing actors, interactions, institutions and infrastructure;
- The GEM-tool proved to provide practical and structural guidance to gather relevant data before the start of eMobility;
- The case confirmed the necessity for an independent advisor to gather, analyze and validate the various data and data sources to increase the validity of the outcomes of the case;
- As an improvement following from the illustrative case, a separate answer category within the scoring system is suggested when no information is identified.

To test and validate the GEM-tool, it is applied to Delhi (the capital of India), a major urban region in a middle-income country. As a whole, India is a frontrunner country of middle-income countries implementing eMobility. Especially electric two- and three wheelers are becoming popular modes of transport. Delhi is therefore expected to perform very well in the GEM-tool and thus provides the opportunity to test the tool and its application and complies with the set criteria for an illustrative case (see section 2.4). It will show if there is something missing in the tool and if the identified preconditions are met in a situation in which the urban region is performing well regarding EV. The following sections cover the steps of the GEM-tool.

6.1 Introducing Delhi

Delhi, officially known as the National Capital Territory (NCT) of Delhi, is the capital city of India and is the largest metropolitan region by area and the second biggest by population in India. According to the Census of India, offering statistical information about India under the Government of India, the population of Delphi has grown to 18,686,902 in 2016. The city is located in northern India and is spread out of an area of 1,483 km2 (Census India 2016).

Delhi was declared as the most polluted city in the world by the World Health Organization in 2014, though it dropped to the 11th place in 2016 (WHO 2014; WHO 2016). Still, the city suffers from air pollution caused by transportation and road dust, industries and domestic air emissions. The local air pollution, caused by fine particle matter, exceeds the national guideline almost four times and the fine particle guideline set by the World Health Organization 15 times (Narain et al. 2014).

The reliance on road based transport and mobility within the urban region has grown with the growth of the city (IUT India 2009). The number of vehicles has grown eight times in the last two decades and is expected to grow (DDA 2010). The transport sector creates a high dependency on oil

in India as a whole as it accounts for about one-third of the total crude oil consumption (Bansal & Bandivadekar 2013). The government can save millions when fossil fuels are replaced with electricity in the transport sector. Furthermore, India's automobile industry is the sixth largest in the world and accounts for 22% of the country's total manufacturing output (IESA 2016). The main source of pollution in cities stems from vehicle emissions. In Delhi, emissions from vehicles rose to 70% of total emissions. Given the established auto manufacturing industry in India, the expected growth in transport demand, the pressing issues stemming from transport and the recent global interest in electric vehicles, India sees the opportunity to become a global leader in EV manufacturing, as well as the chance to create domestic EV market (Shulka et al. 2014; W. Van der Vaart, personal communication, 20th June 2016).

India started with eMobility around 2007, resulting in an immediate increase of electric vehicles followed by a rapid collapse. From 2007 until 2012, various initiatives were taken in the country to promote electric mobility. These past efforts were said to lack the desired level of synergy, top level support and ownership both in the government and industry. Most of the efforts amounted to nothing as they were "isolated in nature, lacked collaborative approach and did not tackle all the issues holistically" (Soediono 2012, p.12). Therefore, the government of India developed a clear, long-term roadmap for the use of cleaner fuels and vehicles to achieve the potential and to create a more collaborative approach (Ministry of Finance of the Government of India 2016; World Bank 2014). This includes different types of electric two-wheelers (scooters and bikes), three-wheelers (rickshaws), four-wheelers (cars and taxi's) and electric busses (Shulka et al. 2014).

Figure 16 Pollution caused by transport is a major problem in Delhi (source: www.outlookindia.com)

6.2 Scoring the system functions

The score per precondition, based on the answer specified under each precondition below, is given per precondition consisting of a negative score (-1), a neutral score (0), a positive score (+1) and an excellent score (+2). The scores will furthermore be filled in within the online GEM-tool.

6.2.1 Guidance of the Search

1) A long term ambition for sustainability & sustainable development of the national government = +2

The government of India expressed their ambition towards sustainable development by 2030, including renewable energy and sustainable transport, in the Intended Nationally Determined Contribution (INDC) as part of the UN Climate Change Conference (COP21 2015). According to the

INCD, the Indian development process follows the "Development without Destruction" path. Furthermore, the National Action Plan for Climate Change (2008-2017) came into force in 2008, aiming to address climate change uses whilst promoting economic growth (GoI 2015). It is implemented through eight missions, including a National Mission on Sustainable Habitat and Energy Efficiency (Soediono 2012). As the Indian government committed to a more sustainable development path, the precondition scores a +2.

2) A national plan for sustainable mobility, focusing on eMobility = +2

There is a general ambition towards sustainable mobility in India: the National Urban Transport Policy (NUTP) came into being in 2006 and is seen as the key guiding policy at the national level focusing on urban transport in India (Mani et al. 2012). It emphasized the use of sustainable modes of travel like public transport and non-motorized modes, as well as the energy efficiency of vehicles and the use of cleaner technologies (Shulka et al. 2014; D. Dash, personal communication, 22nd June 2016). Also, the National Environment Policy (2006) aims to reduce the local emissions from transport (Ebinger & Vandycke 2015). Furthermore, the National Smart Grid mission aims to bring efficiency in the power supply network. It is complemented by the National mission for Enhanced Energy Efficiency, the National Electricity Policy and the Energy Conservation act, which aim to improve energy efficiency and stimulate renewable energy (GoI 2015). Lastly, In January 2013, the Ministry of Petroleum and Natural Gas (MoPNG) created an expert committee on "Auto Fuel Vision and Policy—2025", charged with establishing a roadmap for fuel quality and vehicle emission standards through 2025.

The ministry of Heavy Industry and Public Enterprises under the Government of India launched the *National Electric Mobility Mission Plan (NEMMP)* in 2013 to enhance national fuel security, boost domestic manufacturing of vehicles and mitigate adverse environmental affects by promoting (hybrid) electric vehicles. It provides a roadmap for the faster adoption and manufacturing of EVs in India and reserves $2-3$ billion for this investment (Shulka et al. 2014). The main aim is to have 6-7 million electric vehicles (14-16% of the market) on the road by 2020. The Indian government additionally launched the *Faster Adoption and Manufacturing of Electric Vehicle (FAME)* scheme in 2015 to encourage the diffusion of all kinds of EVs (IESA 2016), which includes several Market Formation measures (see 6.2.6) and Knowledge Development stimulation (see 6.2.3).

However, according to the director of Society for Manufacturers of EV, Sohinder Gill, the government should make their long term commitment to electric mobility more clear and not keep the industry guessing from year to year. In his opinion the investments will not come from the industry unless a 5-10 year clear policy and outlay is committed (IESA 2016). On the other hand, an ethos of 'day-to-day' thinking prevails in India, not encouraging long term policy (W. Van Der Vaart, personal communication, 20th June 2016). Furthermore, India is known for developing nice sounding plans, but execution of this plans often fails. India is a very big country, with a lot of bureaucracy and 'red-tape'. Corruption is also still an issue, making sure that the right money goes to the right people can be a challenge (anonymous, personal communication, 2016). The policy receives a score of +2 as there is a long term (>10) plan for eMobility in place.

3) A local plan for sustainable mobility, focusing on eMobility = 0

In Delhi, around 8 million private vehicles are present which run on petrol and diesel, while there are only 6.000 busses which are running on the less polluting CNG. Therefore, the local government has

chosen private vehicles as focal point for sustainable transport as the impact of an electric private transport is therefore much larger (S. Sharma, personal communication, 15th June 2016). However, this focal point is slowly shifting towards public transport. The main development plan of Delhi is the so-called Delhi Master Plan 2021, developed by the Delhi Development Authority, that came into force in 2010. This plan, however, does not mention sustainable transport but focuses on the development of public transport. It mentions the willingness for "changes in traveling practices, better enforcement, stricter norms, technological improvements and the promotion of environmentally friendly fuels" but does not elaborate upon these concepts (GNCTD 2015).

No local plan or targets for sustainable mobility or eMobility was identified during the research. Delhi has had a long-term roadmap for improving local air quality for some time but a roadmap for the introduction of electric public transport is lacking (S. Sharma, personal communication, 15th June 2016). The focus on air quality is shown in the Delhi Clean Air Action plan and the Air Ambience Fund (2009-2015), which include the reduction of air pollution caused by transport.

Furthermore, a CNG program was introduced in Delhi to reduce particulate pollution, especially toxic diesel-emissions. Currently, nearly 300.000 vehicles run on CNG (Narain et al. 2014; Singal 2010). However, the fast growth of vehicles each year in Delhi is creating problem particularly with more diesel driven vehicles (DPA 2012). In November 2015, the Delhi Transport Department issued an Expression of Interest (EoI) for the supply of Compressed Natural Gas (CNG) and Battery Powered Passenger Transport Vehicles. It wishes to introduce an additional 2000 clean and alternative fuel based passenger transport vehicles for public transportation in Delhi (DoT 2015), which includes CNG and electric vehicles. As the plan includes both CNG and eMobility, not having eMobility as main focus, the precondition scores neutrally.

4) The presence of national government departments & institutes which are working on (subjects related to) eMobility = +2

The main concerned ministries relating to eMobility at the Central Government are the Ministry of Heavy Industries, Ministry of Science & Technology, Ministry of Environment and Forests, Ministry of New and Renewable Energy, the Ministry of Finance, the Ministry of Urban development, ministry of Road transport and highways and the Ministry of Power. Furthermore, the National Planning Committee is involved in the development of infrastructure and incentives for EV. The Central Pollution Control Board of India is working on the improvement of air quality which is very much related to vehicular exhaust (Soediono 2012). Furthermore, the Bureau for Energy Efficiency is pushing for efficient use of fuels and reducing the energy intensity of the Indian Economy, which links directly to eMobility. As multiple institutions have been identified, the precondition scores excellently.

5) The presence of local government departments/institutes which are working on (subjects related to) eMobility = +2

There are five local bodies which govern the NCT of Delhi viz., North Delhi Municipal Corporation, South Delhi Municipal Corporation, East Delhi Municipal Corporation, New Delhi Municipal Committee and Delhi Cantonment Board (Beella et al. 2011). The departments of Transport, Environment and Forests, Power, Industries, Public Works and Urban Development could be linked to the introduction of eMobility. Under these departments, the following institutes have been identified which can be related to transport, air quality and eMobility: the Delhi Dialogue Committee, the Delhi

Pollution Control Committee, the Delhi Development Authority, the Delhi Transport Cooperation, the Delhi Integrated Multi – modal Transit System, the Energy Efficiency & Renewable energy Management Center and the Delhi Electricity Regulatory Commission. As multiple institutions have been identified, the precondition scores excellently.

6) The appointment of someone/a team within the local government to move eMobility forward, willing to take on the responsibility of the introduction of eMobility and having the power, connections and capabilities to do so = 0

On a national level, various councils and initiatives exist to forward eMobility. Examples are the National Automotive Board, the National Council on EV and the National Board on EV. No initiative, person or team was identified at the local government of Delhi which is specifically driving eMobility. In the Delhi Master Plan 2021, the focus lies on the improvement of (conventional) public transport under the Transport Department of Delhi. In November 2015, the Delhi Transport Department issued an Expression of Interest for the supply of Compressed Natural Gas (CNG) and Battery Powered Passenger Transport Vehicles (DoT 2015). But this has not yet led to any further developments. It therefore scores neutrally.

7) A high level of willingness to change of potential EV value chain actors = +1

According to V. Mathur, director general of the Society of Indian Automobile Manufacturers (SIAM), the automobile industry welcomes the national promotion of eMobility and promises to work with the government on this (IESA 2016). Due to the active government involvement, both the consumer side as the manufacturing side of the market are growing (D. Dash, personal communication, 21st June 2016). According to W. Van Der Vaart (personal communication, 20th June 2016), it is hard to say anything about the willingness of the industry. There are actors who are working on eMobility, such as Mahindra India, while other companies are slower and are acting devious. Market forces are very strong in India: with a slight differentiation in the price, a tipping point can be reached which would stimulate the introduction of EV tremendously. Furthermore, the industry feels the pressure of competition and new ideas entering the market, including eMobility (S. Rohilla, personal communication, 1st July 2016). As some of the identified actors have a willingness to change, the precondition scores positively.

8) A high level of willingness to change of (potential) consumers= +1

According to a large survey performed for the National Electric Mobility Mission Plan (NEMMP) 2020, eMobility faces barriers regarding the consumers perception of electric vehicles with regard to charging time, driving range, top speed and acceleration (Soediono 2012). Furthermore, the average Indian consumer is highly value conscious and affordability plays a key role in consumer buying decision (Soediono 2012). Risk perception of the problems with air quality is still very low in Delhi (Chowdhury 2015). The level of knowledge are minimal and the advantages of eMobility are not clear as the awareness on air pollution is just starting to develop now (W. Van Der Vaart, personal communication, 20th June 2016). Therefore, the precondition scores positively as consumers are not aware and therefore not open to eMobility.

6.2.2 Resource Mobilization

9) The presence of international funding which can be employed in the local context = +1

India took part in the Sustainable Urban Transport Program (SUTP), funded by the Green

Environment Finance (GEF) program of the World Bank, UNDP and the national government under the ministry of Urban Development (2006-2016). The program is contained within the 2006 National Urban Transport Program of the government of India. It focuses on the development of urban transport planning and the implementation of sustainable urban transport projects (World Bank 2014). The program does not include Delhi as a demonstration city, nor does it include electric vehicles, but it shows that there is an international interest for more sustainable urban transport in India. Furthermore, under the Low Carbon Transport Program of UNEP, the Promoting Low Carbon Transport plan was set up for India in 2010. The plan focused on three cities in India – not including Delhi – and resulted in an action plan for the national government (UNEP 2014). The program ended in 2015, no results have been identified. As no current funding was identified for eMobility in Delhi, but a general interest is present of the international community, the precondition scores a 1.

10) The presence of national financial resources for the development and diffusion of eMobility = +2

Numerous funds have been identified which can be used for the advancement of eMobility. In the recent past (2010-12), the Ministry of New and Renewable Energy (MNRE) has also incentivized the purchase of electric vehicles through its Alternate Fuels for Surface Transportation Program (AFSTP) scheme which had an outlay of $14 million US dollars (Shulka et al. 2014). When the subsidy stopped, this led to a sharp decrease of EVs (IESA 2015). Therefore, the NEMMP was introduced. To achieve the goals set in the NEMMP, the national government has pledged to spend $2.6–2.8 billion from 2012-2020. The private sector should spend another $1.7–1.9 billion (Bansal & Bandivadekar 2013). The Faster Adaptation and Manufacturing of EVs (FAME) scheme is part of the NEMMP, which supports the market with $123 million in 2015-2017 of which $75 million will be spend on demand creation by offering incentives for consumers and manufacturers and the rest on technological development, charging infrastructure and pilot projects (Pandit & Kapur 2015). Furthermore, the National Department of Science and Technology will also partner in funding the electric mobility R&D program from their budget allocations (Soediono 2012). It should be noted however that it is not always easy to receive money from the government. For example, two years after the agreed date, the ministry of Heavy Industries received the money for the implementation of the NEMMP making it even more difficult for the industry to claim the funds (W. Van Der Vaart, personal communication, 20th June 2016). Also, in many cases, businesses need to make an (indirect) payment to the government before receiving the funds. For example, a so-called 'kick-back' construction can be applied, in which the government receives a percentage of the promised funds (Anonymous, personal communication, 2016). Lastly, a *Partial Risk Guarantee Fund for Energy Efficiency (PRGFEE),* a risk sharing mechanism to provide financial institutions with a partial coverage of risk involved in extending loans for energy efficiency projects, and a *Venture Capital Fund for Energy Efficiency (VCFEE),* a trust fund to provide capital to energy efficiency companies, have been established *(GoI 2015).* As multiple potential funds have been identified, the precondition receives a +2.

11) The possibility of a loan for a new technological innovation such as eMobility = 0

It is very difficult to get a loan in India. In Bangalore, a major city in India, charging infrastructure for electric vehicles has been put on the black list as it does not yield returns (Anonymous, personal communication, 2016). Furthermore, the costs of capital are very high making lending money expensive. It is assumed that entrepreneurs will use money from their own capital or venture capital (W. Van Der Vaart, personal communication, 20th June 2016). The precondition therefore neutrally.

12) A high level of awareness amongst potential EV value chain actors about the potential financial resources (if present) = +2

The awareness about financial resources is certainly present, according to W. Van Der Vaart (personal communication, 20th June 2016). Indians are very much aware of where money can come from and is therefore scored a +2.

13) Insight in the different modes of transport used in the urban region = +2

23 million passenger trips are made in Delhi every day. Busses constitute 1% of the total number of vehicles, but carry 50-60% of the total trip makers, whereas cars and two-wheelers forms 93% of the total vehicles but caters to about 35% of the total trips (IUT India 2009). The average vehicle ownership is 0.97 per household of which 21% households own at least one car while about 44% own at least a two wheeler. (Ministry of finance Government of India 2016). 35% of all trips are by foot, 27% by bus, 14% by 2-wheeler and 9% by car or taxi. The Delhi bus system has a total of about 6500 busses in operation (EVConsult 2015). Delhi government is planning to introduce separate bus lanes to increase the quality of the operation as the busses are currently being blocked by cars (H. Gokulendra, personal communication, 22nd June 2016). As there is knowledge on the use of the different modes of transport, and as the main method of transport is still non-motorized, the precondition scores a +2.

14) The availability of suitable electric vehicles = +1

No companies are manufacturing electric busses in India, as the price is still too high (H. Gokulendra, personal communication, 22nd June 2016). Also, no electric 2- and 3-wheelers are manufactured in India but the components are imported, assembled and sold by dealers. Furthermore, Mahindra was the only manufacturer of electric four wheelers in India and is exporting their fleet as the domestic market is too small (W. Van Der Vaart, personal communication, 20th June 2016). Slowly, other products are entering the market such as the Toyota Cambry Hybdid and the Maruti Suzuki Ciaz Hybrid (S. Rohilla, personal communication, 1st July 2016). It therefore scores a +1.

15) The availability of complementary technology = -1

In India, CNG is used as alternative, clean fuel. CNG however is still a fossil fuel and even though it emits less, it is still not a zero emission fuel. In Delhi, the infrastructure for CNG is already in place (Posada 2009). On the one hand, this shows that Delhi is trying to convert to cleaner fuels. On the other hand, this prevents resources to be used for the advancement of eMobility as the focus does not lie on eMobility but on the less clean CNG. Ather Energy is working on a Lithium-ion battery with digital battery management which would result in eight times faster charging, ten times longer battery and 75% lighter battery (Pandit & Kapur 2015). This could stimulate the EV market considerably. However, this is not in place yet and therefore not included in the score of this precondition. The precondition is therefore scored negatively as the negative implications are larger.

16) The presence of consistent energy supply needed for eMobility = +2

There is a constant supply of energy in Delhi (H. Gokulendra, personal communication, 22nd June 2016) managed by three grid operators namely Tata Power Delhi Distribution, BSES Radjhani Power and BSES Yamuna Power (D. Dash, personal communication, 21st June 2016). On a national scale, the transport sector only uses 1% of the total energy supply and EVS are not expected to have a big impact on energy supply (IEA 2015). The readiness of capacity also depends on the local substation which distribute the electricity. The subsystems use old technology which could pose a problem for

eMobility (H. Gokulendra, personal communication, 22nd June 2016). However, as there is a consistent supply of energy present, the precondition scores a +2.

17) The presence of renewable sources for the energy supply needed for eMobility = 0

Currently, a large part of Delhi's electricity is generated by coal fired power plants. Two of those are located within the urban area of Delhi (EVConsult 2015). In India as a whole, investments are being made to advance renewable energy. Currently, 26 GW of renewable wind energy and 6 GW of solar is being produced in India. However, Delhi is a small state therefore it doesn't take a major chunk of renewable energy (Dash, personal communication, 21st June 2016). No activities regarding renewable energy supply in Delhi have been identified, therefore the precondition scores neutrally.

18) A supporting geographical and climatological environment for eMobility = 0

According to B. Bruno, managing director of battery manufacturer Greenvision Technologies, most urban users of cars and bikes use it for not more than 30 to 40 km every day which is well into the range of an EV (S. Dash, personal communication, 21st June 2016). Furthermore, Delhi is built on a flat, plain area in the northern parts of India. On the other hand, it is a very humid, hot and dusty city which can have an effect on the performance of the batteries in EVs (Institute of Urban Transport India 2009; W. Van Der Vaart, personal communication, 20th June 2016). The exact effect is not known yet, but it can be said that the local environment has both stimulating as hindering factors so the precondition scores neutrally.

19) The presence of experts with knowledge and skills relating to eMobility = 0

According to H. Gokulendra (personal communication, 22nd June 2016), there are no trained experts with knowledge or expertise on electric mobility, its development, operation or maintenance. However, there are various educational institutes with a department of electronic engineering, also focusing on eMobility for example the Indian Institutes of Technology. Furthermore, the Government of India has launched the "Skill India" project with the target to provide skill training in various sectors including sustainable development to about 400 million people by 2022. This can lead to experts on eMobility in the next decade, but as it is not present yet, it receives a score of 0.

6.2.3 Knowledge Development

20) Insights in the existing knowledge about eMobility= +2

(National) Knowledge has been developed on problems related to air pollution and the partial solution electric transport could bring to alleviate some of these problems. Examples are the reports 'Promoting Low Carbon Transport in India project' (Subash, D., Pathak M. & Shukla P.R. 2015), 'Sustainable Urban Transport Policy in India' (Mani et al. 2012), and 'Assessing and Accelerating Electric Vehicle Deployment in India' (CEM 2014). Furthermore, there have been pilots with (fast) charging stations, E-rickshaws, (hybrid) electric busses (of which one in Delhi) and electric cars (NEMMP 2015). However, this knowledge has not been translated yet to the local context in Delhi, apart from the on-going pilot project with one E-bus. Furthermore, the report on benchmarks for urban transport, initiated by the ministry of urban development and performed by the Urban Mass Transit Company, a public-private consultancy, and the Institute of Urban Transport under the Ministry of Urban Development, gives insight in the level of mobility services in Delhi. Concluding from the above, the precondition receives an excellent score.

21) The presence of R&D institutes performing research on eMobility = +2

Various research institutes have been working on the development of (components of) electric vehicles, charging systems and energy systems as well as performing research on the institutional surrounding of eMobility. The Institutes for Indian Technology (IIT), located in various parts in the country including Delhi, are working on eMobility related subjects for example an electric race car. The Institute for Science has published a report on the comparison of eMobility with conventional fuel (diesel). The Center for Science & Technology, the Center for Science & Environment, the Central Power Institute, the National Institutes of Technology, the Institute of Urban Transport and the Institute of Engineering and Technology India have been doing research on e.g. air pollution reduction measures, renewable energy and sustainable transport including eMobility. The Energy and Resource Institute (India) has also been working on eMobility. It was involved in a pilot project with electric rickshaws (E-rickshaws), it collaborated with the University of San Diego on the India California Air Pollution Mitigation Program, resulting in the report Options to Reduce Road Transport Pollution in India (Ramanathan et al. 2014) and it performs research on eMobility and energy security. Additionally, there are also many research institutes touching upon eMobility such as the IIT Kanpur which studies air pollution and greenhouse gas emission rates in Delhi. Also, there are various universities with an electric engineering department. Furthermore, the Indian Space Research Organisation (ISRO), Indian Institutes for Technology, the Council for Scientific and Industrial Research (CSIR) and the Central Electrochemical Research institute are developing Li-ion batteries for EVs (Soediono 2012). Lastly, the Automotive Research Association of India under the Ministry of Heavy Industries, the R&D center International Centre for Automotive Technology and the Central Institute of Road Transport have been authorized by the government of India to test EVs under the FAME scheme. It should be noted however, that it was mentioned during personal communications that many of the R&D institutes in India are not about transferring knowledge, but about gaining money (anonymous, personal communication, 2016). Still, as this has not been supported by other findings, the precondition scores +2.

22) The presence of actors from the potential EV value chain stemming from the automotive industry with knowledge about eMobility = +1

The main actor from the automotive industry with an interest in and knowledge on eMobility is Mahindra Electric which released the Mahindra Reva Electric (Van Der Vaart, personal communication, 20th June 2016). Other companies experimenting with eMobility are Hero, Tata motors, Maruti Suzuki, Toyota and Nissan, working on performance, second-life of EVs, charging infrastructure and battery optimization. This is still early days however (Dash, personal communication, 2016), resulting in a positive score.

23) The presence of actors from the potential EV value chain stemming from the ICT sector with knowledge related to eMobility = +1

The ICT sector in India is not yet very active when it comes to eMobility (Dash, personal communication, 2016). The main actors are Tata consultancy services India and Tech Mahindra India working on smart charging, remote vehicle diagnostic solutions for EVs and driver behavior. Other manufacturers are used starting to work with the ICT-sector on eMobility but this is mostly still in the start-up phase (Dash, personal communication, 2016; W. Van Der Vaart, personal communication, 20th June 2016). Therefore, the precondition scores positively.

24) The presence of actors from the potential EV value chain stemming from the energy sector with knowledge related to eMobility = 0

According to W. Van Der Vaart (personal communication, 20th June 2016), the energy sector sees the development as an opportunity. However, they are not yet involved in eMobility and therefore do not have knowledge on eMobility. Thus, the precondition scores neutrally.

6.2.4 Knowledge Diffusion & Networks

25) Knowledge exchange regarding eMobility = +2

There have been numerous events and conferences on eMobility in India, for example the Auto Expo showcasing 15 EVs (IESA 2016), web seminars of the Indian Energy Storage Alliance (IESA) on the Indian EV market (2015), the international conference on Sustainable Energy Technologies for Smart and Clean Cities (2016) and the conference on Clean Energy Vehicle Programs (2015). Furthermore, knowledge is being exchanged under the NEMMP program of the government (see preconditions above). India is also involved in international knowledge exchange as it is one of the 16 member countries of the Electric Vehicles Initiative, a multi-government policy forum dedicated to accelerate the introduction and diffusion of electric vehicles worldwide (CEM 2014). As multiple opportunities for knowledge exchange have been identified, the precondition scores excellently.

26) Access to generated knowledge on eMobility = +1

Various actors have shared the generated knowledge on eMobility (also applied as sources within this case). However, not all the results of mentioned research has been found indicating (in some part) a restriction of the access to generated knowledge. According to H. Gokulendra (personal communication, 22nd June 2016), the industry is very much doing its own thing which is hampering the development. The precondition therefore receives a score of +1.

27) Collaboration between potential EV value chain actors = +1

According to W. Van Der Vaart, collaboration is not in place at is a very competitive market in India where a trust deficit dominated between market players (personal communication, 20th June 2016). However, five large producers namely Mahindra Electric, Mahindra & Mahindra, Tata Motors, Ford India and Maruti Suzuki, have formed a consortium to form a common platform for the development of an electric car to lower the price as of the bigger scale. The government is funding part of the consortium (W. Van Der Vaart, personal communication, 20th June 2016). The project is being steered jointly by the DHI and industry lobby group Society of Indian Automobile Manufacturers. Furthermore, the India Energy Storage Alliance (IESA) brings together actors from the Indian energy industry, also regarding eMobility. As there is some collaboration between potential EV value chian actors, the precondition receives a score of +1.

28) Collaboration between potential EV value chain actors and the (local) government= +1

Under the National Mission for Electric Mobility, three institutions have been set up: the National Council on Electric Mobility, the National Board for Electric Mobility and the National Automotive Board (Soediono 2012). In all three, representatives of both government and industry are represented i.e. the Society for Indian Automobile Manufactures (SIAM), the Society of Manufacturers of Electric Vehicle (SMEV), the Battery Manufacturers Association, the department of Road Transport and Highways, the department of heavy industry and the ministry of environment & forest. The National Automotive Board (as of 2012) encompasses technical experts and is the agency

for all ongoing and new initiatives of the government and the automotive sector (Soediono 2012). As already mentioned at the precondition above, working groups have been set up between the industry, government and academics to work together on technological development, demand creation and charging infrastructure (NEMMP 2015). No examples have been found of the results from these working groups. Furthermore, the government is steering the consortium mentioned in a previous precondition (27), in which five large car manufacturers are working together. As some collaboration is taking place, but not specifically in Delhi, the precondition scores +1.

29) Collaboration between potential EV value chain actors and R&D institutes = +1

There is collaboration between R&D institutes and the industry, especially on the development of lithium batteries as they are currently imported (D. Dash, personal communication, 21st June 2016). Furthermore, the Indian Institutes of Technology are high quality research institutes which result often in technology incubators i.e. students or researchers working on an innovation which turns into a product and company. An example of this is the start-up Ather Energy that developed a smart electric scooter which will be introduced to the market soon (W. Van Der Vaart, personal communication, 20th June 2016). As some collaboration has been identified, the precondition scores +1.

30) Collaboration between local government and R&D institutes= +1

R&D institutes and experts with knowledge about aspects regarding eMobility are nominated to join the National Board for Electric Mobility, but not yet member (Soediono 2012). It is not clear who are members in this board. Under the FAME scheme, four working groups have been set up in which government, industry and academics are working together on technological development, demand creation, pilot projects and charging infrastructure (NEMMP 2015). No collaboration was identified between the Delhi government and local R&D institutes, therefore the precondition is given a score of +1.

31) Collaboration between local governmental departments regarding eMobility = 0

The level of collaboration between the governmental departments regarding eMobility is low (H. Gokulendra, personal communication, 22nd June 2016) which leads to a slow development of eMobility. As it was not possible to interview someone at the government of Delhi, no further information has been found. As no collaboration regarding mobility or innovation was found, the precondition scores neutrally.

32) Collaboration between local and national government departments regarding eMobility = -1

There is no collaboration between the local and national government regarding eMobility. There are political issues between the leading party in Delhi, the new Aam Aadmi Party, and the national government as the national government would like to see their own state party rule in Delhi. The support is there on paper, but not in in the real world (W. Van Der Vaart, personal communication, 20th June 2016; H. Gokulendra, personal communication, 22nd June 2016). Thus, the precondition is scored negatively.

6.2.5 Entrepreneurial Activities

33) A high level of innovation in the country = +1

India has many Entrepreneurial Activities (see following precondition). However, most of the development is not focused on innovation but on copying. All large start-ups are clones of western

companies, using scale and simplification to lower costs (W. Van Der Vaart, personal communication, 20th June 2016). This also shows in the Global Innovation Index, scoring India at 0.43 and therefore a +1 in the GEM-tool (Global Innovation Index 2016).

34) A high degree of entrepreneurship (culture) of the country = 0

India has a very entrepreneurial culture. There is a lot of *brick and mortar,* entrepreneurs starting small enterprises and start-ups. An example of a start-up involved in eMobility is Ather Energy, who developed a smart electric scooter for the local market (Ather Energy 2016). However, according to World Bank and OECD data of the new business entry density of a country, India scores 0.12 out of 1, indicating a low level of entrepreneurship and therefore receives a neutral score in the GEM-tool (World Bank 2016).

35) The possibility to create a niche market for eMobility = +2

Already some pilot projects have been mentioned during the scoring of previous preconditions (see F3). Examples of pilots are the charging station of Tata power in Delhi, the electric bus managed by the Delhi Transport Cooperation in a trial of six months, the pilot of "odd-even" plan for restricting auto use in Delhi and the various pilots on smart grids (though not yet in Delhi) under the National Smart Grid Mission. The combination of these pilots, the incentives mentioned at F6 and the intentions stemming from the NEMMP, focusing on the advancement of eMobility, resulted in an excellent score for this precondition(NEMMP 2015) .

36) Presence of potential EV value chain actors from the automotive sector with an interest in eMobility = +2

E-Cars

According to S. Rohilla (personal communication, 1st July 2016), the automotive industry is in transition. There is a lot of interest of the Original Equipment Manufacturer in India. But the high costs and lack of charging infrastructure still forms a problem for the market to grow, causing a reserved position of the OEMs. The only Indian electric car manufacturer is Mahindra Reva, recently renamed as Mahindra Electric, producing the Mahindra E20. It sold between 2500 and 3000 of its electric cars in the past few years. The same amount has been exported as the Indian market was not ready for this amount of EVs (W. Van Der Vaart, personal communication, 20th June 2016). Many international brands have set-up part of their business in India, making it the 6sth biggest automobile industry in the world (IESA, 2016). Some of these companies have already introduced their electric car in other markets, such as Toyota, Renault, Audi and Hyundai, and are slowly experimenting with EVs in India (Salvi & Nambiar 2010). For example, Toyota just released the Toyota Cambry Hybdid (S. Rohilla, personal communication, 1st July 2016). Furthermore, one of the main car manufacturing companies in India is Maruti Suzuki, a joint venture between the Japanese Suzuki and the Indian company Maruti, which has around 50% of the passenger vehicle market share in India. They have some electric models in development which will come in to the market space in 1 or 2 years' time (W. Van Der Vaart, personal communication, 20th June 2016). Their model currently entering the market is their Ciaz Hybrid (S. Rohilla, personal communication, 1st July 2016) But it is moving very slowly as they are protecting their own ICE vehicles. Another large player in the automotive industry is Tata motors, who is experimenting and slowly beginning to invest in eMobility, but will not push the market towards EVs.

E-rickshaws: There are no manufacturers of E-rickshaws in India. What is happening a lot, however, is Indian companies importing and assembling the components for the E-rickshaws, or imported and renamed (W. Van Der Vaart, personal communication, 20th June 2016). Examples of suppliers and dealers of E-rickshaws in Delhi are Rahat, Ceeon India, Erickshawindia, Terra Motors, Malik Battery Rickshaws , Shikara, Vahaak, Speedways electric and many others (Rahar Rickshaw 2016; Ceeon India 2016; E-rickshaw India 2016; Malik Battery Rickshaws 2016; Terra Motors 2016; Shikara 2016; Vahaak 2016; Speedways electric 2016).

E-Busses: Electric busses are not yet in place in India. Some pilot projects have just started for example in Delhi and Bangladore. The main electric bus actor is the international company BYD (W. Van Der Vaart, personal communication, 20th June 2016), working together with the distributor Utopia (BYD 2014). It introduced the first full electric bus in Delhi in a three months pilot project in 2016 (GoI 2016). Furthermore, Tata Motors has developed a CNG hybrid Electric Bus which was introduced in Bangladore in 2010 (Tata Motors 2015).

Electric two wheelers: Over two dozen different two wheelers are now available in India (Shulka et al. 2014). Hero electric India is the biggest market player when it comes to electric scooters (ISGF 2015). Electrotherm is owner of the electric scooter brand Yobykes. Furthermore, Ampere Vehicles, Lohia Auto Industries, Ajanta Manufacturing Ltd, Tork Motors Pvt Ltd, Avon Cycles and Ather Energy are examples of Indian companies producing or reselling electric two wheelers. These companies are also member of the Society for Manufacturers of EV (Yobykes 2016; Ampere Vehicles 2016; Lohia Auto 2016; Ajanta Pharma 2016; Tork Motor cycles 2016; Ather Energy 2016; SMEV 2016).

Concluding from the identified information, the precondition scores excellently.

37) Presence of potential EV value chain actors from the ICT sector with an interest in eMobility = +1

The ICT sector in India is not yet very active when it comes to eMobility (Dash, personal communication, 2016). The main actors are Tata consultancy services India and Tech Mahindra India working on smart charging, remote vehicle diagnostic solutions for EVs and driver behavior. Other manufacturers are used starting to work with the ICT-sector on eMobility but this is mostly still in the start-up phase (D. Dash, personal communication, 21st June 2016; W. Van Der Vaart, personal communication, 20th June 2016). Examples are Renesas (smart metering and smart electric cars), Powrtec Energy (smart metering), JnJ Powercom (smart metering), Ericsson India (Intelligent Transport Systems) and Bosch India (software and hardware for sustainable mobility) (Renesas 2016; Powertec Energy 2016; JNJ Powercom 2016; Ericsson 2016; Bosch India 2016). As actors have been identified, the precondition is regarded as good.

38) Presence of potential EV value chain actors from the energy industry = +1

Distribution of energy has been privatized in Delhi as of 2002. 95% of the power in Delhi is now managed by three grid operators namely Tata Power Delhi Distribution, BSES Radjhani Power and BSES Yamuna Power (Dash, personal communication, 2016), of which the latter two are run by the company Reliance Infrastructure lt. In the New Delhi Municipal Cooperation, power is still controlled by the municipal council.

No information was found on the willingness to work with EVs and charging systems of these companies with the exception of Tata Power, who installed one charging station of Tata power in a pilot project in Delhi but so far it has not been used (W. Van Der Vaart, personal communication,

20th June 2016). Furthermore, the national smart grid mission was launched in 2015, resulting in 12 pilot projects. Also, the India Smart Grid Forum, a Public Private Partnership initiative of Ministry of Power (MoP) for the development of smart grid technologies, is in favor of the development of smart grids in combination with eMobility (MoP India 2013). Regarding batteries for EVs, the Indian companies Amara Raja with its brand Amaron, Exide and Epsilon are main battery providers to manufacturers of EVs in India (Amaron 2016; Exide Industry 2016; Epsilon Batteries 2016). ABB is a global company working on power and automation technologies, including charging infrastructure for EVs. It has a local office in India, but their charging infrastructure was not identified for India (ABB 2016).

However, according to W. Van Der Vaart (personal communication, 20th June 2016), the energy sector sees the development as an opportunity as the demand for electricity will increase. However, they are not yet involved in eMobility as the main driver for the early development of eMobility is the diesel ban and the carbon emissions. The energy sector is waiting for the market to develop (D.Dash, personal communication, 2016). However, distribution companies would be willing to supply charging points and electricity if the local government would ask for it (H. Gokulendra, personal communication, 22nd June 2016). Thus, the precondition scores positively.

6.2.6 Market Formation

39) A competing fuel price for eMobility compared to (local) traditional vehicles = +2

According to the website of Mahindra, the biggest producer of electric four wheelers in India, it costs around $11 per month to drive their E2 car, in comparison with $67 for a comparable petrol car and $42 for a comparable diesel car when driving 35 km per day in a month. When looking at the Equated Monthly Installment (EMI), the maintenance costs and the energy costs, the electric car of Mahindra costs $171, while the comparable petrol car costs $217 and the comparable diesel car costs $194 per month based on 35 km per day drive (Mahindra Reva 2016).

For an average passenger car to drive 100 km, you need 6.25l of diesel and 17.37 kw (EVConsult 215). In Delhi, diesel costs on average $0.8 (My Petrol Price 2016). Electricity costs are on average $0.08 in Delhi per kw (BSES 2015). This means that the costs for 100 km in a diesel car are 6.26*$0.8 = $5, while driving 100 km with an electric car will cost $0.08*17.37 = $1.4. This means it is 3.5 times more cheap to drive an electric car in Delhi, and therefore receives a excellent score.

40) A competitive cost structure of eMobility compared to (local) traditional vehicles (focus on purchasing price) = -1

In India, there is a very price sensitive market meaning that a high purchasing prices poses a large problem for the diffusion of EVs. Consumers are not looking at the total costs of ownership, including the much cheaper electricity as fuel, but look mostly at purchasing price (H. Gokulendra, personal communication, 22nd June 2016; S. Rohilla, personal communication, 1st July 2016). No information was found on the total costs of electric two and three wheelers in comparison with comparable conventional vehicles.

According to S. Rohilla (personal communication, 1st July 2016), a normal gasoline (<4m) car in India will cost you around €9.000, while an electric (<4m) car in India will cost you around €12.000. A large normal gasoline (>4m) car in India will cost around €15.000, while a large normal (>4m) car in India will cost around €18.000. This means an EV is between 17% and 25% more expensive. According to

W. Van de Vaart (personal communication, 2016), the purchasing price of EVs is still 30-40% higher than comparable ICE vehicles. This price difference is even larger when it comes to busses (Sharma, personal communication, 2016). Therefore, the precondition receives a negative score.

41) Presence of subsidies which could positively influence the introduction of eMobility = +2

Under the FAME scheme, one third of the differential cost between an EV and a comparable conventional car are provided as subsidy on the purchase of electric vehicles to manufacturers. Furthermore, it provides financial assistance to electric vehicle manufacturers through the creation of infrastructure and R&D facilities (IESA 2016). Furthermore, the *Make in India* (as of 2014) and the *Skill India Programs* (as of 2015) are used to boost domestic manufacturing, including e.g. grants & subsidies, tax deductions and exemptions for R&D, loans, and manufacturing of (components of) EVs. Lastly, India has cut subsidies and increased taxes on fossil fuels (petrol and diesel) turning a carbon subsidy regime into one of carbon taxation (GoI 2015).

In Delhi, some financial incentives have been introduced as well. Firstly, the government of Delhi is imposing a fee on diesel and is using this money for their air ambience fund, promoting clean air policies and technologies. The Air Ambience Fund ran until 2015 and was used for the reimbursement of concession and VAT on purchase of EVs in Delhi. This also included a VAT refund of 12.5% for the conversion of vehicles to clean fuels, subsidies to battery-operated vehicles and a discount on registration and on-time road tax. It is not clear whether or not this scheme has been extended. Still, as subsidies have been identified, the precondition receives a score of +2.

42) Presence of taxes which could influence the introduction of eMobility = +2

In Delhi, EVs are exempted from the VAT (8-12%) and road tax. Furthermore, the government of Delhi gives a subsidy for the purchase of E-rickshaws in some cases which is about 15% discount of the total purchasing price. But this subsidy is not introduced systematically (D. Dash, personal communication, 2016). The national *Make in India* program for automobiles includes income tax deduction for capital and revenue expenditure on R&D and a concessional excise duty of 6% for manufacturers of batteries (Make in India 2016). Furthermore, up until 2016, there was an exemption of customs duty on lithium ion automotive batteries for EVs, exemption of customs duty on components of EVs and a concessional excise duty of 6% to specified parts (Pandit & Kapur 2015). These exemptions, however, are not always clear for stakeholders and not always enforced (taken into account at precondition 44) (W. Van Der Vaart, personal communication, 20th June 2016). Moreover, in June 2016, the central minister of Environment, Prakash Javadekar, announced a tax on the purchasing price of SUVs (4%) and diesels (2.5%). An adverse tax, however, was identified for conventional busses in Delhi: in general, busses are taxed more than twice as much than four wheelers, forming 20% of their operation costs (Sharma 2015). It is not known whether this tax also applies to the electric bus used in the pilot project, but this should be an area of focus. Yet, as there are numerous taxes which (potentially) influence the uptake of EVs, the precondition scores good.

43) Regulation/legislation positively influencing the introduction of eMobility regarding transportation & mobility and the automotive sector = +2

As of 2015, E-rickshaws are seen as a valid form of commercial transport according to the Motor Vehicles (Amendment) Bill (Pandit & Kapur 2015). Furthermore, there is an emission-inspection program and a regulation of timing of freight traffic through the city (Narain et al. 2014). As of 2016, commercial diesel vehicles older than 10 years are forbidden on the roads in Delhi and transit freight

traffic passing through Delhi is restricted. In the beginning of 2016, new policy measures such as the pilot of "odd-even" plan for restricting auto use, the ban on highly polluting trucks and prohibiting the sale of diesel vehicles above 2000cc are being tested and/or are being put into place to address the issue (EVConsult 2015). Other steps include public awareness raising campaign and the use of catalytic converters (Singal 2010). Lastly, India aims to improve fuel standards by switching from Euro IV fuels to Euro V and VI for four wheelers in 2020. For two-wheelers, this standard was already introduced in 2016 (GoI 2014). Furthermore, as of 2016, passenger vehicle fuel efficiency standards will be in place which should lower the carbon emissions significantly (S. Rohilla, personal communication, 1st July 2016). In the near future it is expected that the Ministry of Road Transport and Highway will make it mandatory for car manufacturers to display stickers as star ratings to indicate the fuel efficiency of the car (Economic Times, 2016). Also, until march 2016, there was a ban on the registration of diesel vehicles over 2000 cc in Delhi. This might boost eMobility as well (D. Dash, personal communication, 21st June 2016). As these measures show a positive trend towards stimulating regulation and legislation for eMobility, the precondition receives a score of +2.

44) Regulation/legislation positively influencing the introduction of eMobility regarding import = -1

There are some problems with the import of components of eMobility. According to S. Gill, director of the SMEV, the custom offices across India are forcing electric two wheeler manufacturers to pay five times the import duty on the drive motor. They claim it to be a rim and not an electric motor despite government allowing concessional import duty on electric/electronic components that have not yet been developed in India (IESA 2016). This was also confirmed by W. Van Der Vaart (personal communication 20th June 2016), who explained that the import tax is sometimes 30% while it should be between 0-6%. The precondition therefore scores negatively as the import is hindered.

45) Regulation/legislation positively influencing the introduction of eMobility regarding electricity = 0

In Delhi, the tariff is mainly determined by the Delhi Electricity Regulatory Commission. According to D. Dash (personal communication, 21nd June 2016), there is no hindering regulation regarding electricity for electric mobility. However, it could pose a problem in the future as it is not clear whom can sell and buy electricity. For example, when an actor is operating a charging station and selling electricity as a service, this could be strongly opposed by grid operators. One the one hand this stimulates them to enter the market of electric charging systems, on the other hand it can obstruct the diversity of the market (anonymous, personal communication, 2016). Furthermore, the (local) government might introduce a different tariff plan for charging electric vehicles, for example a 'time of day' tariff or a 'time of use' tariff with different prices for energy use throughout the day, to balance the demand and supply of energy (D. Dash, personal communication, 21st June 2016). The Standards and Labeling Program launched by the GoI stimulates an informed decision of consumers by providing information about the energy consumption of a certain product using electricity (GoI 2015). This could also be applied to EVs. However, as there is no regulating positively influencing eMobility, the precondition scores neutrally.

6.2.7 Creation of Legitimacy

46) The presence of active associations, action groups, companies, pressure groups and professional activists advocating eMobility and other lobbying parties = +1

There is some lobby taking place for the advancement of eMobility. In India, and especially Delhi, air pollution is the main driver for eMobility (Soediono 2012). On a local level, no actors were identified.

On a national level, also focusing on air pollution problems in Delhi, the Center for Science and Environment is a public interest research and advocacy organization (NGO) is pushing for air pollution control, including zero emission transport (Chowdhury 2015; Gokulendra, personal interiew, 2016). Furthermore, Clean Air Asia India is an international NGO based in India who focus on improving air quality. However, the relation between NGOs and government is difficult and the awareness about air pollution problems is still very low. Most of the criticism comes from the international press and embassies (W. Van der Vaart, personal communication, 20th June 2016). The two main lobby groups are the Society of Manufacturers of Electric Vehicles and the Center for Science & Environment. Also, there is pressure form the Environmental Pollution Control Authority of Delhi, the National Green Tribunal of Delhi and the Indian Pollution Control Association (S. Sharma, personal communication, 15th June 2016) for more sustainable transport, including eMobility. Therefore, the precondition scores positively.

47) The absence of active associations, action groups, companies, pressure groups and professional activists and other lobbying parties advocating against eMobility = -1

The lobby is mostly of oil industry and the incumbent companies focused on the existing automotive industry. Their resistance is very hard to overcome (H. Gokulendra, personal communication, 22nd June 2016; W. Van Der Vaart, personal communication, 20th June 2016). It therefore scores negatively.

48) (Powerful) Incumbent companies see the opportunities provided by EV = +1

Most companies are reluctant to invest in a risky and uncertain innovation while they are still making profits of ICE vehicles. Still, manufacturers are slowly developing technology related to eMobility, which is being financially supported and pushed by the government (W. Van Der Vaart, personal communication, 20th June 2016). The best example is Mahindra Reva under the Mahindra & Mahindra group, one of the main car manufacturers in India. According to S. Rohilla (personal communication, 1st July 2016), the EV market is now in traction and moving forward and has high potential for eMobility. It therefore scores positively.

49) A high level of confidence and certainty regarding the use of eMobility of the consumer = 0

On the one hand, in 2011, there were problems with consumers perception of electric vehicles with regard to charging time, driving range, battery costs, top speed and acceleration (Soediono 2012). After the launch of the national NEMMP program, consumer awareness rose BRON. According to S. Rohilla (personal communication, 1st July 2016), consumers will not really differentiate between technologies but they are quite price sensitive. No level of confidence has been identified during the case.

6.2.8 Overall score and evaluation of Delhi

With the above mentioned answers, the online questionnaire has been completed. Table 14 presents the outcomes resulting from the case.

Overall Tool	65%
Guidance of the Search	79%
Resource Mobilization	68%
Knowledge Development	75%
Knowledge Diffusion & Networks	49%
Entrepreneurial Activities	68%

Market Formation	65%
Creation of Legitimacy	43%

Table 14 Overview of the scores of the illustrative case within the GEM-tool

Delhi scores just under 66%, making it an intermediate innovation system following the definition given in section 5.1.5. This score is lower than what was expected beforehand as the case was chosen because of India's front runner status, It was therefore assumed to be a well performing innovation system. However, during the research it turned out that even though India as a nation is promoting and introducing eMobility, Delhi lags behind. The GEM-tool showed a difficult relationship between the Indian government and Delhi government and a lack of focus on eMobility (as CNG is promoted), posing barriers for eMobility in Delhi. Furthermore, a lack of a local plan for sustainable mobility and eMobility reduces the awareness of consumers, local resources and the power to get (incumbent) companies involved. The introduction of the electric bus within a new pilot project is a positive development, however it is not supported in the existing innovation system of Delhi. The GEM-tool helped to identify potential barriers, for example the existing tax on buses in Delhi which should be changed for E-buses. Furthermore, opportunities were identified as well, including a general trend towards sustainable and electric mobility in India as a whole, resulting in national Resource Mobilization, Knowledge Development and Entrepreneurial Activities which Delhi can deploy. This depends, however, in how far the local government can make use of the national trend and mobilization towards eMobility as the GEM-tool has shown some difficulties including confusion on the use of tax exemptions and the difficult relation between local and national government officials.

6.3 Evaluating the illustrative case

The illustrative case provides an excellent example of how an innovation system in its predevelopment phase (in this case Delhi) can make use of the GEM-tool to give an overview of existing barriers and opportunities (in this case through the trend towards eMobility of the Indian government), and to help to make use of existing actors, interactions, institutions and infrastructure. The GEM-tool proved to provide practical and structural guidance to gather relevant data before the start of eMobility. During the case, a literature study was performed and relevant experts were interviewed with extensive knowledge on the situation in India and in specific Delhi regarding eMobility (see Annex VI for an overview). The interviews provided valuable information to the case study and validated the found information of the literature study. The case confirmed the necessity for an independent advisor to gather, analyze and validate the various data and data sources to increase the validity of the outcomes of the case. For example, it reduces the effects of the social desirability effect, when respondents give socially desired answers (Bernard 2006), which was noted during some of the interviews but could be cross-checked using other data sources. Furthermore, the role of the advisor is important when the gathered data do not completely match with the scoring system of the GEM-tool but are still relevant for the local context. As the scoring system is used as indication, the advisor can include specific local data and decide on the final score of the precondition him or herself. Lastly, due to practical constraints, not all necessary data for the complete answer of the preconditions in the GEM-tool has been identified which affects the test of the GEM-tool. But even so, as the case was set out to be a brief application of the GEM-tool on an illustrative case, it has proven the relevance and application of the GEM-tool and contributed to the validity of the GEM-tool. As an improvement, a separate element within the scoring system could be included in the tool when no information was found.

Chapter 7 Conclusion

This research responded to the need for a more structural and successful introduction of eMobility in middle-income countries as reliable knowledge of the (performance of the) local innovation system is lacking, which is hampering the systematic introduction of eMobility in these regions. The research therefore aimed to contribute to the advancement of electric mobility in urban areas in middle-income countries by developing an ex-ante assessment tool to gain insights in the local innovation. This led to the following research question:

What should an ex-ante assessment tool encompass to contribute to the advancement of electric mobility in urban areas in middle-income countries?

To answer the main research question, three sub questions have been used as guidelines throughout the research. They focus on the design, the content and the operationalization of the tool and are briefly explained below

1) *How can the framework for the GEM-tool be developed using the technical innovation system approach guiding its design?*

The framework of the GEM-tool consists of the various components and delineation of the GEM-tool. The components were identified through a combination of the Technical Innovation System (TIS) approach and gathered data on best practices and lessons learned of frontrunner countries regarding eMobility, taking into account the context of urban areas in middle-income countries. The framework of the TIS approach includes the delineation of the innovation system, the identification of structural factors, the performance of system functions and their interactions and a functional structural-analysis, which was used as guidance for the framework of the GEM-tool. To start with , the delineation of the GEM-tool resulted in a focus on the pre-development phase of the introduction of eMobility in urban areas in middle-income countries and the aim to support the decision making process of local policy makers. Furthermore, the system functions and their dynamics, the structural factors, the scale of analysis and systematic instruments goals were included as components of the GEM-tool framework resulting from the TIS analysis. However, as the aim of this research is to design an ex-ante, practical assessment tool for eMobility, the following additional components have been included in the GEM-tool: the core component is the set of preconditions, which have been converted into questions with corresponding answer categories and scores. Furthermore, as not all preconditions are of the same importance, a weight was given to each precondition. Additionally, to give guidance in the use of the GEM-tool, and to use the identified information on eMobility in an urban context in MICs, potential answer are given as well as data collection possibilities. Lastly, an evaluation scheme of the innovation system based on the individual preconditions and the overarching system functions is applied, complemented with policy implications & recommendations. Together these components make up the framework of the GEM-tool, which have been used to gather the relevant data for the development of the GEM-tool.

2) *What does the content of the GEM-tool have to encompass with regard to its framework?*

The combination of TIS literature with the context of eMobility and urban areas in MICs led to the determination of the content of the GEM-tool, according to its previously designed framework. The content analysis resulted in 49 preconditions and their corresponding components. As it is not

feasible to present the content of the GEM-tool within this conclusion, the content is presented according to the overarching system functions.

The first system function, *Guidance of the Search*, includes preconditions related to steering the innovation within its system. It includes long term policies as well as actors influencing the guidance of this process. The focus was placed on the policies of the local government, but the willingness of the industry and consumers was included to show a part of the market system. The second system function, *Resource Mobilization,* aims towards the mobilization of financial, human and material resources. Therefore, preconditions relating to the presence of financial funds and loans, EVs and infrastructure, energy and skills and expertise have been included. As the focus lies on the predevelopment phase, the operationalization is based on the possibility for existing resources to be mobilized for eMobility. The third system function, *Knowledge Development*, includes one precondition relating to insights in the available knowledge but focuses more on the presence of actors with knowledge on eMobility. It is of importance to know beforehand which actors have a certain (potential) knowledge as this can be used as of the beginning of the introduction of eMobility. The fourth function is strongly related to the second as it concentrates on the diffusion of knowledge through (informal and formal) networks, the *Knowledge Diffusion & Networks* function. Even though specific networks related to eMobility do not exist yet, the relations between the stakeholders gives an indication on the relative ease of getting towards the collaboration essential for the development and diffusion of eMobility. The fifth system function relates to *Entrepreneurial Activities*. As it is assumed that there are no entrepreneurial activities directly relating to eMobility, the preconditions have focused on the possibility for them to come into place, looking at the presence of potential actors from the industry and a general insight in the ease of introducing an innovation and kick-starting entrepreneurial activities. The sixth system function revolves around the *Market Formation* for eMobility. As no market exist yet, factors that might be of influence on the market development have been identified. This includes existing regulation and legislation on import, energy sector and the automotive sector, as well as the presentence of subsidies and taxes. Furthermore, it includes two preconditions on the competitiveness of eMobility as the cost structure will influence its uptake. The seventh system function focuses on the *Creation of Legitimacy* for eMobility. The presence of lobby groups and the expectations of companies and consumers were taken into account, which say something about the perceived legitimacy of eMobility. Together, these overarching system functions have sketched the overarching activities needed to form a well-functioning innovation system.

3) *How can the GEM-tool be operationalized including the findings of its framework and contents?*

The GEM-tool has been operationalized according to various parts that have been identified in its framework and content. A questionnaire makes up the core of the GEM-tool. It is based on the preconditions, their related questions, answer categories and additional components (see sub question one). The questionnaire should be used by an appointed, independent advisor with expertise regarding eMobility to increase the reliability of the use of the GEM-tool. Moreover, a scoring system is included of the individual preconditions and of the overarching system functions. The preconditions receive a score of -1 (negative), 0 (neutral), +1 (positive) or +2 (excellent) and their weight depends on the amount of preconditions within the overarching system function. Filling in the questionnaire results in the individual scores of the preconditions, as well as the scores and

evaluation of the overarching system functions. The evaluation is based on the given answers to the preconditions and their corresponding weight, and uses the following classification: a score of <33% is seen as a weak system function, a score of 33-66% is seen as intermediate system function and score of >66% is seen as strong system function. The evaluation is complemented with brief policy implications & recommendations of both the individual preconditions as the overarching system functions. The same categorization is applied for the evaluation of the total innovation system, which is based on the individual preconditions and system functions. No policy implication or recommendation has been developed for the performance of the innovation system as a whole, as this is based on the performance and dynamics of the system functions and preconditions which are elaborated upon per system function. All these components and data have been build online at evconsult.nl/gem-tool. This resulted in an interactive online questionnaire, as well as a PDF including the outcomes of the GEM-tool.

Together these answers to the three sub questions form the answer to the main question and have resulted in the Green Electric Mobility (GEM-) tool. However, as it is difficult to separate the insights of the three sub questions, as briefly attempted above, nor feasible to include the content and all components and functionalities of the GEM-tool within this conclusion, the main insights in the development and use of the GEM-tool are elaborated upon below with regard to the main research question.

The development of the GEM-tool has provided insights in the essential set of preconditions for the successful introduction and diffusion of eMobility. These preconditions are based on the empirically verified theoretical framework of the TIS approach, combined with best practices and lessons learned from frontrunner countries regarding eMobility, also taking into account the context of urban areas in middle-income countries. The data have been gathered through extensive literature search as well as interviews with experts who have considerable knowledge on the fields of innovations and eMobility. This combination of data and data sources secures a solid base for the GEM-tool. Furthermore, its application leads to a structural overview of the local system with regard to preconditions, empowering local policy makers with insights essential for the structural introduction of eMobility, taking into account the desired large scale transition as of the start of the process. This enhances the chance for the uptake and diffusion of eMobility considerably.

The GEM-tool goes one step further than the indicated overview as it provides an operationalization and evaluation of the preconditions. The preconditions are specified including their scale, weight and data collection possibilities. Furthermore, the GEM-tool encompasses a questionnaire based on the identified preconditions including questions, possible answers and specific answer categories which are linked to scores ranging from – (negative), 0 (neutral), +1 (positive) to +2 (excellent). Based on the scores of the individual preconditions and their weight, the overall score per system function is calculated. This provides an unprecedented evaluation of the performance of the system functions which together make up the functioning of the local innovation system. The application of the tool therefore offers a structural method to gather, interpret and evaluate information on the local innovation system beforehand. Furthermore, it shows the barriers and opportunities that need to be overcome to strengthen the local innovation system in place.

In addition, the GEM-tool offers policy implications & policy recommendations for the individual preconditions and the system functions. The policy implications inform the local policy maker what

the score implies for the (dynamics of the) innovation system, including the identification of barriers and opportunities. This is complemented with a brief advice including the possible policy measures to improve or work with the local situation.

All the above leads to the answer of the main research question as it shows what the GEM-tool encompasses and how it may contributes to the advancement of electric mobility in urban areas in middle-income countries. It can be concluded that both the development of the GEM-tool itself as its application result in a considerable amount of new insights regarding the introduction of eMobility and the functioning of local innovation systems in urban areas in middle-income countries.

This thesis has presented the first steps towards the development of such an innovative assessment tool, as well as a more practical use of the TIS approach concentrated on the innovation system of eMobility. The GEM-tool represents a blue-print of the tool, setting up the basics for its development and functioning. As it does not represent yet the final outcome for the design of a practical tool to enhance the innovation system of eMobility in urban areas in developing countries, further research on this topic is encouraged.

Chapter 8 Discussion & Recommendations

This research presents the first steps in the design and application of the Green Electric Mobility Tool. Therefore, certain limitations may be found as well as questions asked regarding its reliability, validity and causality which will be discussed below leading to recommendations for further research.

Firstly, the reliability of the GEM-tool is completely dependent on the data that will be gathered during its application. A first sketch of the data collection has been provided, but still subjective choices will be made which can undermine the reliability of the outcome It is therefore recommended that the tool is used by an independent advisor, who will be expected to apply the tool with consideration and discretion. It furthermore structures the search process in how to obtain an overview and evaluation of the local innovation system. Furthermore, the reliability of the research for the development of the GEM-tool may be lowered due to the choices made based on the expert view of the researcher in determining what to include in the GEM-tool. These choices, however, were founded on an extensive literature search regarding the TIS approach, going back to its origins but also including recent applications and developments, and regarding the context of eMobility, analysing eMobility initiatives of more than 70 cities. Furthermore, this research was conducted in collaboration with EVConsult, which increases the expert view on the content and application of the GEM-tool. EVConsult also assisted in the choices for the expert-interviews, pointing out the most relevant and knowledgeable experts working on both an international, national and local scale. Lastly, a combination of methods and data sources has been used which enhanced the reliability of the research. Therefore, the research is still seen as reliable.

Secondly, the tool aims to provide an overview of the local innovation system by applying the GEM-tool. Therefore, what it measures to obtain the desired conclusion on the local innovation system is based on the identified preconditions and their operationalization. It can be questioned whether or not the preconditions and the corresponding questions and operationalization are valid: do they represent the right indicators to illustrate the overview and performance of the local innovation system? To develop the GEM-tool, an extensive literature study regarding the TIS approach has been performed, as well as a comprehensive analysis of reports and articles relating to the introduction and diffusion of eMobility. Furthermore, experts from the field of innovations, international development, sustainable mobility and electric mobility as well as policy makers dealing with the introduction and diffusion of eMobility, have been interviewed or asked to participate in the survey and brainstorm session for this research. Their extensive knowledge has helped to develop and validate the GEM-tool while the combination of data sources and method has helped to increase the validity of this research. Still, the validity of the GEM-tool can be improved by testing it for empirical evidence and showing the quality of measures included. This is strongly connected to the causality of the GEM-tool. It is assumed that the preconditions will lead to a better understanding of the local innovation system, which is assumed to lead to a more successful transition towards eMobility. Empirical research is, however, strongly recommended to validate and if necessary improve the causality of the GEM-tool.

Furthermore, as the tool can be seen as work in progress, there are still some improvements to be made. Firstly, it is recommended that further research is performed on the specific local context within developing countries. As this is one of the starting points of the GEM-tool, it is an essential part of the tool. Further research could enhance the embeddedness of context of developing

countries within the GEM-tool, as this proved difficult in the limited time of this research. Secondly, the scoring system could be improved by making the answer categories of the preconditions more specific. Normative and qualitative options now make up most of the operationalization, as the local context needs to be taken into account as well as the general applicability of the GEM-tool in MICs. Further research and empirical case studies can provide the necessary information to optimize the operationalization. Thirdly, further research is encouraged on the policy implications & recommendations. A first step has been made, including general policy implications & identified recommendations, but these could become more connected to the scores of the preconditions and system functions. Lastly, the remaining components, e.g. the data collection, possible answers and weight, could be made even more specific as the tool provides a first sketch of their inclusion. Nevertheless, the GEM-tool is seen as a successful first step in designing an ex-ante assessment tool for the advancement of eMobility. Other researchers are encouraged to take up its presented blueprint to improve the above mentioned limitations. This will lead to an advanced assessment tool.

Nevertheless, taking the above stated limitations and improvements into account, the GEM-tool can definitely be seen as an innovative step towards the advancement of eMobility in developing countries and is certainly worth to be taken up further.

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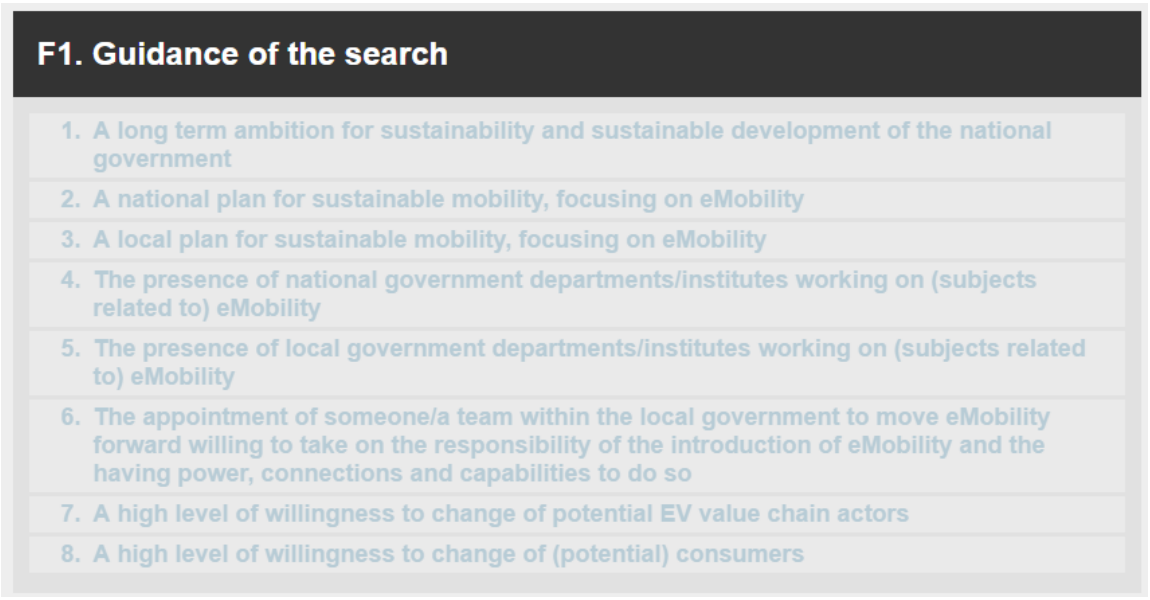
Annex I The GEM-tool

This Annex provides an overview of the outcomes of this thesis, in the form of illustrations of the online GEM-tool (Part I) and the conversion of the PDF forming the outcome of the GEM-tool (Part II) to a Word document.

Part I The online GEM-tool



2. A national plan for sustainable mobility, focusing on eMobility

Clarification precondition

A national plan for sustainable mobility can influence the local adaptation of eMobility, as the support from the national government has an impact on the execution of the ambition of the local government. The presence of a national plan shows the political willingness and the legitimacy regarding the drivers of eMobility. If there is a national plan which focuses on eMobility as the main method for sustainable mobility, this is an opportunity as this implies a level of certainty is required that eMobility will solve the issues related to the drivers of sustainable mobility and EV. If the focus lies on a different kind of vehicle (for example hydrogen powered), this can form a barrier for eMobility as resources can then be deployed for other purposes than eMobility. A national plan should include clear targets, e.g. on the numbers of (sustainable) vehicles, reduction of emissions or improvement in air quality, to steer the direction of the search and to enable monitoring & evaluation of the policy measures. Lastly, there should be a long term vision as every intervention to make the transport system more sustainable includes structural factors that take a long time to be successfully implemented.

Structural factor	Scale	Weight
Institution (presence & quality)	National	7

Question

Is there a national plan for sustainable mobility, focusing on eMobility?

Identification possible answers

The identification of a national plan for sustainable mobility which can stem from various departments, i.e. ministry of transportation, ministry of environment. It can range from a pillar in a general national plan towards sustainability to a national plan dedicated to sustainable mobility and eMobility.

Data collection

The main data source is a national plan for sustainable mobility. The ambition towards sustainable mobility can also be included in plans of general mobility or sustainable development, as long as sustainable mobility is mentioned as a pillar within the policy.

Reasoning behind scoring system

When the need for sustainable mobility is expressed through a national plan, this enhances the chances for eMobility to be taken up. For this indicator, both the interpretation of eMobility as the time frame in which sustainable mobiltiy is implemented is taken into account. As sustainable mobility is a broad concept, it does not automatically include the type of vehicles and is therefore scores positively when no vehicles are mentioned, but it is on the agenda (e.g. using avoid, shift or improve measures). If vehicles are explicitly mentioned, this can be positive (+2) when eMobility is chosen as main method or negative (-1) as another type of vehicle chosen as main method. Additionally, the time frame influences the level of certainty as a short term ambition to uncertainty for market players and policy makers (creating a risk if they want to invest, as investments are made with a long time frame in mind). This is not included in the operationalization, as the focus lies on the main method, but should be included in the identified information.

Answer

Select

- Select
- -1 : A national sustainable mobility plan focusing on other types of vehicles
- 0 : No natioanl plan expressing the ambition for sustainable mobility
- 1 : A national plan for sustainable mobility, not including eMobility as main method or with either a short term ambition or long term ambition
- 2 : A national sustainable mobility plan is in place including eMobility as main method, with a short term ambition or long term ambition

3. A local plan for sustainable mobility, focusing on eMobility

Clarification precondition

A local plan is essential for the uptake of eMobility as there has to be a clear problem description, guidelines and ambition regarding sustainable mobility focussing on the local context. The presence of a local plan shows the political willingness and the legitimacy regarding the drivers of eMobility. If there is a local plan which focuses on eMobility as the main method for sustainable mobility, this is an opportunity as this implies a level of certainty is required that eMobility will solve the issues related to the drivers of sustainable mobility and EV. If the focus lies on a different kind of vehicle (for example hydrogen powered), this can form a barrier for eMobility as resources can then be deployed for other purposes than eMobility. A local plan should include clear targets, e.g. on the numbers of (sustainable) vehicles, reduction of emissions or improvement in air quality, to steer the direction of the search and to enable monitoring & evaluation of the policy measures. Lastly, there should be a long term vision as every intervention to make the transport system more sustainable includes structural factors that take a long time to be successfully implemented.

Structural factor	Scale	Weight
Institution (presence & quality)	Local	6

Question

Is there a local plan for sustainable mobility, focusing on eMobility?

Identification possible answers

The identification of a local plan for sustainable mobility which can stem from various departments, i.e. ministry of transportation, ministry of environment. It can range from a pillar in a general local plan towards sustainability to a local plan dedicated to sustainable mobility and eMobility. However, it should go beyond purely an ambition and include an actual plan for its execution

Data collection

The main data source is a local plan for sustainable mobility. The ambition towards sustainable mobility can also be included in plans of general mobility or sustainable development, as long as sustainable mobility is mentioned as a pillar within the policy.

Reasoning behind scoring system

When the need for sustainable mobility is expressed via a local plan, this enhances the chances for eMobility to be taken up as means to solve sustainability issues regarding mobility. For this indicator, both the interpretation of eMobility as the time frame in which sustainable mobiltiy is implemented is taken into account. As sustainable mobility is a broad concept, it does not automatically include the type of vehicles and is therefore scores positively when no vehicles are mentioned, but it is on the agenda (e.g. using avoid, shift or improve measures). If vehicles are explicitly mentioned, this can be positive (+2) when eMobility is chosen as main method or negative (-1) as another type of vehicle chosen as main method. Additionally, the time frame influences the level of certainty as a short term ambition to uncertainty for market players and policy makers (creating a risk if they want to invest, as investments are made with a long time frame in mind). This is not included in the operationalization, as the focus lies on the main method, but should be included in the identified information.

Answer

Select

- Select
- -1 : A local sustainable mobility plan focusing on other types of vehicles
- 0 : No local plan expressing the ambition for sustainable mobility
- 1 : A local plan for sustainable mobility, not including eMobility as main method
- 2 : A local sustainable mobility plan is in place including eMobility as main method

4. The presence of national government departments/institutes working on (subjects related to) eMobility

Clarification precondition

It should be clear upfront which national government institutes and/or departments (depending on the national context) touch upon sustainable mobility, so that collaboration can be achieved (between national and local level) to enhance the introduction of EV. The interest of the national government in eMobility can have a large influence on the barriers and opportunities for local governments who wish to implement eMobility as this determines policies and resources to implement programs. This precondition aims to create awareness for a local policy maker on the cross sectorial characteristic of eMobility, as well as who to work with at the national government.

Structural factor	Scale	Weight
Actor (presence)	National	3

Question

Are there national government departments/institutes working on eMobility?

Identification possible answers

This answer is context specific but in general the following (kinds of) institutes and departments have been identified which can be related to eMobility: Ministry of environment, ministry of infrastructure/transport, ministry of economic affairs, ministry of energy , minstry of finance and institutes like Entrerprise Agency.

Data collection

Data sources consist of policy documents and reports regarding sustainable mobility and specifically eMobilitly, but also subjects relating to eMobility (e.g. energy eficiency, transition to renewable energy) focusing on information from national departments within the government and related institutes. This can be complemented by interviews with national government officials.

Reasoning behind scoring system

It is assumed that the more departments working towards sustainable mobility, the higher the chance of success for eMobility as it can then become embedded in the national government at various levels. The amount of three is based on the amount of potential departments/institutes identified during this research (around max five per country where identified, on average three). This resulted in a positive score of 1-2, and a high score when >3 where identified. However, this is still context specific so the numbers should be used as indication only. It is up to the researcher to decide upon the final score based on the identified information in the local context and views of interviewees.

Answer

Select

- Select
- -1 : There are national government departments/institutions that are stimulating the traditional mobility sector
- 0 : There are no national government departments/institutions that are working on sustainable mobility
- 1 : There are some (1-2) national government departments/institutions that are working on sustainable mobility or subjects related to eMobility
- 2 : There are (>3) national government departments/institutions that are working on sustainable mobility or subjects related to eMobility

5. The presence of local government departments/institutes working on (subjects related to) eMobility

Clarification precondition

It should be clear upfront which local government departments/institutes (depending on the local context) touch upon sustainable mobility, so that collaboration can be achieved (both on a local level as between national and local level) to enhance the introduction of EV. This precondition is assumed not to be met as the focus of the GEM-tool lies on the predevelopment phase of eMobility so no stakeholders within the local government exist yet that work with eMobility. However, there might be entities touching upon the subject of eMobility who should be included as of the start. It should therefore be considered as a condition which creates awareness for a local policy maker on the cross sectorial characteristics of eMobility, as well as who the stakeholders represent at the local government to work with.

Structural factor	Scale	Weight
Actor (presence)	Local	5

Question

Are there local government departments/institutes working on eMobility?

Identification possible answers

This answer is context specific but generally the following (kinds of) institutes and departments can be related to eMobility: Ministry of environment, ministry of infrastructure/transport, ministry of economic affairs, ministry of energy, ministry of finance and institutes like an Entrerprise Agency.

Data collection

Data sources consist of policy documents and reports regarding sustainable mobility and specifically eMobility, but also subjects relating to eMobility (e.g. energy eficiency, transition to renewable energy) focusing on information from local departments within the government and related institutes. This can be complemented by interviews with local government officials.

Reasoning behind scoring system

It is assumed that the precondition will not to be met, as the GEM-tool focuses on the predevelopment phase of eMobility. Therefore, the operationalization includes actors from the lcoal government touching upon subjects related to sustainable mobility or eMobility. It is assumed that the more departments working towards sustainable mobility, the higher the chance of success for eMobility as it can then become embedded in the national government at various levels. The amount of three is based on the amount of potential departments/institutes identified during this research (around max five per country where identified, on average three). This resulted in a positive score of 1-2, and a high score when >3 where identified. However, this is still context specific so the numbers should be used as indication only. It is up to the researcher to decide upon the final score based on the identified information in the local context and views of interviewees.

Answer

Select

- Select
- -1 : There are local government departments/institutes that are stimulating the traditional mobility sector
- 0 : There are no local government departments/institutes that are working on sustainable mobility
- 1 : There are some (1-2) local government departments/institutes that are working on sustainable mobility or subjects related to eMobility
- 2 : There are (>3) local government departments/institutes that are working on sustainable mobility or subjects related to eMobility

6. The appointment of someone/a team within the local government to move eMobility forward willing to take on the responsibility of the introduction of eMobility and the having power, connections and capabilities to do so

Clarification precondition

Of the total amount of identified departments on a local level, key actors/a team within a department should be in place which functions as driving force behind the introduction of eMobility. This person or team should have the right capabilities, network and power relations to do so. The clear appointment of tasks and responsibilities can help to enhance the eMobility implementation.

Structural factor	Scale	Weight
Actor (presence & capability)	Local	4

Question

Is there someone/a team within the local government driving the innovation who has the right connections and power to make this happen?

Identification possible answers

Identify the main person or team who is the driving force behind eMobility.This person/team can be located at different places within the government departments/institutes.

Data collection

Data sources consist of policy documents and reports regarding sustainable mobility and specifically eMobility, to identify the actor(s), complemented with interview with actors from the local government who can elaborate upon the capabilities and power of the identified actor(s).

Reasoning behind scoring system

Partly objective (presence of actors) and partly subjective (the capability, power and connections of these actors). Due to time constraints of the implementation of the tool, it is not desirable to map the complete set of connections, power and capabilities of identified actors. Therefore, the answer is depdentent on the views of key actors within the local government whose answers make up the eventual score (as decided by the researcher in consultation with the key actors). It is up to the researcher to decide upon the final score based on the identified information in the local context and in consultation with they identified key actors.

Answer

Select

- Select
- -1 : There is a person/team driving explicitly driving traditional mobility
- 0 : It is not clear who has the responsibility of the introduction of EV
- 1 : Someone/a team has been appointed without the right capabilities, connections or power to set things in motion
- 2 : Someone/a team has been appointed with the right capabilities, connections and power to set eMobility in motion

7. A high level of willingness to change of potential EV value chain actors

Clarification precondition

It is essential that potential EV value chain actors are willing to change their behavior and see the opportunities eMobility can provide. When incumbent countries and/or potential new EV-players have expressed their willingness to get involved in the sustainable mobility, this positively influences eMobility. However, when they are reluctent to get involved, this poses a large barrier. The precondition focuses on all actors from the potential EV value chain (energy, ICT, automotive sectors) as all three are essential for the diffusion of eMobility. The will be mentioned in more detail and divided per sector in other system functions.

Structural factor	Scale	Weight
Institution (presence & quality)	National	2

Question

Are potential EV value chain actors willing to change their behavior?

Identification possible answers

The answer is baed on partly objective (examples/ambition towards sustainable mobility) and partly subjective (general trend as it is not possible to ask all potential market players) data. It also includes the expectations of actors of the impact of eMobility on the set targets and drivers of EV.

Data collection

Interviews with potential EV value chain actors will be the main data source as willingness is hard to measure willingness from objective information. However, as a starting point, documents can be used in which states interests, ambitions etc. regarding sustainable mobility (or eMobility) are expressed.

Reasoning behind scoring system

It is not feasible to score the willingness of actors based on specific levels of willingness. Furthermore, the question is too context specific to say anything about optimal numbers of market actors needed for the optimal diffusion of eMobility. The operationalization of the precondition is therefore kept general. It is assumed that potential EV value chain actors are not aware about the possibilities of eMobility, they will not be open. This criterion is therefore left out of the scoring system. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : The potential EV value chain actors are aware but not open for eMobility
- 0 : The potential EV value chain actors are not aware of the opportunities of eMobility and therefore not open
- 1 : Some of the potential EV value chain actors are aware and open for eMobility
- 2 : Most of the potential EV value chain actors are aware and open for eMobility

8. A high level of willingness to change of (potential) consumers

Clarification precondition

It is of importance that potential consumers of eMobility are willing to change their behavior and see the opportunities eMobility can provide. Insight in the attitude of consumers can provide a starting-point for the introduction, as it gives local policy makers an understanding of the incentives necessary to influence the willingness of consumers. It can also provide information on the willingness of a specific consumer group.

Structural factor	Scale	Weight
Institution (presence & quality)	Local	1

Question

Are potential consumers of eMobility willing to change their behavior?

Identification possible answers

The answer is in some part objective (examples/ambition towards sustainable mobility) and partly subjective (general trend as it is not possible to ask all potential consumers). It also includes the expectations of actors regarding the (dis)advantages for them of eMobility.

Data collection

Several options:

- Short survey among various potential customers (in this case the operationalization should be made more specific)

- Interviews with overarching consumer organisations (focussing on sustainable mobility)

- Learn from other similar introduced innovations (relating automotive industry)

Reasoning behind scoring system

It is not feasible to score the willingness of actors based on specific levels of willingness. Furthermore, the question is too context specific to say anything about optimal numbers of consumers or consumer groups that should be in favor of eMobility. The operationalization is therefore kept general. It is assumed that potential EV value chain actors are not aware about the possibilities of eMobility, they will not be open. This criterion is therefore left out of the scoring system.

Answer

Select

Select
-1 : Consumers are aware but not in favor of eMobility
0 : Consumers are not aware and not open for eMobility
1 : Consumers are not aware of the opportunities of eMobility and therefore not open
2 : Consumers are aware and in facor for eMobility

F2. Resource mobilization (financial, human & material)

9. The presence of international funding which can be deployed in the local context
10. The presence of national financial resources for the development and diffusion of eMobility
11. The possibility of a loan for eMobility
12. A high level of awareness amongst potential EV value chain actors about the potential financial resources (if present)
13. Insight in the different modes of transport used in the urban region
14. The availability of suitable electric vehicles and charging points
15. The availability of complementary technology
16. The presence of consistent energy supply (strength and stability of the grid) needed for eMobility
17. The presence of renewable sources for the energy supply needed for eMobility
18. A supporting geographical and climatological environment for eMobility
19. The presence of experts with knowledge, capabilities and skills relating to eMobility

9. The presence of international funding which can be deployed in the local context

Clarification precondition

International institutes such as the World Bank often have funds available which can be claimed by local governments. These funds can also stem from (international) market players. The precondition aims to raise awareness of potential funds which can be claimed for deployment in the local context. It should be noted however, that this should only be part of the total financial scheme to maintain independency, ownership and security of money flows.

Structural factor	Scale	Weight
Infrastructure (presence)	International	6

Question

Are there international funds available for the introduction of eMobility which can be applied to the local context?

Identification possible answers

International funding can stem from institutions like the World Bank, IMF, GEF, the Rockefeller Foundation, Activity fund of the EU (Civitas), IA-HEV project funding, Ford Foundation, Volvo Research and Educational Foundations and other projects regarding sustainable mobility. It should however be narrowed down to funds that connect specifically to the driver/project of eMobility and the local context.

Data collection

An online search and interviews with the most apparent potential actors regarding funding for sustainable mobility.

Reasoning behind scoring system

Having a choice in financial donor gives the city some room for manoeuvre. Local decision makers can either choose the best fit or apply for the various funds thereby spreading their chances. This is therefore scored higher than having just one potential financial donor. A negative score does not apply to this precondition, as international funds for traditional mobility or fuels are abundantly present and too broad to be taken into account.

Answer

Select

- Select
- -1 : N.A.
- 0 : There are no identified international programs or funds
- 1 : There is one potential international financing program or funds potentially available for the local context
- 2 : There are >1 potential international financing programs or funds potentially available for the local context

10. The presence of national financial resources for the development and diffusion of eMobility

Clarification precondition

This precondition focuses on the identification of (potential) financial resources which could stimulate (funds for eMobility or sustainable mobility) or hinder (funds for ICE vehicles) the development and diffusion of eMobility. Insight in the financial resources helps to identify potential barriers and opportunities regarding financing of eMobility, which helps the local policy makers to get an overview of the prevailing situation and potential policy measures.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	11

Question

Are there financial funds that influence the development and diffusion eMobility?

Identification possible answers

These funds can stem various sources, i.e. from the national and local government, the automotive indusdy, R&D funds etc. The focus is placed on the availability of public funds, as it is assumed (and based on theoretical insights) that these will especially important in the pre-development phase of the innovation. Examples of financial resources that could stimulate eMobility include funds for air quality, sustainable mobility, technological innovations, venture capital. Examples of financial resources that could hinder eMobility include funds for ICE vehicles, deployment of polluting transport etc.

Data collection

The main data sources are reports and policy documents on funding (and programs). This can be complemented with interviews with various local (and national) governments officials, who have an overview of fundings (stemming from different departments) which can influence eMobility.

Reasoning behind scoring system

When there are funds for traditional transport, this has a negative influence on the diffusion of eMobility (as the wedge between eMobility and traditional transport gets even bigger) and therefore gets a score of -1. Furthermore, it indicates that the general (financial) trend and mind-set is not suitable for eMobility. A score of +1 is given when there is a fund for eMobility in place. When there are more stimulating funds that can be deployed for EV, this raises the chances of uptake of eMobility and indicates a broad inclusion of actively involved stakeholders.

Answer

Select

- Select
- -1 : There are (more) funds for traditional vehicles
- 0 : There are no funds for eMobility
- 1 : There is one fund for (subjects related to) eMobility
- 2 : There are >1 funds which can be used for (subjects related to) eMobility

11. The possibility of a loan for eMobility

Clarification precondition

Investments in the transition towards eMobility is essential for its development and diffusion. Loans are therefore needed to make these investments possible. If it is very difficult for a company to loan money for an investment, this could hamper the uptake of eMobility and indicates other necessary sources of financial resources (e.g. funding, venture capital).

Structural factor	Scale	Weight
Infrastructure (presence & quality)	National & Local	3

Question

Is it possible to get a loan for an innovation such as eMobility?

Identification possible answers

The answer depends of course on the business case and means of the company that applied for a loan. Still, a general overview can be given looking at other loans regarding innovations and the general trend and ease regarding loans.

Data collection

Interviews with actors who have and haven't received a loan for a new technological innovation & interview with banks, complemented with financial reports.

Reasoning behind scoring system

It is not feasible to identify the height of a loan for eMobility as this is context specific. Therefore, the score is based on the general ease of receiving a loan (yes/no) for a new innovation. As it is not possible to support this question with specific financial figures, examples will be used as base for the scoring of the precondition, complemented with interviews. A negative score does not apply to this precondition, as the absence of a loan is scored neutral (consistent with the applied scoring system of this tool). It is up to the researcher to to differ between the possible scores and decide on the final score, based on (subjective) answers on the ease of getting a loan and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : N.A.
- 0 : It is very difficult or impossible to get a loan for a new technical innovation
- 1 : It is possible to get a loan for a new technical innovation such as eMobility
- 2 : It is relatively easy to get a loan for a new technical innovation such as eMobility

12. A high level of awareness amongst potential EV value chain actors about the potential financial resources (if present)

Clarification precondition

There should be a level of awareness and communication about the potential funds that can be used for the development and diffusion of eMobility. When there are funds (made) available without key actors knowing about it, this could hinder the uptake of eMobility. As it is assumed that R&D funding within companies is known at company level, the focus lies on public (R&D) funds which can be used by EV value chain actors.

Structural factor	Scale	Weight
Institution (presence & quality)	National & Local	7

Question

Are key actors generally aware of the financial resources present for the stimulation of eMobility?

Identification possible answers

The answers will consist of statements from key actors within the potential EV-value chain regarding potential financial resources, which can be compared with answers stemming from the government about the actual available financial resources.

Data collection

Interviews with key stakeholders from the potential EV-value chain will make up the main sources and can be complemented with reports and policy documents regarding programs including financial funds.

Reasoning behind scoring system

It is not feasible to measure the qualitative outcomes regarding awareness in this tool. Therefore, key stakeholders will be asked about their awareness and based on these answers and the existing resources, the researcher will determine the score (taking into account the score key stakeholders ascribe to the precondition). The level of awareness can score negatively when people are not aware about the potential funds and have a general negative attitude (not based on information but on speculation). This precondition is not relevant when there are no identified funds for eMobility (and eMobility related subjects). It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There is a negative attitude towards the lack of resources for eMobility
- 0 : There is no awareness of the potential resources for eMobility at the potential market players
- 1 : There is some awareness of the potential resources for eMobility at the potential market players
- 2 : There is significant awareness of the potential resources for eMobility at the potential market players

13. Insight in the different modes of transport used in the urban region

Clarification precondition

Insight in the use of various transportation modes can show where eMobility can have the largest impact and what can form a starting point for the introduction of eMobility. Furthermore, it shows which electric vehicles might be most suitable for the local context.

Structural factor	Scale	Weight
Infrastructure (presence)	Local	1

Question

What is the share of the different modes of transport in the urban area under study?

Identification possible answers

Different modes of transport which are taken into account in the GEM-tool are: private motorized vehicles (cars, two and three-wheelers), shared private motorized vehicles (taxi's), public transport (buses) and non-motorized transport (bicycles).

Data collection

The main data source for this precondition are reports on transport and mobility in the local region (including statistics).

Reasoning behind scoring system

This preconditoin aims to give insights to the local context regarding transportation. It is therefore not scored according to the barrier or opportunities for eMobility, but is scored with regards to the modes of transport and its impact on the environment. It is linked, when possible, to the opportunities for eMobility. It should therefore be noted that the operationalization should be used as indication only as it does not include an operationalization of the kind of vehicles nor does it provide an inclusive picture of the local settings. This can be included in the data identified but cannot be scored accordingly.

(Shared) private motorized vehicles score negatively as they have a negative environmental impact and are assumed to be most difficult to convert to eMobility in the short term as it needs a change of individual mindsets and behaviors. Furthermore, in MICs, public transport generally takes up a large share of mobility as personal vehicle ownership is low. Therefore, when this can be converted to eMobility, it can more quickly contribute to set targets and therefore scores positively. Furthermore, a high share of non motorized transport is scored high (+2) as this has a low impact on the environment.

Answer

Select

- Select
- -1 : Private motorized vehicles
- 0 : Shared private motorized vehicles
- 1 : Public transport
- 2 : (Private) non-motorized transport

14. The availability of suitable electric vehicles and charging points

Clarification precondition

It is essential for the introduction of eMobility to have electric vehicles available, either through import, assemling or manufacturing of new vehicles or the conversion of traditional vehicles. When there is no large automotive manufacturing sector, there is a larger chance that components of EVs have to be imported or the industry needs to be developed. This implies the need for new knowledge, resources and new businesses. The local government should anticipate on this. The same goes for charging points: it is assumed that there are no charging points before the introduction of eMobility, but the deployment of EVs goes hand in hand with the deployment of charging infrastructure and should therefore be included from the start. Other regions might have EVs or charging infrastructure, or research institutes might be working on eMobility advancement which can result in a supply of material resources. Therefore, the relating question and operationalization focus on a supply of EVs in the country as a whole.

Structural factor	Scale	Weight
Infrastructure (presence)	National	10

Question

Is there already a supply of EVs or charging points (in the country)?

Identification possible answers

The answers can be deducted from the presence of pilot programs using EVs , export (nationwide) indicating manufacturing or import (nationwide) indication the supply of vehicles and charging points.

Data collection

Documents regarding projects, programs, plans etc. on the introduction/presence of eMobility can be used and complemented by interviews with key actors of the national government and potential EV value chain actors.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists. Therefore, the precondition is scored based on a yes/no answer, therefore not taking into account a negative score as this is not applicable. The precondition scores positively when there are some EVs in place for example prototypes or used as pilot projects. It scores +2 when there is a structural supply of electric vehicles already in place (for example in other regions). It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information.

Answer

Select

- Select
- -1 : N.A.
- 0 : There is no supply of electric vehicles in the country
- 1 : There is some supply of electric vehicles in the country (prototype/pilot vehicles)
- 2 : There is a supply of electric vehicles in the country

15. The availability of complementary technology

Clarification precondition

When there is complementary technology in place, this can support the introduction of eMobility and is therefore seen as an opportunity. However, if there is already competing technology in place regarding sustainable mobility, this can hamper its introduction as this leads to a lack of focus on eMobility and therefore to less resources.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	4

Question

Is there complementary technology present?

Identification possible answers

Possible answers regarding complementary technology include: battery technology, charging possibilities, smart grid technology etc. Other technologies that could compete with eMobility include hydrogen vehicles, (cleaner) ICE vehicles, CNG vehicles and biofuel based vehicles.

Data collection

Documents regarding projects, programs, plans etc. on the introduction/presence of technology (innovation) and mobility, complemented by interviews with potential EV value chain actors.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists. Therefore, it was chosen to be based on a yes/no construction. Competing technologies such as CNG vehicles, biofuel vehicles, hydrogen vehicles, have a negative influence on the deployment of EVs and therefore score negatively. On the other hand, complementing technology can stimulate the deployment of EVs (as the knowledge & materials are already present which are needed for EVs e.g. batteries suitable for EVs) and scores positively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There is competing technology present
- 0 : There is no complementary technology present
- 1 : There is complementary technology present
- 2 : There are various complementary technologies present

16. The presence of consistent energy supply (strength and stability of the grid) needed for eMobility

Clarification precondition

There should be a consistent, accessible and stable energy supply, preferably on a grid which can be used small scale. Furthermore, it should be prevented that eMobility will use electricity needed for other purposes (with a higher priority). Insights in the energy grid are therefore of high importance before the implementation of eMobility.

Structural factor	Scale	Weight
Infrastructure (presence & quality)	National & Local	9

Question

Is the electricity grid suitable for the uptake of EV?

Identification possible answers

The answer will include i.e. the number of blackouts and power cuts, the amount of sources of energy which can be deployed and the variation in energy supply over the region.

Data collection

(Policy) documents, reports and statistics about energy in the local region.

Reasoning behind scoring system

It is not possible to quantify the right amount and consistency of energy as this is dependent on the local context. The precondition are therefore scored with information about the local context regarding energy. As eMobility has not been deployed yet, no information can be provided about the influence of eMobility in the electricity grid. This is dependent on the kind of vehicles and the intensity of use. As eMobility will not require significant increases in electrical infrastructure in the beginning of their deployment, it is assumed that it will not form a problem in the beginning (based on frontrunners experiences) but should be taken into account in the long term and local context.

Answer

Select

- Select
- -1 : N.A.
- 0 : There is no consistent energy supply
- 1 : There is a consistent energy supply in some parts of the region
- 2 : There is consistent energy supply without EV

17. The presence of renewable sources for the energy supply needed for eMobility

Clarification precondition

The importance of renewable energy sources is dependent on the driver for eMobility and the current energy source in place. It is important for the long term planning of eMobility that in the long run renewable energy will be used for eMobility as this contributes to a more sustainable future and forms one of the main drivers for EV.

Structural factor	Scale	Weight
Infrastructure (presence & quality)	Local	2

Question

Is there a supply of renewable energy?

Identification possible answers

Renewable energy consists of: hydro and ocean power, bioenergy, nuclear, geothermal power, solar power and wind power.

Data collection

(Policy) documents, reports and statistics about energy in the local region, complemented by online data of the CDP (carbon disclosure project - see https://data.cdp.net/Cities/2015-Cities-Electricity-Mix-Map/kwjr-j78z).

Reasoning behind scoring system

Municipalities and cities around the world have set targets for renewable energy supply. Furthermore, a lot of MIC's use renewable energy by default (especially hydrogen). A rate of >30% was chosen as high score for MICs. This percentage is based on CDP, the Carbon Disclosure Project, which keeps track of the energy sources of more than 300 countries worldwide. As it focuses mostly on the biggest cities within the countries, which are assumed to form the same countries in which eMobility will be stimulated, its data is used as indication. In 2015, Asian cities scored 15%, cities in Latin-America 79% and Africa was not measured. However, they take nuclear energy into account as clean energy source. This is not included as sustainable energy for the GEM-tool. Therefore, a rough estimate is made based on the available data coming to 30% on average. As MICs in Africa and Asia still have a long way to go, and not all cities were included, 30% was taken as high score.

Answer

Select

- Select
- -1 : N.A.
- 0 : There is no renewable energy supply
- 1 : There is between 1 - 30 % renewable energy supply of total energy supply in the local region
- 2 : There is >30% renewable energy supply of total energy supply in the local region

18. A supporting geographical and climatological environment for eMobility

Clarification precondition

The performance and range of electric vehicles is dependent on distances, altitude differences and temperature. The temperature and altitude differences decrease the range of the electric vehicle. The distance should also be taken into account. Even though the focus lies on an urban environment, the distance influences the methhods used for charging and the time in between charging moments.

Structural factor	Scale	Weight
Infrastructure (presence)	Local	5

Question

What are the geographical and climatological circumstances in which eMobility is implemented?

Identification possible answers

The temperature, altitude and distance performance differs per vehicle and per battery. Therefore, no optimum has been identified. The answer is subjective. Very cold or very high temperature decrease the range of the vehicle. Furthermore, altitude differences also shorten the range of the electric vehicle. Short distances are seen as more suitable for electric vehicles.

Data collection

Reports on climate and weather circumstances in the local region. Geographical maps showing the altitude differences and distances.

Reasoning behind scoring system

As no optimal temperatures, altitudes or distances where identified during the research, the answer and the operationalization are based on subjective answers supported with (as much as possible) objective information on geography and climatology/weather statistics. The precondition scores negatively when there are very cold or high temperatures, altitude differences and long distances. It scores neutral when there are both hindering as supporting conditions. It scores positively when there are supporting conditions. This means average temperatures, a plain area and short distances. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information.

Answer

Select

- Select
- -1 : A hindering environment for eMobility
- 0 : Not a supporting neither a hindering environment for eMobility
- 1 : A supporting environment for eMobility
- 2 : An excellent environment for eMobility

19. The presence of experts with knowledge, capabilities and skills relating to eMobility

Clarification precondition

Insight in the knowledge and skills present in the country can help local policy makers to work together with the right actors during the development and diffusion of eMobility. This precondition is strongly linked to the system function knowledge development, but has been included separately as it shows the skills and capabilities of local actors which might not be identified. Furthermore, the focus of this precondition lies on the diffusion of eMobility and practical skills and knowledge on how to do so (e.g. installing and maintaining charging points).

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	8

Question

Can experts regarding (the diffusion of) eMobility be identified?

Identification possible answers

Possible answers include experts stemming from the automotive sector, energy sector and ICT sector, officials of the national/local government (i.e. when the energy sector is not privatized) and consultants/advisors. As this tool will be applied in advance, the expectation is that there is no or very limited knowledge/skills relating to eMobility. It can be helpful however to identify experts who have knowledge about subjects relating to eMobility such as sustainable mobility, battery technology, energy supply, ICT solutions for monitoring & evaluating transport etc.

Data collection

Documents regarding projects, programs, plans etc. on the introduction and presence of eMobility (and related subjects), complemented by interviews with potential EV value chain actors, consultants working on subjects related to eMobility and local government officials.

Reasoning behind scoring system

No right amount of experts was identified as optimal for the uptake of eMobility. Furthermore, this is very context specific. The operationalization of the precondition is therefore based on the general presence of experts (yes/no) relating to eMobility or having knowledge about EV. A negative score for this precondition is not possible, as knowledge on traditional mobility can still support eMobility. For example, knowledge about the existing infrastructure, routes and distances, safety requirements etc. can help eMobility.

Answer

Select

- Select
- -1 : N.A.
- 0 : There are no experts in the country that have knowledge, capabilities and/or skills regarding subjects touching upon eMobility
- 1 : There are experts in the country that have knowledge, capabilities and/or skills regarding subjects touching upon eMobility
- 2 : There are experts in the country that have knowledge, capabilities and/or skills directly relating to eMobility

F3. Knowledge development

20. Insights in the existing knowledge about eMobility
21. The presence of R&D institutes performing research on eMobility
22. The presence of actors from the potential EV value chain stemming from the automotive industry with knowledge about eMobility
23. The presence of actors from the potential EV value chain stemming from the ICT sector with knowledge related to eMobility
24. The presence of actors from the potential EV value chain stemming from the energy sector with knowledge related to eMobility

20. Insights in the existing knowledge about eMobility

Clarification precondition

Insight in the amount of eMobility related knowledge already present in the country shows the starting point of the eMobility implementation. National knowledge could potentially be converted or directly applied to a local scale. When there already is some knowledge about eMobility, this should be known in advance by the local policy makers to prevent double work and to make optimal use of the knowledge present. This is also a start of the identification of potential key actors. This precondition relates strongly to the other preconditions of the knowledge development function but is focused on the infrastructure (knowledge) as structural factor and has a focus on the knowledge produced in the country or local region itself.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	4

Question

Are there relevant R&D programs/projects in the country itself focussing on (subjects related to) eMobility?

Identification possible answers

The presence of knowledge can be measured by the presence of R&D projects and R&D programs. As knowledge on eMobility is assumed to be scarce, related subjects such as battery technology, smart grids, energy supply, sustainable mobility and IT relating to energy/transport sector are also taken into account. Projects and research programs can stem from the (national and local) government, research institutes, and sector specific actors stemming from the automotive sector, the energy sector and the battery sector.

Data collection

The main sources of knowledge are the reports related to R&D programs and projects (including pilots). This can be complemented with interviews with R&D institutes and the local government on their take on existing knowledge.

Reasoning behind scoring system

If the focus of R&D programs lies upon competing technologies, this poses a barrier for eMobility and is therefore scored negatively. This is also the case when R&D outcomes show negative elements of eMobility. When there is no knowledge about or related to eMobility, this forms a potential barrier as knowledge then needs to be imported and/or developed (0). If there is already a level of knowledge about related subjects this can be used when starting with eMobility (+1). If there already is some knowledge on eMobility, this can be used to further develop and diffuse eMobility (+2).

Answer

Select

- Select
- -1 : There are R&D programs/projects focussing on competing technologies/the research shows negative outcomes regarding eMobility
- 0 : There are no R&D programs/projects that touch upon EV
- 1 : There are R&D programs/projects focussing on subjects touching upon eMobility
- 2 : There are R&D programs/projects focussing on eMobility specifically

21. The presence of R&D institutes performing research on eMobility

Clarification precondition

R&D institutes developing knowledge regarding mobility can enhance (also incorporating eMobility/sustainable mobility) or hinder (focusing on competing innovations or traditional mobility) the development of eMobility. It is important to know which R&D institutes already have knowledge and experts with skills regarding eMobility. These R&D institutes can perform research on eMobility development diffusion, monitoring & evaluation in the future and should be partnered with local policy makers from the start.

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	1

Question

Are there research institutes performing research on eMobility?

Identification possible answers

Potential R&D institutes which could develop knowledge about eMobility are universities, knowledge institutes, non-profit organizations and governmental institutions.

Data collection

Websites of research institutes, reports and articles to identify R&D projects and pilots, complemented by interviews with key actors of R&D institutes.

Reasoning behind scoring system

It is not feasible to say anything specific about the optimal number of research institutes, as it depends on the projects and programs they have. The operationalization is therefore kept general. As it is assumed that there is no or a low level of institutes performing research on eMobility, other subjects touching upon eMobility are taken into account in the scoring system, such as battery technology, energy systems, sustainable mobility, ICT solutions for the transport or energy sector etc. The presence of knowledge on these subjects is scored positively.

Answer

Select

- Select
- -1 : There are R&D institutes performing research on competing technologies / the research is negative regarding eMobility
- 0 : There are no R&D institutes performing research on sustainable mobility
- 1 : There are R&D institutes performing research on subjects touching upon eMobility
- 2 : There are R&D institutes performing research on eMobility

22. The presence of actors from the potential EV value chain stemming from the automotive industry with knowledge about eMobility

Clarification precondition

This precondition refers to (international) companies which are already working with eMobility, for example in other countries or regions. This can form an opportunity for eMobility, as they will already have a form of knowledge about eMobility.

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	3

Question

Are there potential EV value chain actors stemming from the automotive sector present that have knowledge about eMobility?

Identification possible answers

This precondition includes actors who are working on eMobility stemming from the automotive industry. It can for example be an international vehicle manufacturer with an establishment in the country with other establishments already working with eMobility or another actor from the EV value chain with establishments in the country which can be used in the local area.

Data collection

Interviews with key stakeholders from the potential EV value chain of the automotive sector, includingproducers of raw materials, producers of components & power techniques, vehicle manufacturers, assemblers & converters, vehicle importers & dealers. Complemented with (annual) reports about sustainable mobility ambitions from these actors.

Reasoning behind scoring system

The optimal number of actors is not used in the operationalization as this is context specific and was not identified in the literature. A negative score is not taken into account as it is presumed that there is no negative knowledge as in this case knowledge on traditional mobility can help to set up eMobility as well (e.g. through knowledge on safety requirements, usage of vehicles). It is up to the researcher to differ between the possible scores and the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : N.A.
- 0 : There are a no actors present which have knowledge about eMobility
- 1 : There are some actors present which have knowledge about eMobility
- 2 : There are actors present which have knowledge about eMobility

23. The presence of actors from the potential EV value chain stemming from the ICT sector with knowledge related to eMobility

Clarification precondition

When implementing eMobility, having the automotive industry on board is not enough as eMobility links various technological fields. Potential actors who could play a role in the development and diffusion of eMobility stemming from other sectors should be identified. It is therefore important to have insight in knowledge of potential EV value chain actors not yet related to the (sustainable) automotive industry, focusing on ICT companies working with transport and/or energy and their knowledge about eMobility.

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	2

Question

Are there actors from the potential EV value chain stemming from the ICT sector present that have knowledge related to eMobility?

Identification possible answers

Actors who are working in the ICT sector, focusing on technology related to energy and mobility for example monitoring of routes of buses or an intelligent transport system within vehicles.

Data collection

Interviews with key stakeholders from the potential EV value chain stemming from the ICT sector, complemented by reports of the ICT sector on innovation relating to energy and mobility.

Reasoning behind scoring system

The optimal number of actors is not used in the operationalization as this is context specific and was not identified in the literature. A negative score is not taken into account as it is presumed that there is no negative knowledge as in this case knowledge on traditional mobility can help to set up eMobility as well. It is up to the researcher to differ between the possible scores and the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : N.A.
- 0 : There are a no actors present which have knowledge about eMobility
- 1 : There are some actors present which have knowledge about eMobility
- 2 : There are actors present which have knowledge about eMobility

24. The presence of actors from the potential EV value chain stemming from the energy sector with knowledge related to eMobility

Clarification precondition

When implementing eMobility, having the automotive industry on board is not enough as eMobility links various technological fields. Potential actors who could play a role in the development and diffusion of eMobility should be identified. It is therefore important to have insight in knowledge of potential EV value chain actors not yet related to the (sustainable) automotive industry, such as battery producers, energy producers and their knowledge about eMobility.

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	2

Question

Are there actors from the potential EV value chain stemming from the energy sector present that have knowledge related to eMobility?

Identification possible answers

Actors from the energy sector can be energy producing, (component) supplying, distributing (operation & maintenance) and installation actors.

Data collection

Interviews with key stakeholders from the potential EV value chain stemming from the energy sector. Complemented with (annual) reports about sustainable mobility ambitions from these actors.

Reasoning behind scoring system

The optimal number of actors is not used in the operationalization as this is context specific and was not identified in the literature. A negative score is not taken into account as it is presumed that there is no negative knowledge as in this case knowledge on traditional mobility can help to set up eMobility as well. It is up to the researcher to differ between the possible scores and the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

Select
-1 : N.A.
0 : There are a no actors present which have knowledge about eMobility
1 : There are some actors present which have knowledge about eMobility
2 : There are actors present which have knowledge about eMobility

F4. Knowledge diffusion and networks

25. Knowledge exchange regarding eMobility
26. Access to generated knowledge on eMobility
27. Collaboration between potential EV value chain actors
28. Collaboration between potential EV value chain actors and the local government
29. Collaboration between potential EV value chain actors and R&D institutes
30. Collaboration between the local government and R&D institutes
31. Collaboration between local governmental departments regarding eMobility
32. Collaboration between local and national government departments regarding eMobility

25. Knowledge exchange regarding eMobility

Clarification precondition

The knowledge that is developed as of the predevelopment phase should be communicated to and accessible for all relevant stakeholders. Events, conferences, platforms, meetings etc. can facilitate this exchange of knowledge. eMobility can make use of existing platforms or created platforms. The exchange of knowledge can take place between all actors from the EV value chain, (local and national) government officials and R&D institutes. Knowledge can stem from all levels but should spread to the local level.

Structural factor	Scale	Weight
Interaction (presence)	Local, national & international	1

Question

Do workshops, conferences, platforms and other events revolving around knowledge exchange regarding eMobility exist?

Identification possible answers

It can be both local, national as international (e.g. EVI, IA-HEV initiatives, ZEV-alliance) and can include workshops, meeting, conferences, events but also online activities such as platforms and fora.

Data collection

Interviews with key stakeholders from the potential EV-value chain, R&D institutes and local government as these are assumed to generate knowledge, in combination with a web based search on the events, conferences, platforms etc. in which knowledge exchange is facilitated.

Reasoning behind scoring system

Knowledge exchange regarding eMobility is assumed to be low as the focus of the tool lies on the predevelopment phase of eMobility. Therefore, other initiatives which can take up eMobility are taken into account as well. When there are knowledge exchange platforms from the beginning, eMobility has a higher chance to be adopted as knowledge exchange is made easier. It is not possible to score negatively as all knowledge exchange (even on traditional mobility) is seen as positive as it paves the way for knowledge exchange regarding eMobility (for example first as side event and becoming more important). It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : N.A.
- 0 : There are no knowledge exchange possibilities for eMobility
- 1 : There are some existing knowledge exchange options which could take up eMobility
- 2 : There are knowledge exchange possibilities focused on eMobility

26. Access to generated knowledge on eMobility

Clarification precondition

The generated knowledge and data should be accessible for knowledge diffusion to take place. If there is identified knowledge but this is in the hands of one or a few actors (government, automotive business), this does not contribute to the diffusion of knowledge of eMobility.

Structural factor	Scale	Weight
Infrastructure (presence)	Local, national & international	3

Question

Is the knowledge that is being generated on (subjects related to) eMobility open access knowledge?

Identification possible answers

Identification of knowledge being shared or being withheld from other stakeholders. The latter category will be difficult to trace, but can be addressed during interviews.

Data collection

Interviews with key stakeholders from the potential EV-value chain, R&D institutes and local government as these are assumed to generate knowledge.

Reasoning behind scoring system

Most likely, it will proof to be a challenge to find out which knowledge is not open access. The answer therefore will be mostly based on statements from key actors about sharing generated knowledge. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : N.A.
- 0 : There is no knowledge being shared regarding eMobility as it is not open access information
- 1 : Knowledge sharing regarding eMobility partly takes place as some information is open access
- 2 : Knowledge sharing regarding eMobility takes place as it is accessible to all

27. Collaboration between potential EV value chain actors

Clarification precondition

Within the EV value chain, there should be a high level of collaboration as it is an innovative product linking three sectors (automotive, ICT and energy). Existing linkages between potential EV value chain actors might facilitate more and easier knowledge exchange and are therefore relevent to identify in advance.

Structural factor	Scale	Weight
Interaction (presence)	National & Local	6

Question

Is there some form of collaboration between potential EV value chain actors?

Identification possible answers

The answer is partly subjective, based on the evaluation of collaboration of key actors, and partly objective, supported by documents about projects, events, collaboration efforts (alliances) etc.

Data collection

Interviews with identified potential EV value chain actors, complemented by reports on mobility and innovations linking to the automotive sector, energy sector and ICT sector within the country.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. Negative experiences are included as well in the operationalization as this can hamper further collaboration on eMobility. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There have been negative experiences with collaboration between potential EV value chain actors
- 0 : There is no form of collaboration between potential EV value chain actors
- 1 : There is some collaboration between potential EV value chain actors
- 2 : There is collaboration between potential EV value chain actors

28. Collaboration between potential EV value chain actors and the local government

Clarification precondition

Existing partnerships between local policy makers and potential EV value chain actors could enhance the ease for cooperation on the development of eMobility. Therefore, it is important to identify this collaboration upfront, so that local policy makers can build upon existing networks.

Structural factor	Scale	Weight
Interaction (presence)	National & Local	7

Question

Is there some form of existing collaboration between the local government and potential EV value chain actors?

Identification possible answers

The answer is partly subjective, based on the evaluation of collaboration between key actors, and partly objective, supported by documents about projects, events, collaboration efforts (alliances) etc.

Data collection

The answer will be based on statements from key actors about the level of collaboration. This information can be gathered through interviews with local government officials and identified potential EV value chain actors, and complemented by reports on mobility and innovations linking to the automotive sector, energy or battery sector within the country.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. Negative experiences are included as well in the operationalization as this can hamper further collaboration on eMobility and therefore scores negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There have been negative experiences with collaboration between the local government and potential EV value chain actors (regarding mobility or innovation)
- 0 : There is no form of existing collaboration between the local government and potential EV value chain actors (regarding mobility or innovation)
- 1 : There is some collaboration between the local government and potential EV value chain actors (regarding mobility or innovation)
- 2 : There is collaboration between the local government and potential EV value chain actors (regarding mobility or innovation)

29. Collaboration between potential EV value chain actors and R&D institutes

Clarification precondition

Existing partnerships between R&D institutes and potential EV value chain actors could enhance the ease for cooperation on the development of eMobility. Therefore, it is important to identify this collaboration upfront, so that local policy makers can build upon existing networks.

Structural factor	Scale	Weight
Interaction (presence)	National & Local	2

Question

Is there some form of existing collaboration between R&D institutes and actors from the potential EV value chain?

Identification possible answers

The answer is partly subjective, based on the evaluation of collaboration between key actors, and partly objective, supported by documents about projects, events, collaboration efforts (alliances) etc.

Data collection

The answer will be based on statements from key actors about the level of collaboration. This information can be gathered through interviews with identified R&D institutes and identified potential EV value chain actors complemented by reports on mobility and innovations linking to the automotive sector, energy or ICT sector within the country.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. Negative experiences are included as well in the operationalization as this can hamper further collaboration on eMobility and therefore score negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There have been negative experiences with collaboration between R&D institutes and the potential EV-value chain (regarding mobility or innovation)
- 0 : There is no form of collaboration between R&D institutes and potential EV-value chain actors (regarding mobility or innovation)
- 1 : There is some collaboration between R&D institutes and potential EV-value chain actors (regarding mobility or innovation)
- 2 : There is collaboration between R&D institutes and potential EV-value chain actors (regarding mobility or innovation)

30. Collaboration between the local government and R&D institutes

Clarification precondition

If there is already a form of collaboration in place, this enhances the chance of collaboration for the implementation of eMobility. Therefore, it is important to identify this collaboration upfront, so that local policy makers can build upon existing networks.

Structural factor	Scale	Weight
Interaction (presence)	National & Local	5

Question

Is there some form of existing collaboration between R&D institutes and the local government?

Identification possible answers

The answer is partly subjective, based on the evaluation of collaboration between key actors, and partly objective, supported by documents about projects, events, collaboration efforts (alliances) etc. For example collaboration on the introduction of a different form of public transport, the demonstration of a new kind of car with government support etc.

Data collection

The answer will be based on statements from key actors about the level of collaboration. This information can be gathered through interviews with local government officials and identified R&D institutes, complemented by reports on mobility and innovations linking to the automotive sector, energy or battery sector within the country.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. Negative experiences are included as well in the operationalization as this can hamper further collaboration on eMobility and therefore score negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There have been negative experiences with collaboration between R&D institutes and the local government (regarding mobility or innovation)
- 0 : There is no form of existing collaboration between R&D institutes and the local government (regarding mobility or innovation)
- 1 : There is some collaboration between R&D institutes and the local government (regarding mobility or innovation)
- 2 : There is collaboration between R&D institutes and the local government (regarding mobility or innovation)

31. Collaboration between local governmental departments regarding eMobility

Clarification precondition

eMobility is related to various departments within the local government (such as environment, infrastructure and finances). Within local governments, the collaboration between departments does not have to be self-evident. Therefore, it is useful to gain insights in the existing links between the various departments linking to eMobility as cooperation between these departments can enhance the knowledge diffusion necessary for the uptake of eMobility.

Structural factor	Scale	Weight
Interaction (presence)	Local	4

Question

Is there a form of knowledge exchange between the different departments within the local government which relate to eMobility?

Identification possible answers

The answer is partly subjective, based on the evaluation of collaboration between key actors form the local government, and partly objective, supported by documents about projects, events, collaboration efforts (alliances) etc.

Data collection

The answer will be based on statements from key actors about the level of collaboration. This information can be gathered through interviews with local government officials from various departments touching upon eMobility.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. Negative experiences are included as well in the operationalization as this can hamper further collaboration on eMobility and therefore score negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

Select
-1 : There have been negative experiences with collaboration between local government departments (regarding mobility or innovations)
0 : There is no collaboration between the different departments within the local government (regarding mobility or innovations)
1 : There is some collaboration between the different departments within the local government (regarding mobility or innovations)
2 : There is collaboration between the different departments within the local government (regarding mobility or innovations)

32. Collaboration between local and national government departments regarding eMobility

Clarification precondition

The local government should be aware of the activities of the national government to prevent double work, missed opportunities and/or unforeseen barriers. Furthermore, collaboration between the local and national government can stimulate the development and diffusion of eMobility when it fits into the national trend towards sustainable mobility (related to precondition 1).

Structural factor	Scale	Weight
Interaction (presence)	National & Local	8

Question

Is there a form of collaboration between the local and national government divisions regarding eMobility?

Identification possible answers

The answer is partly subjective, based on the evaluation of collaboration between key actors from the national and local government, and partly objective, supported by documents about projects, events, collaboration efforts (alliances) etc.

Data collection

The answer will be based on statements from key actors about the level of collaboration. This information can be gathered through interviews with local and national government officials touching upon eMobility.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. Negative experiences are included as well in the operationalization as this can hamper further collaboration on eMobility and therefore score negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

Select
-1 : There have been negative experiences with collaboration on local and national government departments (regarding mobility or innovation)
0 : There is no collaboration between local and national government departments (regarding mobility or innovation)
1 : There is some collaboration between local and national government departments (regarding mobility or innovation)
2 : There is collaboration between local and national government departments (regarding mobility or innovation)

F5. Entrepreneurial activities

33. A high level of innovation in the country
34. A high degree of entrepreneurship (culture) of the country
35. The presence of a niche market for eMobility
36. Presence of potential EV value chain actors from the automotive sector with an interest in eMobility
37. Presence of potential EV value chain actors from the ICT sector with an interest in eMobility
38. Presence of potential EV value chain actors from the energy sector

33. A high level of innovation in the country

Clarification precondition

If there is a high degree of innovation, developing and introducing new products, services and technologies to the market on a regular base, the chance that eMobility will be taken up is assumed to be higher as it can become embedded in this trend of innovations.

Structural factor	Scale	Weight
Infrastructure (presence)	National	4

Question

Is the country open for new technology and innovations?

Identification possible answers

This precondition is measured using the global innovation index which gives values for the innovation rate of a country, ranging between 0-1. The global innovation index was chosen as it provides a ranking per country on the degree of innovation. The index is developed by INSEAD, Cornell University & WIPO. Data is provided by i.e. the World Bank and the World Economic Forum. Innovation is measured on a national level but affects the local level and is therefore taken into account.

Data collection

Data from the Global Innovation Index can be found online.

Reasoning behind scoring system

The global innovation index provides a ranking per country on the degree of innovation, ranging between 0 and 1. The potential ranking is divided under the scoring system used in this tool (0,1,2), exept for the negative score as this is not included in the online ranking used. A low level of innovation is not scored negatively, but neutral which is consistent with the operationalization of preconditions within the GEM-tool.

Answer

Select

Select
-1 : N.A.
0 : The country ranks between 0.00 - 0.33 and is not open to innovations
1 : The country ranks between 0.34 - 0.66 and is somewhat open to innovations
2 : The country ranks between 0.67 - 1 and is open to innovations

34. A high degree of entrepreneurship (culture) of the country

Clarification precondition

Entrepreneurs are crucial for the development and diffusion of a technological innovation such as eMobility. As the GEM-tool focuses on the pre-development phase, it will be hard to predict which entrepreneurs will take up the challenge and which start ups will be developed. The degree of entrepreneurship therefore gives an indication of the ease and time frame during which eMobility will be taken up. With a high level of entrepreneurship, the chances are higher that eMobility will be taken up more quickly. The level of entrepreneurship can differ per region but as long as there is exchange between regions, this can stimulate the development of eMobility.

Structural factor	Scale	Weight
Infrastructure (presence & quality)	National	6

Question

What is the degree of entrepreneurship in the country?

Identification possible answers

The answer can be based on the World Banks/OECD's indicator 'new business entry density', defined as the number of newly registered corporations per 1,000 working-age people (those ages 15–64, using World bank indicators). It should be noted that ranking is limited to the formal sector nor does it include the successfullness and time period of active entrepreneurs.

Data collection

Using OECD and World Banks statistics on new business entry density.

Reasoning behind scoring system

The degree of entrepreneurship, measured in new business entry density (NBED), ranges from 0-45 worldwide. Therefore, the max amount was divided between the three indicators used in this tool. A neutral score is given when the NBED ranges from 0-15. A score of +1 is given when it ranges between 16-30. >30 is given a score of +12 indicating a high degree of entrepreneurship.

Answer

Select

- Select
- -1 : N.A.
- 0 : There is a low level of entrepreneurship when the country ranks between 0-15
- 1 : There is a medium level of entrepreneurship when the country ranks between 16-30
- 2 : There is a high level of entrepreneurship when the country ranks >30

35. The presence of a niche market for eMobility

Clarification precondition

As the focus lies on the pre-development phase, it is assumed that no niche (market) focused on eMobility exists. Furthermore, the system function F6 Market Formation incorporates the incentives used to develop a niche market for eMobility. Still, entrepreneurial activities can be identified which stimulate the formation of this niche market. These activities consist of the testing of innovations through pilot projects, experiments, demonstrations etc. regarding a combination of the ICT sector, energy sector and automotive sector. These activities are used as indication for this precondition as they pave the way for (a niche markt for) eMobility.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	2

Question

Are there experiments, pilot projects and/or demonstrations in other niche markets which focus on mobility, energy and ICT?

Identification possible answers

A niche is a protected space in which innovations that deviate from existing market regimes can be tested and further developed. For example, pre-collision technology and start-stop technology are potential experiments which could eventually take a place in the mobility (niche) market. Also niche markets for specific brands of cars or type of vehicles (two/threeweelers) might exist. It refers to demonstration projects, pilots, experiments, special types of users, unique technology etc.

Data collection

The main data sources are reports on developments of projects combining the automotive, energy and ICT sectors, complemented by interviews with key actors from these sectors.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists. Therefore, the operationalization is based upon the amount of sectors related to an identified niche as the energy, IT and automotive sector should work together for eMobility to develop. A negative score is not taken into account as it is presumed that there is no negative knowledge as in this case knowledge on traditional mobility can help to set up eMobility as well (e.g. pilots of safety requirements, start-stop technology etc.).

Answer

Select

- Select
- -1 : N.A.
- 0 : There are no identified niche markets relating to eMobility or traditional mobility
- 1 : There are niche markets identified relating to two of the three potential sectors (energy, ICT and automotive)
- 2 : There are niche markets identified relating to all of the potential sectors (energy, ICT and automotive)

36. Presence of potential EV value chain actors from the automotive sector with an interest in eMobility

Clarification precondition

It is important to have insight in the position of the potential EV value chain actors stemming from the automotive industry regarding eMobility. When there is support for eMobility, this enhances the chances for its uptake. This also helps local policy makers who to include as of the start of the process of eMobility, creating a sense of ownership of companies stemming from the automotive sector. Furthermore, it can be related to the kind of policy measures (e.g. (non-) financial incentives, awairness raising)

Structural factor	Scale	Weight
Actor (presence)	National & Local	5

Question

Are there actors from the incumbent automotive sector which are interested in taking up in eMobility?

Identification possible answers

If incumbent countries express their willingness to get involved in sustainable mobility, this makes them potential eMobility value chain actors. This includes all designers, Original Equipment Manufacturers (OEMs), vehicle manufacturers, dealerships and maintenance shops for two, three, four and +4 wheelers.

Data collection

The main data source is interviews with actors from the automotive industry which form potential actors for the EV-chain, complemented with business reports from the automotive sector to identify their ambition to work on sustainable mobility. However the focus lies on the attitudes and is therefore in a large part subjective.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. When the identified automotive companies have a negative attitude towards eMobility, this forms a barrier for eMobility and is therefore scored negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information, the size of the automotive sector and the score key stakeholders ascribe to the precondition.

Answer

Select

Select
-1 : Potential actors from the automotive industry have a negative attitude towards eMobility
0 : There are no potential actors from the automotive industry interested in the uptake of eMobility
1 : There are some potential actors from the automotive industry interested in sustainable mobility and eMobility
2 : There are several potential actors from the automotive industry interested in sustainable mobility and eMobility

37. Presence of potential EV value chain actors from the ICT sector with an interest in eMobility

Clarification precondition

When implementing eMobility, having the automotive industry on board is not enough as eMobility links to various technological fields. Potential actors who could play a role in the development and diffusion of eMobility should be identified. It is therefore important to have insight in potential EV value chain actors not yet related to the (sustainable) automotive industry, including ICT companies working with transport and/orenergy and their knowledge about eMobility.

Structural factor	Scale	Weight
Actor (presence)	National & Local	1

Question

Are there actors from the ICT sector which are interested in taking up eMobility?

Identification possible answers

If there are already ICT companies working with the energy sector or mobility, or a combination of the two, they are seen as potential EV value chain actors. It is seen as positive when ICT companies are involved in innovations in the energy sector, for example measuring the strenght and utility of the grid, as this forms a basic level of knowledge about energy which can be used for eMobility. This is also true for mobility and transport. If the ICT sector is already working with mobility, for example by making it possible to get insights in the modes of travel, travelbehaviour, travel distances, this forms an opportunity for eMobility to use this knowledge.

Data collection

The main data source is interviews with actors from the ICT sector which form potential actors for the EV-chain, complemented with business reports to identify their ambition to work on sustainable mobility. However the focus lies on the attitudes of companies and is therefore in a large part subjective.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. When the identified ICT companies have a negative attitude towards eMobility, this forms a barrier for eMobility and is therefore scored negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

Select
-1 : Potential actors from the ICT sector have a negative attitude towards eMobility
0 : There are no potential actors from the ICT sector working with energy and/or mobility
1 : There are some potential actors from the ICT sector working with energy and/or mobility
2 : There are several potential actors from the ICT sector working with energy and/or mobility

38. Presence of potential EV value chain actors from the energy sector

Clarification precondition

Having the energy companies on board is crucial for the introduction of eMobility as a new way of supplying energy in the form of electricity for transportation needs to be developed. Therefore, it is important to identify potential actors which would be interested in the uptake of eMobility in advance to include them as of the start of the development of eMobility. This also gives insight in the attitude of these companies, which influences policy measures and decisions of local policy makers .

Structural factor	Scale	Weight
Actor (presence)	National & Local	3

Question

Are there actors in the energy sector which are interested in taking up eMobility?

Identification possible answers

Actors from the energy sector are context specific. It includes energy producing, (component) supplying, distributing (operation & maintenance) and installation actors. The tool does not differentiate between distributer network operators or energy suppliers as not all countries use this division (though when they do, both should be on board).

Data collection

The main data source is interviews with actors from the energy sector which form potential actors for the EV-chain, complemented with business reports to identify their ambition to work on sustainable mobility. However the focus lies on the attitudes of companies and is therefore in a large part subjective.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists and the amount of active actors is very context specific. When the identified energy companies have a negative attitude towards eMobility, this forms a barrier for eMobility and is therefore scored negatively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information, the organization of the energy sector and the score key stakeholders ascribe to the precondition.

Answer

Select

Select
-1 : Most local actors from the energy industry have a negative attitude towards eMobility
0 : There are no local actors from the energy industry interested in the uptake of eMobility
1 : There are some actors from the energy industry interested in the uptake of EV
2 : There are various actors from the energy industry interested in the uptake of EV

F6. Market formation

39. A competing fuel price for eMobility compared to (local) traditional vehicles
40. A competitive cost structure of EVs compared to (local) traditional vehicles (focus on purchasing price)
41. Presence of subsidies which could positively influence the introduction of eMobility
42. Presence of taxes which could influence the introduction of eMobility
43. Regulation/legislation positively influencing the introduction of eMobility regarding transportation & mobility and the automotive sector
44. Regulation/legislation positively influencing the introduction of eMobility regarding import
45. Regulation/legislation positively influencing the introduction of eMobility regarding electricity

39. A competing fuel price for eMobility compared to (local) traditional vehicles

Clarification precondition

It is important to have some insights in the competitiveness of fuel for eMobility as compared to the traditional ICE vehicle system. When there is a low electricity price compared to the traditional fuel, this creates an opportunity for eMobility.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	4

Question

How does the electricity price compare to traditional fuels?

Identification possible answers

Due to the broad scope of the GEm-tool regarding the kind of vehicles, it is not possible to take into account the benefits from fuel efficiency of EVs, which are more efficient than ICE vehicles, as this differs per vehicle. Furthermore, it is not possible to take into account the distance as this also related to the type of vehicle. Therefore, the average price for 1 liter traditional fuel or 1 kilowatt will be taken as measure. Note that the type of traditional fuel should be adapted to the most common local fuel for ICE vehicles.

Data collection

Information (reports) on fuel and electricity pricing.

Reasoning behind scoring system

On average, electric vehicles are 33% cheaper than traditional ICE vehicles when looking at fuel price and range. 33% was therefore chosen as chosen as indication for a positive score. It should be noted however that this is based on frontrunner countries, and that fuel prices are very context specific, so it should be seen as an indication.

Answer

Select

- Select
- -1 : Local traditional fuels are more cheap than electricity
- 0 : Local traditional fuels and the electricity price are equal
- 1 : Electricity is less than 1/3 cheaper than local traditional fuels
- 2 : Electricity is more than 1/3 cheaper than local traditional fuels

40. A competitive cost structure of Evs compared to (local) traditional vehicles (focus on purchasing price)

Clarification precondition

It is important to have some insights in the competitiveness of EVs compared to the traditional ICE vehicle system. This focus lies on purchasing prices for compatible vehicles.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	6

Question

How does the purchasing price of electric vehicles compare to traditional (local) vehicles?

Identification possible answers

Due to the broad scope of this tool regarding the kinds of vehicles, it is not possible to take into account all the potential vehicles and their price in this tool. It is also dependent on the availability of electric vehicles in the local region, national region or import options. Still, it is important to gain insights in the competitivenessof EVs.Therefore, local traditional vehicles will be compared with (potential or estimated) purchasing costs of electric vehicles.

Data collection

Information (reports) on purchasing prices of local traditional vehicles and electric vehicles.

Reasoning behind scoring system

It is assumed that the purchasing price of electric vehicles is almost always more expensive than that for a comparable traditional vehicle. Therefore, the operationalization of this precondition differs from the standard scoring system: when the purchasing price of electric vehicles is similar to that of comparable traditional vehicles, this is seen as positive and scores positively (not neutral).

Answer

Select

- Select
- -1 : Electric vehicles are more expensive (>20%) than comparable traditional vehicles
- 0 : Electric vehicles are more expensive (<20%) than comparable traditional vehicles
- 1 : Electric vehicles are as expensive as comparable traditional vehicles
- 2 : Electric vehicles are cheaper than comparable traditional vehicles

41. Presence of subsidies which could positively influence the introduction of eMobility

Clarification precondition

Subsidies can be in place before the introduction of eMobility which can stimulate or hinder the uptake of eMobility. Insights in existing subsidies relating to eMobility and their potential influence (+/-) helps the local government official to form an image of the prevailing situation and how to deal with or use the subsidies available.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	7

Question

Are there subsidies in place which could influence (+/-) the introduction of eMobility ?

Identification possible answers

Subsidies can be both local as national and can be applied to the advancement of (R&D on) conventional fuel, ICE vehicles, battery technology advancement, (R&D on) sustainable mobility, innovations and energy and ICT companies working on the advancement of the transport/energy sector.

Data collection

The main source of data consits of national and local policy documents regarding subsidies relevant for the local level and the introduction of eMobility, complemented with local government officials.

Reasoning behind scoring system

This precondition is given a score of -1 when subsidies can be identified which negatively influence eMobility, through the funding and stimulation of opposite mobility paths. When there are no identified subsidies relating to eMobility, this is given a neutral score of 0. It is scored positively as stimulating subsidies relating to eMobility are still seen as positive, even if there are other subsidies in place which counteract this. A score of +2 was given when subsidies positively influencing eMobility are in place which can be used or are being used to stimulate eMobility.

Answer

Select

- Select
- -1 : There are subsidies in place which negatively influence eMobility
- 0 : There are no subsidies in place which influence eMobility
- 1 : There are both positive as negative subsidies in place which influence eMobility
- 2 : There are subsidies in place which positively influence eMobility

42. Presence of taxes which could influence the introduction of eMobility

Clarification precondition

(National) fiscal policy is a powerful mechanism to reduce the costs of eMobility or increase the costs of traditional mobility. In some cases, taxes exist before the introduction of eMobility which can stimulate or hinder the introduction of eMobility. Insights in existing taxes which can be related to eMobility and their potential influence (+/-) helps local policy makers to form an image of the prevailing situation and how to deal with or use the taxes available.

Structural factor	Scale	Weight
Infrastructure (presence)	National & Local	5

Question

Are there taxes in place which could influence (+/-) the introduction of eMobility?

Identification possible answers

Taxes can be both local as national and include i.e. road tax, fuel tax, electricity tax, tax on specific modes of transport, tax on emissions, import taxes, battery taxes, lower surcharge on income taxes and tax deductible investments, exemption on purchasing tax of EV.

Data collection

The main source of data consits of national and local policy documents regarding taxes relevant for the local level and the introduction of eMobility, complemented with local government officials.

Reasoning behind scoring system

This precondition is given a score of -1 scored negatively gives a score of -1 when taxes can be identified which negatively influence EV, through the funding and stimulation of opposite mobility paths. When there are no identified taxes positively influencing eMobility, this is given a neutral score of 0. It is scored positively as stimulating tax measures relating to eMobility are still seen as positive, even if there are other taxes in place which counteract this. A score of +2 was given when taxes positively influencing eMobility are in place which can be used or are being used to stimulate eMobility.

Answer

Select

- Select
- -1 : There are taxes in place which negatively influence EV
- 0 : There are no taxes in place which influence EV
- 1 : There are both positive as negative taxes in place
- 2 : There are taxes in place which positively influence EV

43. Regulation/legislation positively influencing the introduction of eMobility regarding transportation & mobility and the automotive sector

Clarification precondition

Adapting particular regulation & legislation is an important component in the development of eMobility. As the tool focuses on the pre-development phase, it is assumed there is no specific regulation or legislation regarding eMobility. Existing regulation and legislation can, however, influence the development of eMobility. For example, emission or efficiency standards of fuels and vehicles can influence the uptake of eMobility. Insights in policies regarding the automotive industry which could (directly or indirectly) influence the introduction of eMobility might help local policy makers to get an overview of the prevailing situation and potential policy measures.

Structural factor	Scale	Weight
Institution (presence)	National & Local	2

Question

Is there regulation/legislation regarding transportation, mobility and the automotive industry that could influence the uptake of eMobility?

Identification possible answers

Possible (identified) regulations and legislations include: low emission zones, parking zones, exemption of tolls , different lanes, transferable licence plates for EV, building codes, national motor vehicle standards, licensing requirements etc. eMobility could make use of these initiatives.

Data collection

The main source of data consits of policy documents on regulation/legislation as well as reports on transport and sustainable development. This is complemented with interviews with (national & local) government officials and stakeholders from the automotive business.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists. Both hindering as stimulating regulation and legislation is taken into account in the operationalization of the precondition. When there are both hindering as stimulating standards, this is still scored positively as stimulating standards relating to eMobility are still seen as positive, even if there are other standards in place as well. It is up to the researcher to decide which of the identified policies are hindering or stimulating eMobility and to decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There are (more) hindering regulations and legislations in place regarding the automotive business and transport which influences eMobility
- 0 : There are no regulations or legislations regarding the automotive business and transport which influences eMobility
- 1 : There are both stimulating and hindering regulations and legislation regarding the automotive business and transport which influences eMobility
- 2 : There are (more) positive regulations and legislations in place regarding the automotive business and transport which influences eMobility

44. Regulation/legislation positively influencing the introduction of eMobility regarding import

Clarification precondition

Adapting particular regulation & legislation is an important component in the development of eMobility. As the tool focuses on the pre-development phase, it is assumed there is no specific regulation or legislation regarding eMobility. Existing regulation and legislation can, however, influence the development of eMobility. Insights regarding the import of cars and components for EVs and charging infrastructure which could (directly or indirectly) influence the introduction of eMobility might help local policy makers to get an overview of the prevailing situation and potential policy measures and the policy measures. Import is seen as separate from the automotive sector as there are many forms of import regulation that could potentially influence EVs, and therefore it makes up a separate precondition.

Structural factor	Scale	Weight
Institution (presence)	National	3

Question

Is there regulation/legislation regarding import of vehicles (supply parts) that could influence the uptake of eMobility?

Identification possible answers

Possible (identified) regulations and legislations include: tax on import of raw materials, tax on import of new and second hand vehicles, customs tariff, licensing requirements and preferential trade agreements & VAT/duty/excise in trade.

Data collection

The main source of data consits of reports and policy documents regarding the import of different types of vehicles and vehicle components. This is complemented with interviews with key stakeholders dealing with import regulation and legislation.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists. Both hindering as stimulating regulation and legislation is taken into account in the operationalization of the precondition. When there are both hindering as stimulating standards, this is still scored positively as stimulating standards relating to eMobility are still seen as positive, even if there are other standards in place as well. It is up to the researcher to decide which of the identified policies are hindering or stimulating eMobility and to decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There are (more) hindering regulations and legislations in place regarding import which influence eMobility
- 0 : There are no regulations or legislations in place regarding import which influence eMobility
- 1 : There are both stimulating and hindering regulations and legislation regarding import which influence eMobility
- 2 : There are (more) positive regulations and legislations in place regarding import which influence eMobility

45. Regulation/legislation positively influencing the introduction of eMobility regarding electricity

Clarification precondition

Adapting particular regulation & legislation is an important component in the development of eMobility. As the tool focuses on the pre-development phase, it is assumed that there is no specific regulation or legislation regarding eMobility and electricity. Existing regulation and legislation can, however, influence the development of eMobility. It is important for local policy makers to have some insight in the regulation and legislation regarding the supply and use of energy beforehand as this is an essential element in the introduction of EV. Insights might help local policy makers to get an overview of the prevailing situation and potential policy measures.

Structural factor	Scale	Weight
Institution (presence)	National & Local	1

Question

Is there regulation/legislation regarding electricity that could influence the uptake of eMobility?

Identification possible answers

Possible influential regulations and legislations (+/-) focus on the existing energy laws local distribution of energy, energy contracts, energy standards on safety and supply, energy funds and flexibility for new projects.

Data collection

The main source of data consits of policy documents on regulation/legislation as well as reports regarding electricity.This is complemented with interviews with key stakeholders from the local government (energy department) and energy sector.

Reasoning behind scoring system

It is not feasible to support this question based on a quantitative information as no optimal amount exists. Both hindering as stimulating regulation and legislation is taken into account in the operationalization of the precondition. When there are both hindering as stimulating standards, this is still scored positively as stimulating standards relating to eMobility are still seen as positive, even if there are other standards in place as well. It is up to the researcher to decide which of the identified policies are hindering or stimulating eMobility and to decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There are (more) hindering regulations and legislations in place regarding energy which influence eMobility
- 0 : There are no regulations or legislations in place regarding energy which influence eMobility
- 1 : There are both stimulating as hindering regulations and legislation regarding energy which influence eMobility
- 2 : There are (more) stimulating regulations and legislations in place regarding energy which influence eMobility

F7. Creation of legitimacy

46. The presence of lobbying parties advocating in favor of eMobility

47. The absence of lobbying parties advocating against eMobility

48. (Powerful) Incumbent companies see the opportunities provided by EV

49. A high level of confidence and certainty regarding the use of eMobility of the consumer

46. The presence of lobbying parties advocating in favor of eMobility

Clarification precondition

A lobby for eMobility can create political urgency and willingness to change, influence the decision making process and steer the general opinion towards eMobility. It can therefore enhance its uptake. Lobbying parties - such as Civil society organisations, NGOs and branche organisations - play an important role in the creation of legitimacy as they can put pressure on the local government and businesses to change their behavior.

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	4

Question

Are there lobbying parties advocating for eMobility?

Identification possible answers

Possible indicators for the answer include active associations, action groups, companies, pressure groups and professional activists advocating for eMobility but also sustainable mobility, air quality improvement, climate change and other subjects which relate to eMobility.

Data collection

The main data source consists of interviews with identified lobby groups, complemented with reports advocating for eMobility stemming from these actors.

Reasoning behind scoring system

Lobbying does not necessarily mean having the power to change the political path. Therefore, both power and lobby should be identified and are used as indicators for the scoring system. A lobby against eMobility is therefore taken into account in another precondition. The operationalization of this precondition deviates from the standard indicators used in the GEM-tool as the lobby against eMobility is not taken into account but the focus lies on power and lobby in favor of eMobility. A negative score is therefore not included in the operationalization. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : N.A.
- 0 : There are no groups advocating for eMobility
- 1 : There are groups advocating for eMobility with limited power
- 2 : There are groups advocating for eMobility with power

47. The absence of lobbying parties advocating against eMobility

Clarification precondition

Identify the lobby for tradtional mobility, including ICE vehicles and traditional fuels, which can hinder the development and diffusion of eMobility.

Structural factor	Scale	Weight
Actor (presence & capability)	National & Local	2

Question

Are there lobbying parties advocating against eMobility?

Identification possible answers

Possible indicators for the answer include active associations, action groups, companies, pressure groups and professional activists advocating for traditional fuels and an automotive industry focused on ICE vehicles.

Data collection

The main data source consists of interviews with identified lobby groups complemented with interviews with other key stakeholders from the automotive industry and the local government as to obtain a more comprehensive picture of the lobby, as this is a politically sensitive subject.

Reasoning behind scoring system

Lobby does not necessarily mean the power to change the political path. Therefore, both power and lobby should be identified and are use as indicators for the scoring system. Furthermore, as the precondition focuses on the absence of certain groups, a positive score is given when these groups are not present, also differing from the standard operationalization system. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer

Select

- Select
- -1 : There are groups advocating against eMobility with power
- 0 : There are groups advocating against eMobility with limited power
- 1 : There are no groups advocating against eMobility
- 2 : N.A.

48. (Powerful) Incumbent companies see the opportunities provided by EV

Clarification precondition

If there are a lot of companies afraid of the introduction of eMobility as they cannot quickly adapt to this development or have high stakes in the prevailing situation (ICE vehicles, fuels), this could hamper the diffusion of eMobility. It is therefore important for a local government official to be aware of these companies and if possible involve them in the development from the beginning. Furthermore, if there are companies willing to invest in eMobility, they can have a role as frontrunner and example to others.

Structural factor	Scale	Weight
Actor (presence)	National & Local	1

Question

Are there influential companies who have high stakes in ICE vehicles and/or traditional fuels ?

Identification possible answers

This precondition focuses on the identification of the stakes and positions of incumbent companies, focussing on the automotive sector and the energy sector. Some of this players might have already been identified at the above mentioned preconditions (F1, F3 & F5). However, their stakes and influence have not yet been examined which is part of the creation of legitimacy of eMobility and is therefore included.

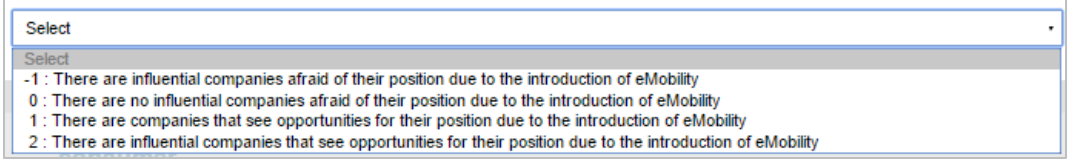
Data collection

The main data source consists of interviews with incumbent companies, focussing on actors stemming from the automotive sector and energy sector as they are identified as having the highest stakes in the traditional situation.

Reasoning behind scoring system

The operationalization is based on subjective answers of actors within the incumbent automotive industry and energy companies. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer



49. A high level of confidence and certainty regarding the use of eMobility of the consumer

Clarification precondition

If there are many uncertainties and disadvantages identified relating to the diffusion of eMobility, this could hamper its introduction as it spreads doubt and creates a lack of support. The focus of this precondition lies on the consumer, as the opinion of local government officials and market players have already been identified at other system functions.

Structural factor	Scale	Weight
Institution (presence)	Local	3

Question

Are consumers confident and certain regarding the use of eMobility?

Identification possible answers

Uncertainties or disadvantages regarding eMobility can be related to their performance, their range, their costs influencig the feasibility of the introduction and the legitimacy eMobility. This precondition therefore focuses on the expectations of the use of eMobility of the consumer that eMobility should meet.

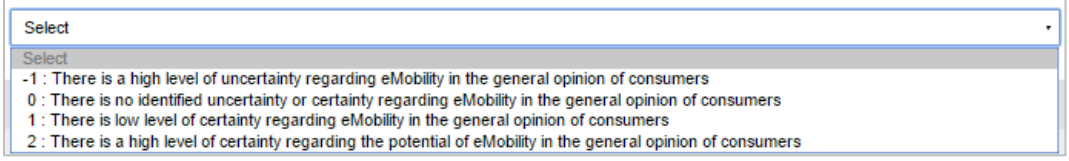
Data collection

It is difficult to measure the general opinion of the consumer. Possible options are a short survey among various potential customers (in this case the operationalization should be made more specific), learn from overarching consumer organisations or learn from other similar introduced innovations (relating automotive industry). Furthermore, this information can be complemented (if necessary) with media coverage and reports.

Reasoning behind scoring system

Uncertainty negatively influences the legitimacy of eMobility. When there is no identified uncertainty or certainty - for example because knowledge on (drivers of) eMobility lacks - this scores neutrally. When there is some certainty regarding eMobility, this provides an opportunity and is therefore scored positively. It is up to the researcher to differ between the possible scores and decide on the final score based on the identified information and the score key stakeholders ascribe to the precondition.

Answer



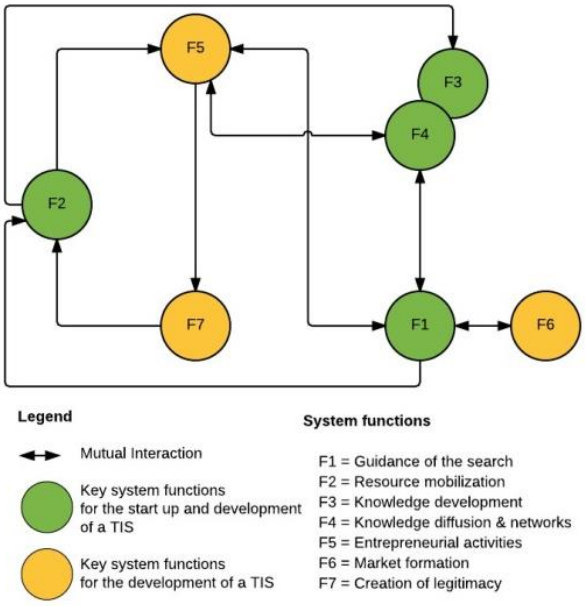
Part II The outcomes of the online GEM-tool

Green Electric Mobility Tool

Before you lies the outcome of the Green Electric Mobility (GEM-) Tool. The GEM-tool has been developed to contribute to a successful implementation of eMobility in middle-income countries. Its application provides an overview and evaluation of the existing local innovation system before the introduction of eMobility, based on relevant preconditions for the successful introduction and diffusion of eMobility. Its application provides an opportunity for local policy makers to make use of the (local) actors, institutions, interactions and infrastructure, and enhances the structural introduction of eMobility starting from the existing local system and thus increases the chance of eMobility becoming embedded in the local context. Insights in the functioning of an existing innovation system is a necessary first step to determine the optimal policy strategy.

This report encompasses the outcomes of the online application of the GEM-tool. It shows the performance of the preconditions as well as individual policy implications & brief recommendations. The preconditions receive a score of -1 (negative), 0 (neutral), +1 (positive) or +2 (excellent).

Furthermore, the functioning of the overarching system levels is presented. For their evaluation, the following categorization is applied: a score from <33% is seen as a weak system function, a score of 33-66% is seen as intermediate system function and score of >66% is seen as strong system function. Furthermore, brief policy implications & recommendations are presented. As the system functions are interconnected as illustrated in the figure below, the dynamics between the system functions are part of the policy implications per system function as the malfunctioning of one system function has implications for other system functions. The presented policy implications & recommendations per system function provide a systematic overview of the policy advise for its corresponding preconditions and the innovation system as a whole.



The total score of the GEM-tool shows the performance of the existing innovation system. The same evaluation categorization is applied as for the system functions: a score of <33% is seen as a weak innovation system, a score of 33-66% is seen as intermediate innovation system and score of >66% is seen as strong innovation system, taking into account the predevelopment phase of the local system. No policy implication or recommendation has been developed for the performance of the innovation system as a whole, as this is based on the performance and dynamics of the system functions and preconditions which are explained per system function.

F1. Guidance of the Search

Policy implications & recommendations for F1 Guidance of the Search

Guidance of the Search refers to all activities that shape the needs and requirements for the support of an emerging technology. When the system function Guidance of the Search scores low, this affects the whole cycle necessary in the beginning of the innovation system as it is the main system function in this phase. This indicates that the focus of the existing innovation system has not been placed on eMobility but lies on a variety of technological innovations for the advancement of sustainable mobility. This lowers the chances for eMobility, as resources will be used for these innovations, leaving less resources to be used for eMobility. Furthermore, when a new product is introduced, financial, psychological and practical uncertainties have to be removed to make consumers accept a new product and stimulate producers to get involved in the innovation system. The lack of a clear vision about the technological change increases uncertainty and discourages the participation of relevant actors and hinders the Creation of Legitimacy. To counter these barriers, the following policy measures are suggested:

* Develop a roadmap for the implementation of eMobility:

Both short term targets and long term ambitions should be included in a clear local plan or strategy for eMobility. Long-term policies are essential in the transition to eMobility, as this decreases uncertainties for the producers as well as consumers. However, a plan should also be flexible, as adjustments and adaptations are inevitable in a dynamic environment influenced by e.g. external effects. So called 'road signs' can be created which present the identification of developments that form a reason to adapt existing policies. Furthermore, the plan should include the introduction and dismantling of incentives for eMobility as of the beginning, focusing on both eMobility as the roll out of charging infrastructure, aiming to find a balance between them. Moreover, targets can be set for e.g. the improvement of air quality, the decrease of emissions, the share of electric vehicles on the road or of the total sales. Additionally, there should be a monitor & evaluation system in place as of the first phase of eMobility resulting in a timeline of a certain period. This increases awareness of the progress made with regards to the set objective and shows the barriers and opportunities over time.

* Stimulate the propulsion of eMobility:

It should be clear from the start who bears the responsibility for the development of eMobility with the power and connections to put it on the (political) agenda. Therefore, someone or a team should

be appointed who drives eMobility. Moreover, there should be a commitment and alignment between the different governmental levels (horizontal & vertical) as policy makers need to bring together many different stakeholders from various sectors for the advancement of eMobility. A strong policy framework and a competent team are therefore essential.

*** Raise awareness of the opportunities provided by eMobility:**

eMobility should become embedded in the local context, therefore awareness raising is an essential part of the diffusion of eMobility. The positive effects of eMobility should be made clear to relevant actors and linked to the desired situation with regards to the local social (e.g. better air quality), environmental (e.g. less emissions) and economic problems (e.g. less dependency on fossil fuels) it is meant to solve. This includes the bigger picture in which eMobility is set-up e.g. the drivers of eMobility, the energy transition, general sustainability etc. There should be a communication plan, addressing different segments of the population and market (from early adaptors to mass). This should include a plan to disseminate the information on the incentives in place. This can have an effect on the knowledge on eMobility, the willingness to change from consumers and potential EV market players and the legitimacy of eMobility in the local context. Raising awareness of eMobility can be done through signage, labelling (e.g. the level of pollution of a vehicle), cost- benefit tools (to calculate toe total costs of ownership), awareness campaigns including public events (such as EV parades, show case projects etc.), testing possibilities, advertisement, websites and platforms. The local government can provide an example through the electrification of their own fleet.

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

1. A long term ambition for sustainability and sustainable development of the national government

Secure the presence of a national plan, while making sure to prevent to make it too weak or stringent: This precondition gives insight in the support and general trend towards sustainability which, when present, enhance the chances for the uptake of eMobility. However, the development of a national plan regarding sustainable development is not in the hands of local policy makers. Nonetheless, they can develop a local plan for sustainable development to ensure that the local trend is aimed towards sustainable development, including eMobility as main method for sustainable mobility.

2. A national plan for sustainable mobility, focusing on eMobility

Secure the presence of a national plan, while making sure to prevent to make it too weak or stringent: This precondition gives insight in the support and general trend towards sustainability mobility, when present, enhance the chances for the uptake of eMobility. However, the development of a national plan regarding sustainable development is not in the hands of local policy makers. Nonetheless, they can develop a local plan for sustainable mobility to ensure that the local trend is aimed towards sustainable development. This plan can include eMobility as main method towards sustainable mobility.

3. A local plan for sustainable mobility, focusing on eMobility

Secure the presence of a local plan for eMobility, while making sure to prevent it being too weak or stringent: It is recommended to develop a local plan before eMobility is implemented, which includes eMobility as main method towards sustainable mobility. The plan should include targets, which relate to the drivers for sustainable mobility both for the short and long term. Short term goals are necessary for putting the development and diffusion of the innovation in motion. Long term targets should be included as they pave the way forward and give policy makers and industry time to invest in the innovation.

4. The presence of national government departments/institutes working on (subjects related to) eMobility

Stimulate and organize the participation of relevant actors, in this case referring to national government officials from different departments: Even though this is not within the influence sphere of the local government, insight in the various national departments/institutes working on eMobility can help local policy makers to understand where they stand and where they can find support and opposition. When the precondition scores low, participation of actors can be enhanced by providing knowledge on the opportunities and advantages of eMobility.

5. The presence of local government departments/institutes working on (subjects related to) eMobility

Stimulate and organize the participation of relevant actors, in this case referring to local government officials from different departments: Insight in the various local departments/institutes working on sustainable mobility (EV) helps the local policy makers working on eMobility to understand where they stand and where they can find support or opposition. When the precondition scores low, participation of actors can be enhanced by providing knowledge on the opportunities and advantages of eMobility, as well information about the necessity for different departments to work together as eMobility cuts across various sectors.

6. The appointment of someone/a team within the local government to move eMobility forward willing to take on the responsibility of the introduction of eMobility and the having power, connections and capabilities to do so

Stimulate and organize the participation of actors who wish to mobilize the electrification of transport. There should be a clear division of tasks and clarity on who is responsible to make sure eMobility will be taken up. Also make sure that this person or team is connected to the right people and has a certain level of power to change conventional ways of transport.

7. A high level of willingness to change of potential EV value chain actors

Secure the willingness of potential EV value chain actors to change their behavior: It is recommended to raise awareness of the opportunities provided by eMobility and/or create incentives to provide a viable business case for eMobility for businesses. The former could be achieved by providing more information on the advantages of eMobility and facilitate knowledge sharing via events and conferences etc. (see F3). The latter could be financial and non-financial (see F6) incentives which can enhance the willingness of businesses (e.g. through tax measures).

8. A high level of willingness to change of (potential) consumers

Secure the willingness of consumers to change their behavior: It is recommended to raise awareness of the opportunities provided by eMobility and/or create incentives to provide a viable business case for eMobility for consumers. The former could be achieved by providing more information on the advantages of eMobility and facilitate knowledge sharing via events and conferences etc. (see F3). The latter could be financial and non- financial (see F6) incentives which can enhance the willingness of consumers (e.g. through subsidies on purchasing price).

F2. Resource mobilization (financial, human & material)

Policy implications & recommendations for F2 Resource Mobilization

Financial, human and material resources are necessary for the development and diffusion of an innovation such as eMobility. When Resource Mobilization is weak, this lowers the development and diffusion of eMobility significantly, as this is one of the main system functions in the pre-development phase. It will discourage Entrepreneurial Activities as well as the Knowledge Development and diffusion as there are no human, financial and material resources available, necessary for these system functions to develop. The following suggestions could help to strengthen the Resource Mobilization:

*** Increase financial support for eMobility:**

This policy measure relate to various funding on different levels (local, national, international) which could be deployed for eMobility. This includes funding for research and development on eMobility as well as funding for demonstrations and experimentations, funding for initial investments of companies and covering risks (for early adopters, market parties, experiments etc.), funds to support collaboration between relevant actors (i.e. public- private partnerships) and funds for air quality improvement. This also implies mobilizing stakeholders with sufficient resources, as no actor has all of the necessary resources to introduce eMobility.

*** Ensure the supply of material resources:**

It is essential for the rollout of eMobility that vehicles and infrastructure are (made) available, either through import, assemblage or complete local production, which fit the local context. This includes the hardware as the software of the innovation system. The hardware refers to the electric vehicle components, charging infrastructure and energy, and complementary technology such as batteries and Intelligent Transport Systems. The software encompasses knowledge on the application in the local context, such as the average range and use of vehicles, and the geographical and climatological environment, included in the innovation system. Furthermore, it is of high importance that there is a balance between the introduction of EVs and the charging infrastructure. Both should be deployed as of the start of the process.

*** Enhance electricity supply:**

If the main aim of eMobility is to reduce emissions, the source of electricity should be renewable. However, the share of renewable energy in the energy mix of a country might counteract a successful implementation of EV, since it can form a threat for the energy security as it can be unstable. This should be taken into account as of the start. Enhancing the knowledge on the local energy system (see F3) and including key actors from the energy sector (see F5) should therefore be focused on. In addition, the use of energy for EV should not compete with other priorities of electricity. If there is a risk, a buffering system should be developed (i.e. using other sources of energy). Furthermore, the supply and demand of electricity should match for eMobility to develop on a large scale, which should be a point of focus from the beginning of the introduction of eMobility.

*** Stimulate knowledge, skills and capacity development:**

For eMobility to be deployed on a large scale, human resources in the form of experts with knowledge, skills and capabilities relating to eMobility are essential. This includes researchers of the technology as well as people with the practical skills and expertise for the set-up and the maintenance of EVs and charging infrastructure. Therefore, educational programs about eMobility should be set up, as well as the possibility for R&D programs.

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

9. The presence of international funding which can be deployed in the local context

Stimulate financial infrastructure, in this case international funding: It is not possible for local policy makers to change the situation when there are no international funds available or when they are not able to make a claim on them. This indicates that local policy makers should look for funds for eMobility elsewhere, either on a national or local scale. It could also be that they have not yet been identified or have not yet been applied for. In this case, this can be considered by the local policy makers. It should be noted however, that this should only be part of the total financial scheme to maintain independency, ownership and security of money flows.

10. The presence of national financial resources for the development and diffusion of eMobility

Stimulate financial infrastructure, referring to national and local funds: When there are no identified financial funds related to EV, this should be set up by local policy makers. This can be directly, via funds for eMobility, or indirectly, by financial incentives such as tax exemptions (see F6). Furthermore, funds for traditional vehicles can hinder the uptake of electric vehicles. Local policy makers should be aware of these hindering funds and if possible, convert them to funds for eMobility.

11. The possibility of a loan for eMobility

Stimulate the presence and quality of financial infrastructure: The presence of funding refers to a loan while the quality refers to the ease of getting a loan. This does not fall under the direct influence of local policy makers. Therefore, if the precondition scores low, other financial funds or financial

incentives should be made available to compensate for the difficulty of a loan such as venture capital, start-up funding or funding for the deployment of an innovation such as eMobility.

12. A high level of awareness amongst potential EV value chain actors about the potential financial resources (if present)

Secure the presence of awareness of financial funds: When there is little awareness about the potential funds available, local policy makers can raise awareness on the potential financial funds available via awareness building measures such as information campaigns and events during which knowledge can be spread (see F1).

13. Insight in the different modes of transport used in the urban region

Stimulate the present physical infrastructure relating to the different modes of travel: It is not directly in the hands of local policy officials to change the modes of travelling. But insights in the local use of transport can help to make a decision on the kind of vehicles and projects being implemented (focus of the deployment of eMobility, see F6). When public transport makes up a high share of daily trips, eMobility is likely to have the biggest impact on the local region when applied to (polluting) public transport. If there is more private motorized transport, this means a different strategy more focused on the consumer side.

14. The availability of suitable electric vehicles and charging points

Stimulate the presence of physical infrastructure, referring to the availability of electric vehicles and charging points: It is not directly in the hands of local policy officials to introduce electric vehicles and charging points if they are not yet available within the country. However, it should form a main point of focus as it is essential for the introduction of eMobility. A plan should be developed how to obtain electric vehicles and charging points, either via import or via the development of the local market, in collaboration with the national government and/or potential EV value chain actors. This is important as it prevents illegal charging points and conversion of traditional vehicles to EVs, as this is not feasible in the long run and can pose safety hazards.

15. The availability of complementary technology

Stimulate the physical infrastructure regarding complementing technologies: local policy makers should be aware of the choices they make not only regarding eMobility but also regarding complementary and competing technologies. As there are only so many resources available, there should be a specific focus on eMobility (linked to the specific drivers and targets related to sustainable mobility, see F1). When there is no complementary technology, this can form a barrier for eMobility and should be taken into account for example by making financial resources available for Knowledge Development or lower the costs of the import of essential complementary technologies. When the latter are identified, this eases the introduction of eMobility which can make use of the existing situation and resources.

16. The presence of consistent energy supply (strength and stability of the grid) needed for eMobility

Stimulate the physical infrastructure relating to energy. It is not possible to immediately influence the consistency of the energy supply as local policy maker. Insights in the amount of energy,

however, can form a starting point for eMobility and shows the relevance of the involvement of the energy department. If it scores low, the involvement of the energy sector and energy department is of high importance. Furthermore, if there is no consistent energy supply, resources should be made available to improve the local situation (e.g. a buffering station or a diversifying energy sources).

17. The presence of renewable sources for the energy supply needed for eMobility

Stimulate the physical infrastructure relating to renewable energy. It is not possible to immediately influence the source of energy for eMobility as local policy maker. Insights in the source of energy can, however, form a starting point for eMobility and shows in what way it will contribute to certain drivers of eMobility. On the other hand, renewable energy can also form a barrier as it is unstable which should be taken into account during the introduction of eMobility as well.

18. A supporting geographical and climatological environment for eMobility

The stimulation of the physical infrastructure relating to the geographical and climatological conditions is not possible. Insight in these conditions, however, is essential as it influences the choice and use of electric vehicles. The optimal geographical and climatological conditions differ per vehicle, vehicle use and per battery. When the local conditions are in general unfavorable for EVs (very hot, very cold, altitude differences, large distances to be covered), R&D on the adaptation to the local context becomes more important as well as the choice of the kind of vehicles.

19. The presence of experts with knowledge, capabilities and skills relating to eMobility

Stimulate and organize participation of actors relating to eMobility and create space for their capability and skills development. If the precondition scores low, it is recommended that actors should be educated to gain knowledge about eMobility and related subjects. This includes both the technical R&D side of eMobility, as well as the system around eMobility (e.g. the local use of vehicles and local conditions) and the practical deployment of EVs (e.g. maintenance). If the precondition scores high, the identified experts should be involved from the pre-development phase of eMobility.

F3. Knowledge Development

Policy implications & recommendations for F3 Knowledge Development

Knowledge Development is key for the roll out of eMobility. This system function therefore includes all activities focused on learning and Knowledge Development on eMobility and related subjects. When the system function is weak, it implies that knowledge on eMobility is lacking or very limited, because the research & development is focusing on other technologies or because there are no actors with some knowledge on eMobility (or related subjects). This directly influences the diffusion of knowledge as well as the Guidance of the Search as a lack of knowledge will not lead to commitment or diffusion of the technology. To stimulate the development of knowledge, the following general policy measures are proposed:

*** Stimulate Research & Development (R&D):**

R&D of various (public and private) actors should be encouraged. However, it should be noted that within this system function the aim is specifically to generate knowledge, not to stimulate Entrepreneurial Activities.

Furthermore, as eMobility connects different fields of knowledge, knowledge should be developed on mobility, energy and ICT related subjects and the combination of those three. The stimulation of technology and Knowledge Development through R&D programs relating to eMobility (i.e. charging infrastructure, intelligent transport models, energy systems, range and performance of battery, development of prototypes) as well as learning activities around marketing, usage, consumer preferences etc. can help to develop the technologies needed for the diffusion of eMobility.

*** Set- up demonstration and pilot projects:**

The adaptation of the technology to the local context is crucial for its diffusion. Feasibility studies, experiments, pilots and demonstrations regarding electric vehicles, charging infrastructure, the geographical and climatological context, ICT applications and the energy system can help to create a fit within the local context.

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

20. Insights in the existing knowledge about eMobility

Stimulate the knowledge infrastructure: If there is no- or a low level of knowledge relating to eMobility, investments should be made in R&D (e.g. carrying out pilots projects) through programs and funds. When there is already some activity, local policy makers should build upon the existing knowledge of eMobility.

21. The presence of R&D institutes performing research on eMobility

Stimulate & organize the participation of R&D institutes and create space for their capacity development: local policy makers should make use of the existing actors with knowledge about (subjects related to) eMobility which can help the development and diffusion of eMobility. If the precondition scores low, local policy makers should stimulate R&D institutes to perform research on eMobility, also making sure it is open access information. A low level of local knowledge also implies that outside knowledge (international or national) is more likely to play a role. Furthermore, R&D institutes performing research on competing technologies can hinder the Knowledge Development of electric vehicles (due to limited resources). Local policy makers should be aware of these hindering funds and if possible, stimulate research on eMobility or try to combine the existing knowledge with eMobility. When this precondition scores positive, local policy makers can involve these actors as of the start which enhances the feeling of ownership, increases the knowledge base and increases the embeddedness of the technology within the local innovation system.

22. The presence of actors from the potential EV value chain stemming from the automotive industry with knowledge about eMobility

Stimulate & organize the participation actors from the automotive sector who already have some connection with eMobility and create space for their capacity development: Local policy makers should make use of the existing actors with knowledge about (subjects related to) eMobility which can help the development and diffusion of eMobility. Therefore, when this precondition scores positive, local policy makers can involve these actors as of the start which enhances the feeling of ownership, increases the knowledge base and increases the embeddedness of the technology within the local innovation system. If these actors are not present, local policy makers should be aware of the fact that the level of knowledge of the automotive industry is very low and has to be developed from scratch, needing more support and involvement through e.g. awareness raising of the business opportunities or creating a viable business case for the automotive industry via (non-) financial incentives.

23. The presence of actors from the potential EV value chain stemming from the ICT sector with knowledge related to eMobility

Stimulate & organize the participation actors from the ICT sector who already have some connection with eMobility and create space for their capacity development. Local policy makers should make use of the existing actors within the ICT sector with knowledge about (subjects related to) eMobility which can help the development and diffusion of eMobility. Therefore, when this precondition scores positive, local policy makers can involve these actors as of the start which enhances the feeling of ownership, increases the knowledge base and increases the embeddedness of the technology within the local innovation system. If these actors are not present, local policy makers should be aware of the fact that the level of knowledge at the level of the EV value chain is low and should ensure awareness building measures of the business opportunities which has a more prominent role when there is little knowledge in place.

24. The presence of actors from the potential EV value chain stemming from the energy sector with knowledge related to eMobility

Stimulate & organize the participation of actors from the energy sector who already have some connection with eMobility and create space for their capacity development: local policy makers should make use of the existing actors within the energy sector with knowledge about (subjects related to) eMobility which can help the development and diffusion of eMobility. Therefore, when this precondition scores positive, local policy makers can involve these actors as of the start which enhances the feeling of ownership, increases the knowledge base and increases the embeddedness of the technology within the local innovation system. If these actors are not present, local policy makers should be aware of the fact that the level of knowledge at the level of the EV value chain is low and should ensure awareness building measures of the business opportunities which has a more prominent role when there is little knowledge in place.

F4. Knowledge diffusion and networks

Policy implications & recommendations for F4 Knowledge Diffusion & Networks

The primary function of networks is to facilitate the exchange of knowledge between all relevant actors in the innovation system. This is especially true for eMobility as it brings together multiple fields of knowledge. When the diffusion of knowledge & networks is weak, this could indicate a lack of Knowledge Development (see F3) or a lack of collaboration and networks for the knowledge to diffuse. This has negative implications for the Guidance of the Search and Entrepreneurial Activities as knowledge does not reach the right persons. The following policy measures are suggested:

*** Create knowledge sharing opportunities:**

There should be knowledge exchange opportunities in the form of conferences, events, meetings, (online) platforms etc. for heterogeneous actors to come together, share knowledge and build up their network.

*** Promote open access knowledge**

Generated knowledge should be open access (as much as possible) as this accelerates the build-up of knowledge on eMobility and prevents double work. The local government can play an important role in the stimulation of open access knowledge through their involvement in research networks, public-private partnership etc. but also as launching customer or participant in pilot projects for Knowledge Development, ensuring that this knowledge is open access.

*** Stimulate collaboration between heterogeneous parties:**

Collaboration between heterogeneous parties is essential for the development and diffusion of eMobility, as eMobility cuts across different sectors and levels. Examples of the kind of networks, collaboration & partnerships are: cross- sectoral partnerships (i.e. procurement consortia with players in- and outside the traditional automotive sector), collaboration between different governmental departments within and between the local & national government, public-private programs (i.e. cost sharing programs; research networks) with an active dialogue between private and public parties. The local government can have an active role in the creation of the above mentioned networks through the facilitation of information exchange and the financial support for collaborative programs.

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

25. Knowledge exchange regarding eMobility

Stimulate the knowledge exchange by the occurrence of interactions: local policy makers should enable knowledge exchange as off the first phase of development, thereby including the different stakeholders (i.e. local government, potential actors from the eMobility chain, R&D institutes). This can be done by organizing or facilitating meetings, platforms, events, conferences and/or meetings regarding eMobility but also through cooperative research programs, technology transfer and

debates. Knowledge exchange accelerates the development and diffusion of eMobility, prevents double work and helps to form the right knowledge networks.

26. Access to generated knowledge on eMobility

Stimulate the knowledge infrastructure: the knowledge generated should be made public as much as possible. If this precondition scores low, this means that there is either little knowledge to share or the knowledge is not available (open access). For the former, this means stimulating Knowledge Development. For the latter, this implies more collaboration between stakeholders and more knowledge sharing. The local government can play a facilitating role in this development by enhancing knowledge exchange as well as providing information that is open access (e.g. through the collaboration with R&D institutes).

27. Collaboration between potential EV value chain actors

Stimulate the occurrence of interactions between potential EV value chain actors to facilitate Knowledge Development and diffusion as off the first phase of eMobility. This can be done in the form of (online) platforms, workshops, meetings, events or conferences but also through cooperative research programs, technology transfer programs and debates.

28. Collaboration between potential EV value chain actors and the local government

Stimulate occurrence of interactions between the local government and potential EV value chain actors to facilitate Knowledge Development and diffusion as off the first phase of eMobility. This can be done in the form of (online) platforms, workshops, meetings, events or conferences, stimulating the interaction and knowledge exchange between actors, but also through cooperative research programs, public-private partnerships, technology transfer and debates.

29. Collaboration between potential EV value chain actors and R&D institutes

Stimulate occurrence of interactions between R&D institutes and potential EV value chain actors to facilitate Knowledge Development and diffusion as off the first phase of eMobility. This can be done in the form of (online) platforms, workshops, meetings, events or conferences, stimulating the interaction and knowledge exchange between actors, but also through cooperative research programs, public-private partnerships, technology transfer programs and debates.

30. Collaboration between the local government and R&D institutes

Stimulate occurrence of interactions the local government and R&D institutes to facilitate Knowledge Development and diffusion as off the first phase of eMobility. This can be done in the form of (online) platforms, workshops, meetings, events or conferences, stimulating the interaction and knowledge exchange between actors, but also through cooperative research programs, public-private partnerships, technology transfer programs and debates.

31. Collaboration between local governmental departments regarding eMobility

Stimulate occurrence of interactions between the different departments touching upon eMobility to facilitate Knowledge Development and diffusion as off the first phase of eMobility. This can be done in the form of (online) platforms, workshops, meetings, events or conferences, stimulating the

interaction and bringing together government officials from different departments, but also through cooperative research programs and debates with actors stemming from different departments.

32. Collaboration between local and national government departments regarding eMobility

Stimulate occurrence of interactions between local and national government officials touching upon eMobility to facilitate Knowledge Development and diffusion from the first phase of EV. This can be done in the form of (online) platforms, workshops, meetings, events or conferences, stimulating the interaction and knowledge exchange between national and local government officials, but also through cooperative research programs.

F5. Entrepreneurial Activities

Policy implications & recommendations for F5 Entrepreneurial Activities

Entrepreneurs are crucial for the development and diffusion of an innovation such as eMobility. Entrepreneurial Activities influence the development and diffusion of knowledge, the Guidance of the Search and the legitimacy of eMobility. With entrepreneurs entering the market, new knowledge is developed, a stimulant is given to eMobility influencing the general steering of the innovation and legitimacy is created as it is seen by these entrepreneurs as a legitimate choice for mobility and this mind-set can be adopted by other actors. When the system function is weak, this means that few or homogenous actors have been identified. The barriers to enter the market and the resistance to the innovation should be taken away. To do so, incentives can be provided for entrepreneurs from various sectors to enter the market and for demonstration projects and experiments to be carried out by actors from the EV value chain. The following policy advice is therefore suggested:

*** Create opportunities for entrepreneurs and make room for Entrepreneurial Activities:**

Local policy makers should have insights into the local situation regarding innovation and entrepreneurship. New entrepreneurs and incumbent companies should be stimulated to adopt eMobility as their (one of their) product(s). (Successful) companies that are involved from the beginning could be portrayed as frontrunners and examples and stimulate others to enter the market. Furthermore, entrepreneurs need space to experiment with eMobility. Therefore, funds for demonstrations projects, experiments and pilots should be made available. Incentives to generate this boost are subsidies and funds for innovations which eMobility can use, funds for the set-up of new businesses as well as business start-up support services (e.g. increasing ease of registration, provision of basic information) and public-private programs and partnerships. Also, stimulating regulation and legislation and (non-) financial incentives for eMobility in general can encourage entrepreneurs (see F6 Market Formation).

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

33. A high level of innovation in the country

Stimulate knowledge infrastructure: Local policy makers are not able to directly influence the degree of innovation. However, awareness about the general level of innovation can help local policy makers to gain insights in the difficulty or ease of the introduction of eMobility. More policy support is needed when innovations are not supported generally. For example, creating (non-) financial incentives such as funds for R&D on innovation or support for start-ups with an innovative idea.

34. A high degree of entrepreneurship (culture) of the country

Stimulate the human infrastructure, in other words the skills and capacities of entrepreneurs: Local policy makers are not able to directly influence the degree of entrepreneurship. However, insights in the degree of entrepreneurship can help local policy makers to steer policy measures in the right direction. When this precondition scores low, local policy makers can attempt to raise awareness of the business opportunities provided by eMobility for start-ups, entrepreneurs or create incentives to provide a viable business case or provide business support services. The former could be achieved by providing more information on the advantages of eMobility, knowledge sharing via events and conferences etc. (see F1 and F4). The latter could be through financial and non-financial incentives (see F6).

35. The presence of a niche market for eMobility

Stimulate infrastructure, in this case the formation of niche markets: The local government can support the development and diffusion of eMobility through the creation of protected spaces in which the innovation can develop. When there are no niche markets in place which relate to eMobility, this implies the local government that more effort needs to be put in the development of niche markets for the advancement of eMobility. This can be done through financial and non-financial incentives (see F6) to stimulate both the market itself as entrepreneurial activities.

36. Presence of potential EV value chain actors from the automotive sector with an interest in eMobility

Stimulate & organize the participation of actors stemming from the automotive sector: When actors from the automotive industry have a negative or neutral attitude towards eMobility, it will take more time and effort for local policy makers to get them on board. local policy makers can attempt to raise awareness of the business opportunities provided by eMobility for the sector or create incentives to provide a viable business case. The former could be achieved by providing more information on the advantages of eMobility, knowledge sharing via events and conferences etc. and enhancing collaboration between the energy, automotive and ICT sector. (Successful) pilot projects can also form a stimulation for the industry to get involved. The latter could be financial and non-financial which can enhance the willingness of companies.

37. Presence of potential EV value chain actors from the ICT sector with an interest in eMobility

Stimulate & organize the participation of relevant actors stemming from the ICT sector. It is important to have the IT companies on board as of the start of the process as it facilitates the connection between the energy system and EVs as well as for the monitoring and evaluation of the vehicle and infrastructure use. When this precondition scores low, local policy makers can attempt to

raise awareness of the business opportunities provided by eMobility for the ICT sector, the relevance for the ICT sector to be the link between the energy and automotive sector or create incentives to provide a viable business case for the ICT sector. This could be achieved by providing more information on the advantages of eMobility, knowledge sharing via events and conferences etc. (see F1 and F4), or by providing financial and non-financial which can enhance the willingness of companies. Furthermore, stimulating collaboration between the energy, automotive and ICT sector can be done through public-private partnerships and collaborative research programs. (Successful) pilot projects can also form a stimulation for the industry to get involved.

38. Presence of potential EV value chain actors from the energy sector

Stimulate & organize the participation of relevant actors from the energy sector. It is important to have the energy companies on board as of the start of the process, as the deployment of EVs should be balanced with the deployment of charging infrastructure. When actors from the energy sector have a negative or neutral attitude towards eMobility, it will take more time and effort for local policy makers to get them on board and therefore to diffuse eMobility. When this precondition scores low, local policy makers can attempt to raise awareness of the business opportunities provided by eMobility for the energy sector or create incentives to provide a viable business case for the energy sector. This can be achieved by providing more information on the advantages of eMobility, knowledge sharing via events and conferences etc. (see F1 and F4), enhancing collaboration between the energy, automotive and ICT sector, e.g. through public-private partnerships, and providing financial and non-financial incentives (see F6). (Successful) pilot projects can also form a stimulation for the energy industry to get involved.

F6. Market Formation

Policy implications & recommendations for F6 Market Formation

The Market Formation function involves activities that contribute to the creation of demand and supply for the emerging technology. A weak Market Formation negatively influences the Guidance of the Search, and therefore the willingness and activities of key actors. When the system function scores low, it indicates hindering or impeding regulation and legislation in place. Furthermore, it signals that the competitiveness of eMobility with regards to traditional mobility is low, which hampers the diffusion of eMobility. Even though Market Formation does not form a large part of the first development phases of an innovation system, insights in these barriers can help policy makers to overcome them as of the beginning of the process. To do so, the following policy measures are suggested which support early market developments:

* Use financial incentives to encourage eMobility and discourage traditional mobility:

Financial incentives such as subsidies and funding can be used to create a protected market for eMobility in which it can further develop. Possible financial incentives (both demand as supply side) include: funding for electric vehicles (components) and charging infrastructure development, subsidies for corporate EVs (taxi, lorries, delivery and lease companies), funding for the placement of charging infrastructure, funding for alternative fuels, funding through public- private partnerships

and programs, seed funds, customized electricity pricing (e.g. free recharging for EV), grants for demonstration projects and testing possibilities, subsidy on the purchase of an EV, a vehicle purchase rebate, free parking for EV, reduced lease rates and depreciation arrangements for EVs. In addition, a simple representation of the incentives, for example posted on government websites in an understandable language for consumer and market players, should be made available to help stimulate communication and awareness. Lastly, incentives reducing purchasing costs are more attractive to consumers than incentives received at a certain point in the future.

*** Use tax measures to encourage eMobility and discourage traditional mobility:**

Tax measures, for both the demand side as supply side, can also be used to create a protected market. Possible tax measures are: exemptions or lower surcharge on registration tax, ownership tax, road taxes, income taxes, license fees, VAT, annual circulation tax on vehicles, company vehicles tax, toll roads, energy tax, tax for alternative fuels, deductible/exemption of tax on loans or investments related to innovations such as eMobility. Also, tax measures on conventional fuels and vehicles can be increased while EVs are exempted from these charges.

*** Create conditions and incentives through regulation and legislation for eMobility to develop:**

Development of stimulating general regulation and legislation refers to i.e. adapting building codes (energy; charging points), (renewable) energy (electricity) standards, introduction of (low) emission standards, environmental zones, stricter fuel regulations and requirements, regulation for charging infrastructure and the design protocols, the placement of vehicles in company, rental, and car-sharing fleet, and government fleet, standards and codes of practice for vehicles and charging infrastructure. Incentives related particular to eMobility are i.e. special parking spots for EV, parking permits for EV, dedicated taxi ranks, reduced waiting time for parking permits, use of restricted lanes by EV users (creating an EV corridor/avenue), exemption from vehicle emission inspection programs, expedited permitting & installation of EV and transferable license plates. Furthermore, EVs can be included in tender procedures or public procurements while increasing the period of these tenders/concessions (for EV to win back the investment). The latter measures can be seen as large-scale demonstration programs to help kick-start the market

*** Focus the development of EV:**

The local government should focus on areas with promising market segments, business cases and earning potential of eMobility, which depend on the position of the country regarding mobility, automotive production sector, energy and ICT sector. This can increase the chance for acceleration of the first diffusion phase of eMobility. Furthermore, it can stimulate potential leading customers i.e. tourism industry, emission free public transport, emission free cooperate transport (i.e. taxi services, delivery services and lease companies) or itself as launching customer through the electrification of the local government fleet. Additionally, the introduction and phasing out of the incentives should be communicated properly. For a larger market transition, long term and consistent incentives are essential to decrease uncertainty within the market.

It should be noted that the creation of (financial) incentives should be done carefully. Governments need to enable EV related business to develop but should be careful not to distort markets excessively with unsustainable levels of financial incentives. It should be clear where the tax burden

lies before starting with financial incentives and the relation between expenses and income. Furthermore, it should not be at the expense of social investments and it should be clear where the money is coming from. Also, it should as of the start of the process be clear when the incentives should be build-up and be dismantled as this gives actors time to respond to the development. However, the timing and the particular mix of incentives differs very much per context.

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

39. A competing fuel price for eMobility compared to (local) traditional vehicles

Stimulate financial infrastructure to increase the competitiveness of EVs: For local policy makers, it is important to have insight in the compatibility of electric vehicles compared to traditional vehicles as this has a big impact on the diffusion of EVs and therefore influences the necessary policy measures. The purchasing price makes up a large part of the competitiveness of EVs as it influences the demand and supply of EVs. When the precondition is scored positively, local policy makers can use this information to promote eMobility. When it scores negatively or neutral, measures can be taken to create a positive business case for eMobility i.e. through financial and non-financial incentives (e.g. subsidies for purchasing or manufacturing of EVs).

40. A competitive cost structure of EVs compared to (local) traditional vehicles (focus on purchasing price)

Stimulate financial infrastructure to increase the competitiveness of eMobility: For local decision makers, it is important to have insight in the compatibility of electric vehicles compared to traditional vehicles as this has a big impact on the diffusion of EVs and therefore influences the necessary policy measures. The fuel price makes up a large part of the competitiveness of EVs. When the precondition is scored positively, local policy makers can use this information to promote eMobility e.g. through online cost-benefit tools for consumers. When it is scored negatively, financial (e.g. differentiation in tax rate) and non-financial measures (e.g. use of restricted lanes for EVs) can be taken to create a positive business case and attitude towards eMobility.

41. Presence of subsidies which could positively influence the introduction of eMobility

Stimulate financial infrastructure, focused on subsidies: Subsidies are difficult to influence for local policy makers and are a complex policy tool. Their feasibility very much depends on the local context. The recommendation is therefore to make use as much as possible from existing subsidies, for example subsidies for subjects related to eMobility, such as air quality improvements, and introduce new subsidies when possible.

42. Presence of taxes which could influence the introduction of eMobility

Stimulate financial infrastructure, focused on taxes. Taxes are difficult to influence for local policy makers and are a complex policy tool. Their feasibility depends on the local context. The recommendation is therefore to make use as much as possible from existing taxes which hamper the use of traditional vehicles, for example higher taxes on traditional fuels, and introduce new taxes when possible which stimulate (directly or indirectly) eMobility.

43. Regulation/legislation positively influencing the introduction of eMobility regarding transportation & mobility and the automotive sector

Secure the presence of positive regulation and legislation regarding mobility in general: Insights in the regulation and legislation in place before eMobility helps to steer policy measures in the right direction and help policy makers to understand the transport system and its barriers/opportunities. Local policy makers can influence the regulation/legislation regarding transportation and the automotive sector in a local context. They can create (protective) space for eMobility to develop, for example by creating regulations which stimulate EVs (e.g. environmental zoning, free parking space, use of restricted bus lanes etc.).

44. Regulation/legislation positively influencing the introduction of eMobility regarding import

Secure the presence of positive regulation and legislation regarding import of (components of) EVs and charging infrastructure. Local policy makers are not able to influence the regulation/legislation regarding import of vehicles and components when this decided upon on a national level. However, insights in the regulation and legislation of import help to steer policy measures in the right direction and help local policy makers to understand the context in which eMobility is being introduced (e.g. with high import tariffs for components of EVs, a higher subsidy might be necessary for EVs).

45. Regulation/legislation positively influencing the introduction of eMobility regarding electricity

Secure the presence of positive regulation and legislation regarding electricity. Local policy makers have limited influence on the regulation/legislation regarding electricity, especially when this is decided upon a national level. However, insights into the regulation and legislation of the energy sector help to steer policy measures in the right direction and help policy makers to understand the energy system and the barriers and opportunities within this system (e.g. energy standards).

F7. Creation of Legitimacy

Policy implications & recommendations for F7 Creation of Legitimacy

The Creation of Legitimacy will lead to the acceptance of eMobility as method for sustainable mobility and in the long run it can become the norm for transportation. If the system function is weak, however, there is resistance towards this change and/or the lobby for the advancement of eMobility is weak. It indicates that the actors lobbying for eMobility do not have the power to change the conventional ways, that incumbent companies do not have an interest in eMobility and/or that there is uncertainty about eMobility at the consumer side. To counteract this barriers, the following policy advice is proposed:

*** Create support for eMobility:**

As discussed at F1 Guidance of the Search, eMobility should become embedded in the local context. Awareness about its opportunities is therefore an essential part of the Creation of Legitimacy and support for eMobility (see F1). Furthermore, frontrunner companies can lead by example and can be portrayed as ambassadors for eMobility.

Additionally, testing opportunities (e.g. trial programs, showcase pilots) for consumers can be an effective policy instrument as this reduces uncertainty and shows the advantages of the electric propulsion. When done properly, this can lead to an increase in confidence and certainty about the use of EVs. Furthermore, the resistance towards eMobility should be decreased, i.e. by creating business opportunities of eMobility (see F5). The involvement of all relevant stakeholders from the beginning, including those opposed to eMobility, can create a sense of inclusion and ownership and can help to overcome resistance. Lastly, for an active lobby for eMobility, advocacy coalition groups should be formed to create a stronger voice for eMobility together. The local government can play a facilitating role in this, by bringing actors together through conferences, platforms but also via partnerships for eMobility etc.

Below an overview is presented of the scores of the individual preconditions as well as the corresponding policy implications & brief recommendations:

46. The presence of lobbying parties advocating in favor of eMobility

Lobby activities do not fall under the direct influence of local policy makers. Insights in the existing lobby for eMobility can help local policy makers understand the necessity and willingness to change towards eMobility. Furthermore, the local government can facilitate the creation of lobbies by bringing actors together to form networks and share knowledge.

47. The absence of lobbying parties advocating against eMobility

Local decision makers do not directly influence lobby activities. Insights in the existing (power of) the lobby against eMobility shows policy makers the forces which they need to counteract. They can do so by raising the awareness of the business opportunities provided by eMobility for the sector or create incentives to provide a viable business case. The former could be achieved by providing more information on the advantages of eMobility, knowledge sharing via events and conferences etc. (see F1 and F4), or through (non-) financial incentives. (Successful) pilot projects can also form a stimulation for the industry to get involved and the lobby to decrease.

48. (Powerful) Incumbent companies see the opportunities provided by EV

When several powerful incumbent companies are identified which do not support eMobility, local policy makers need to overcome this resistance by including the identified companies in the process from the beginning. They can do so by raising the awareness of the business opportunities provided by eMobility for the sector or create incentives to provide a viable business case. This could be achieved by providing more information on the advantages of eMobility, knowledge sharing via events and conferences etc. (see F1 and F4), or through (non-) financial incentives. (Successful) pilot projects can also form a stimulation for the industry to get involved and the lobby to decrease. Furthermore, incumbent companies that do see the opportunities provided by eMobility can be supported, and can be used as ambassador for the innovation, using their frontrunner status as example to others.

49. A high level of confidence and certainty regarding the use of eMobility of the consumer

Secure the feeling of confidence and certainty regarding the potential of eMobility at the consumer side. When there is a high level of doubt, a stronger case for eMobility should be made, raising

awareness of the opportunities eMobility provides but also being honest about the challenges (see also F1). (Successful) pilot projects can increase the confidence of consumers and can be used as example for other consumers.

Annex II Different approach to the TIS framework

Several studies about the TIS approach or using the TIS approach adopt different focuses, resulting in a variety of identified and applied multiple steps to be included in the approach, beginning from different starting points of the analysis and using various structural factors.Table 15 This annex provides a brief overview of focus, steps and structural factors identified[5].

Source	Focus	First step	Structural factors
Bergek et al. (2008)	Operationalization of the functional approach (six steps)	Defining the TIS including phase of development	Actors, networks, institutions
Bergek et al. (2010)	Functional analysis – identifying blocking and inducing mechanisms (two levels of key activities namely structural factors and system functions), illustrated by two cases	X	Actors, networks, institutions
Alkemade et al. (2007)	Components and structure of a TIS linking it to system functions using a case study	Structural factors	Actors, networks, institutions
Alkemade & Hekkert (2009)	Exploration of different phases of development of a TIS	X	X
Eveleens et al. (2015)	Structural – functional analysis	Geographical analysis	Actors, networks, institutions
Hekkert et al. (2007)	Focus on the system function analysis	X	Actors, networks, institutions
Hekkert & Negro (2009)	Dynamics of a TIS	X	Actors, networks, institutions
Hekkert & Ossenbaard (2010)	De innovatiemotor (six steps using the TIS approach)	Defining a TIS (with step two being its phase of development)	Actors, networks, institutions
Hekkert et al. (2011)	Analysis of the steps within a system analysis for policy makers (seven steps)	Determining policy goal (followed by demarcation and after determining phase as separate steps)	Actors, networks, institutions, technology
Hellsmark et al. (2016)	Identification system strengths through a case study (linking weaknesses and strengths to functions)	Technology overview	Actors, networks, institutions, technology
Markard & Truffer (2008)	Developing a TIS approach that allows integrating the multi-level framework	System delineation	Actors, networks, institutions
Negro (2007)	Case study TIS for dynamics of a TIS	Historical overview used for systems functioning	Actors, networks, institutions
Negro et al. (2008)	Case study TIS using a functional analysis	Technology overview	Actors, networks, institutions
Negro et al. (2011)	Identification and review system problems	X	X

[5] The system functions have not been included as there is too much variation between them. See section 2.3.4 for an overview of the system functions applied in this research.

Suurs (2009)	Identification of motors of innovation	System boundaries	Actors, institutions and technologies
Suurs et al. (2015)	TIS based cluster analysis	Description regional structure	Resources, Actors, Technologies, Institutions,
Van Alphen et al. (2011)	Case study TIS on renewable energy technologies	Start with actor analysis	Actors, networks, institutions
Wieczorek et al. (2012)	Functional- structural analysis	Structural dimensions	Actor, institutions, interactions and infrastructure
Wieczorek et al. (2013)	Case study Wind energy	Functional analysis (using structural factors)	Actor, institutions, interactions and infrastructure

Table 15 Overview of the several steps and focus identified in the TIS literature

Annex III Input of the interviews

The following experts have been consulted for the identification and validation of the preconditions.

Name	Organization	Function	Date of interview
Bernhard Truffer	Swiss Federal Institute of Aquatic Science and Technology (eawag) and the Copernicus Institute of Sustainable Development	Professor and researcher	28th January 2016
Pierpaolo Cazola	International Energy Agency and the Electric Vehicle Initiative	Senior energy and transport analyst	8 March 2016
Cornie Huizenga	Partnership on Sustainable Low Carbon Transport (SLoCaT)	Secretary General	22nd March 2016
Julia Williams-Jacobse	Independent consultant electric mobility	Previously project manager of Electric mobility at the Ministry of Economic Affairs	22nd March 2016 & 24 March 2016
Joeri Wesseling	Centre for Innovation, Research and Competence in the Learning Economy (CIRCLE), Lund University in collaboration with Utrecht University	Post-doctoral Researcher	24th March 2016
David Beeton	Urban Foresight	Founder and managing director	4th april 2016
Remco Mur	Royal Tropical Institute of the Netherlands	Senior advisor	12th april 2016
Sonja Munnix	Netherlands Enterprise Agency	Senior advisor	19th April 2016

The following statements have been extracted from the interviews due to their relevance for the system functions and have been (partly) translated into preconditions and/or their related components.

System function	Identified preconditions and/or policy measures	Source
F1 Guidance of the Search	Have to ask yourself whether EV is integrated in the planning structure of the country. A pilot in a country where a low-medium strategy is present for EV, there is a lower change that a next step will result in the upscaling of EVs.	Huizenga
F1 Guidance of the Search	It is of importance to have a short, medium and long term policy, having a specific time horizon is important.	Huizenga
F1 Guidance of the Search	Targets can help to adjust policy for both the short and the long term.	Huizenga
F1 Guidance of the Search	When there is no support for sustainable mobility in general, EV will not diffuse .	Huizenga

F1 Guidance of the Search	Need a champion/enthusiastic person in place who can build a compelling case or seek the information for this case. A lot of city and countries where this has happened..	Beeton
F1 Guidance of the Search	As policy maker you have to deal with a dynamic set of choices and considerations, in collaboration with other parties with influence when it comes to eMobility.	Williams-Jacobse
F1 Guidance of the Search	The person who bares the responsibilities for the introduction of eMobility should also have the capabilities, possibilities and power to structurally influence the essential elements needed to carry out the policy.	Williams-Jacobse
F1 Guidance of the Search	Make sure that the desired strategy falls in the hands of persons with steering power, to make sure that all essential structural elements are taken care of.	Williams-Jacobse
F1 Guidance of the Search	As policy maker, you want to declare where you will be in 5 or 10 years. But in reality this is not the case. Continuous adaption and adjusting are necessary. This is very important to acknowledge as policy maker in advance as they can develop a policy which makes sure that they regularly have an overview of what is happening, if there are changes or barriers etc.	Williams-Jacobse
F1 Guidance of the Search	Sustainability is a long term goal. Should be clear in advance which preconditions are necessary and which barriers are hindering this process.	Mur
F1 Guidance of the Search	Ideally, the policy makers also has the power to use the instruments with which he wants to shape and implement the policy.	Williams-Jacobse
F1 Guidance of the Search & F6 Market Formation	It would have been much easier for policy makers to do business with lease companies as of the beginning. It is therefore of importance to know as policy maker what the triggers are which will persuade people to use EVs. These triggers are not always in the hands of the policy makers.	Willems-Jacobs
F1 Guidance of the Search	Local policy is very much influenced by national policy & the shared mobility aspect is of importance (as this will decrease the amount of transport)	Cazola
F1 Guidance of the Search	Who do you need, where are the people calling the shots, who can carry out the changes that you want to see. And what triggers them.	Williams-Jacobse
F1 Guidance of the Search & F2 Resource Mobilization	You don´t solve the problem with the introduction of 10 electric busses. As policy maker, you want large scale adoption of eMobility. You need capabilities, knowledge and skills to do so which should be which should be developed from the start.	Mur
F2 Resource Mobilization	One of the preconditions is the financial opportunities in place which lower the initial purchasing costs. Also know who will pay for this using what kind of money.	Huizenga
F2 Resource Mobilization	It is of high importance to look at the local energy supply, you have to make sure that the eMobility will not compete with more important purposes. When there are power cuts or a shaky energy system, it takes a very specific approach to introduce EVs and good governance but this is very difficult. It depends on the specific situation whether or not eMobilty is applicable.	Williams-Jacobse
F2 Resource Mobilization	You have to match peak demand with supply. This becomes even more important when renewable energy sources are used which still have a high level of uncertainty.	Williams-Jacobse

F2 Resource Mobilization	It is important when developing policy to look at the main drivers and challenges in the economy and energy system of MICs. You can improve the situation with a grey economy and the introduction of eMobility and it will prove to be positive. But when you use the combination of renewable energy, electric vehicles and batteries, this can prove to be an opportunity for many MICs, which can support the system instead of a burden.	Williams-Jacobse
F2 Resource Mobilization	Power outlets can be found everywhere. But there might be a unstable energy system in which case it will be difficult to charge all EVs at the same time. You have to know in advance how many energy you need, if there is some kind of buffering system, a possibility for storage etc.	Williams-Jacobse
F2 Resource Mobilization	Producing sustainable electricity is of low importance when looking at the improvement of local air quality.	Williams-Jacobse
F2 Resource Mobilization	A chicken and egg situation: the role out of EVs and their infrastructure should happen simultaneously. Having a balanced introduction is very important.	Willems-Jacobs
F2 Resource Mobilization	Have to understand the business model behind the vehicles and vehicles use in the local context and how this relates to eMobility.	Willems-Jacobs
F2 Resource Mobilization	It is often hard to receive money from the international community, often promises are not kept.	Williams-Jacobse
F2 Resource Mobilization	Experimentation is often risky so there should be a possibility to cover this risk, i.e. a form of public financing which can be justified when it comes to a common goal for society.	Mur
F2 Resource Mobilization	Mobilize the right stakeholders as no individual has all of the necessary resources to introduce EV. 2 levels: the practitioner level, implementing the project + the level of influences, making EV a priority which they can unlock .	Beeton
F2 Resource Mobilization	Necessities for up/scaling: take into account the costs, what are the tariffs and taxes, there is a need for electricity, the demand and supply of energy should be balanced, is should be renewable energy in the long run, the amount of electricity needed for EVs with regard to other uses of electricity in the city.	Huizenga
F2 Resource Mobilization	You need people who can connect the charging infrastructure to the grid. Mistakes are made with this technology (even in the Netherlands). Knowledge Development is essential.	Williams-Jacobse
F3 Knowledge Development	It involves a change in hardware (the vehicles, charging infrastructure) as software (*dienstregeling and usage of vehicle which influences the type of charging i.e. continuous or opportunity)*.	Williams-Jacobse
F3 Knowledge Development	A lot of duplication of effort. Good for stimulating the market but not good for market uptake. In the MIC, there is no need for pilots. The technology has been proven so shouldn't have to be proven again. Can be used to adapt to local context.	Beeton
F3 Knowledge Development	You need demonstrations and experiments: start with adapting the technology to the local context, changing policies to fit the new technology, change incentives and policy measures, increase capacity etc. all these capacity building factors will be mapped during the experiment. This can then be scaled-up in a later phase .	Mur
F3 Knowledge Development	Need to ask in how far is R&D important in the country itself: this depends on how much the technology should be adapted in to the	Mur

	local context. It can be adapted e.g. through the conversion of existing local vehicle models.	
F2 Knowledge Diffusion & Networks	Commitments exist on different levels – e.g. urban, regional, national, international – and there should be an alignment between these levels.	Huizenga
F4 Knowledge Diffusion & Networks	For the government is to work across departments to embed it in all related policies at the local and national level.	Beeton
F4 Knowledge Diffusion & Networks	Major differences exist between national and local policies. Often the collaboration between these entities is not structured. Even in the Netherlands this is a challenge. But you need local governments, especially for EV implementation.	Munnix
F4 Knowledge Diffusion & Networks	The Netherlands is known for its so called 'poldermodel', in which all stakeholders are involved during the decision making process and implementation to create DRAAGVLAK . This is not the case in many other countries. But it does help, especially when you involve stakeholders from the beginning to lower the resistance to the technology. If you involve them from the beginning you can get them on your own side and make it theirs as well.	Munnix
F4 Knowledge Diffusion & Networks	Knowledge on level of collaboration between departments: it are not necessary the same people that would work together – might be an indicator but might be other individuals.	Beeton
F4 Knowledge Diffusion & Networks	Board from senior people from the industry coming together with ministers – macro perspective. What are missions and ambitions and visions and ambitions. Trying to create this situation, peer pressure. But these people don't have the expertise how to make these things happen. Those are the officers and practitioners on the ground who face practical challenges.	Beeton
F4 Knowledge Diffusion & Networks	There should be communication between the national and local level.	Williams-Jacobse
F4 Knowledge Diffusion & Networks	It depends on the relationship between the government and civil society actors and companies. Even in a country with a good relationship between the two, such as the Netherlands, this poses a challenge. It is difficult to tell a company what to do.	Williams-Jacobse
F4 Knowledge Diffusion & Networks	It should become an interactive process during which all actors receive ownership through collaboration, an honest process during which the challenges per actor group can be identified. This should also be handled by someone from within the process, not someone from outside.	Mur
F4 Knowledge Diffusion & Networks	The unique thing about EV is that multiple sector need to come together.	Munnix
F4 Knowledge Diffusion & Networks	It helps when ministries are working together, as you need the energy side for eMobility. The ministry of finances is very important when you want to implement financial measures. This happens in consultation with market actors and other ministries	Munnix
F5 Entrepreneurial Activities	New business models are very important for market uptake. Need a certain level of local entrepreneurial on the local level.	Beeton

F4 Knowledge Diffusion & Networks	There are many different parties and policies with the power to shape the situation. The coordination between them did not always happen smoothly in the Netherlands.	Williams-Jacobse
F5 Entrepreneurial Activities	Initially, there was some resistance at the energy companies. But currently they see the chances EV offers (especially through its connection with renewable energy)	Munnix
F5 Entrepreneurial Activities	For example, Turkey has always been a country with a large automotive sector and is using this to develop and diffuse EVs. There are many entrepreneurs involved, even though it is mostly state driven.	Munnix
F5 Entrepreneurial Activities	Innovation: when there is an issue and an opportunity to tackle it through new technology. You can experiment with it with solutions on a local scale and seeing what comes up during the experiment.	Mur
F6 Market Formation	You can also discourage other kinds of transportation and vehicles.	Williams-Jacobse
F6 Market Formation	In the Netherlands, all benefits that we give are a deviation of the basix tax. These deviations exists for a particular period of time and seeze to exist afterwards. In Norway, they have a better system and a long term policy including adaptation. They have begun building the stimulating incentives for EV and discouraging measures regarding other transportation methods and when EVs is up and running, they will start dismantling these initiatives as planned from the start.	Williams-Jacobse
F6 Market Formation	Charging pollution, financial measures etc. It should be made more convenient for people.	Cazola
F6 Market Formation	One way is to have an active dialogue with parties that own big fleets which can be converted to EVs. You would rather have a form of collaboration as a local policy maker, than to steer this from 1 place.	Williams-Jacobse
F6 Market Formation	Environmental targets are often, especially in developing countries, quite a weak motivator. More importantly is industrial policy (very strong motivator, the one that is mobilizing the change forward) for their own future industries. And one of the elements to push their own industry is deployment policy.	Truffer
F6 Market Formation	We don't have a large automotive sector in the Netherlands, so producing private electric vehicles did not do so well (with the exception of Tesla). It is therefore important to know what the local situation is.	Williams-Jacobse
F6 Market Formation	You should be careful with stimulating measures: is it politically possible, where does the money come from and for what is it used exactly, need knowledge on the entrepreneurial climate, on the tax system, on the drivers of the development etc.	Williams-Jacobse
F6 Market Formation	You should reduce the differences in costs between traditional vehicles and cleaner vehicles, as reward for this improvement. However, when you use subsidies for this, money from one group is shifted to another group. You should be careful with this as you don't want tesla drivers to get the money used for child benefits for example.	Williams-Jacobse
F6 Market Formation	What makes up the forces of influence. Where is the tax burden put and how can you change this (shifting the tax from one vehicle to the other.	Williams-Jacobse

F6 Market Formation	There is no link between revenues and costs within the Netherlands. You cannot say that you will use less tax benefits to finance a subsidy. This is completely separated. This is important for a policy maker to take into account and to know whether or not you can influence it.	Williams-Jacobse
F6 Market Formation	You have to have insights in the tax pressures on e.g. cars, import, energy, technology etc.	Mur
F6 Market Formation	Should be aware of the business case of EVs and look also where the losses in the economy are made.	Williams-Jacobse
F6 Market Formation & F3 Knowledge Development	The business case of EVs: so many triggers and structural elements which do not relate well to EVs. A lot of effort and attention needs to go to this. Have to know the types of vehicles and the model behind it, and how this relates to EV. When this is not positive, you can forget about EV being diffused.	Willems-Jacobs
F7 Creation legitimacy	You have to know where the losses will be, for example at a company like Shell if we all transfer to electric vehicles. The green economy is growing while the grey economy is shrinking.	Williams-Jacobse
F7 Creation legitimacy	It is important to know where the lobbies are.	Williams-Jacobse
F7 Creation legitimacy	As a policy maker you should know who has a lot of power: for example Tata motors has a lot of power in India and therefore should be connected to the plans to get them on board an giving them a leading role.	Mur
F7 Creation legitimacy	Is there something that the different actors have in common. When the interest are all going against each other it will be impossible to get everybody on board. It could be a strategic move for them to lobby against the innovation and they should therefore be on board.	Mur
F7 Creation legitimacy	Often, there is a lot of resistance from the conventional, incumbent industry against something new or an innovation .	Munnix
F7 Creation legitimacy	An advantage of the Netherlands is that we don't have a large automotive industry which would be against EV. This is one of the things that gave us our frontrunner status.	Munnix
F7 Creation legitimacy	The starting question is: who are you and where are you placed in the system and where can you influence the system, what story fits. You should both have influence and power.	Willems-Jacobs
F7 Creation of Legitimacy	You should know in advance who has power, and connect them to the development, for example by giving them a role of a pioneer and example.	Williams-Jacobse
Overall tool	It would have gone smoother in the Netherlands if we had had more time in the beginning to map the entire system and would have know where the influence and power was. We would have liked to know what has changed with regard to previous governance, what is working with us and working against us, what kind of institutions do we have etc. When you have the time and a broad perspective to ask the right question, you can take the time to map the path you want to take. For a policy maker it is essential when and where a window of opportunity opens and to already know how to respond.	Williams-Jacobse

Annex IV Input of the brainstorm session

The following statements of the brainstorm session have been used as input for the identification and operationalization of preconditions, as well being used for the policy implications & recommendations per system function and per precondition.

System functions	Input EVConsult (10 experts)	Kind of factor
External factor	Urbanization	Inducing factor
External factor	Low oil price	Blocking factor
External factor	National GDP dependent on oil and gas production	Blocking factor
External factor	Economic crisis	Inducing factor
External factor	A scandal like the diesel cars of VW	Inducing factor
External factor	The Acceleration of global warming	Inducing factor
External factor	Sustainable energy supply	Inducing factor
F1 Guidance of the Search	Active adaptation program Amsterdam	Inducing factor
F1 Guidance of the Search	Prins Maurits has stimulated EV	Inducing factor
F1 Guidance of the Search	Awareness about the energy transition	Inducing factor
F1 Guidance of the Search	Campaigns which show the opportunities and importance of EV	Inducing factor
F1 Guidance of the Search	Too little correlation between EVs and renewable electricity	Blocking factor
F1 Guidance of the Search	Not a priority on the political agenda	Blocking factor
F1 Guidance of the Search	Too little commercial stakes for EV which results in too little campaigns, commercials etc.	Blocking factor
F1 Guidance of the Search	No national long term comprehensive vision	Blocking factor
F1 Guidance of the Search	The NGO Natuur&Milieu has pushed the prime minister at the time Balkenende + de Jager (minister of finance) to support EV (financially)	Inducing factor
F1 Guidance of the Search	Progressive minds in the Netherlands	Inducing factor
F1 Guidance of the Search	A clear vision expressed through policy goals and targets	Inducing factor
F1 Guidance of the Search	The NL aims for a frontrunner position regarding eMobility	Inducing factor
F1 Guidance of the Search	All public transport vehicles and targeted transport should be converted to EV	Inducing factor
F2 Resource Mobilization	A reliable charging infrastructure network	Inducing factor
F2 Resource Mobilization	Lack of (fast) charging infrastructure	Blocking factor
F2 Resource Mobilization	Interoperability of eMobility	Inducing factor
F2 Resource Mobilization	The underachievement and not meeting expectations	Blocking factor
F2 Resource Mobilization	Tesla 'high-cost' image & performance	Inducing factor
F2 Resource Mobilization	Ugly EVs	Blocking factor
F2 Resource Mobilization	The (perceived) range of EVs	Blocking factor

F2 Resource Mobilization	Stimulating the conversion of ICEs to EVs	Blocking factor
F2 Resource Mobilization	A fast battery development reducing costs and improving performance	Inducing factor
F2 Resource Mobilization	Support of the ministry of Economic Affairs for the establishment of the DOET foundation	Inducing factor
F2 Resource Mobilization	Using charging points in existing infrastructure (e.g. a lamp post)	Inducing factor
F2 Resource Mobilization	Smart Grid development	Inducing factor
F2 Resource Mobilization	Appropriate distances in the Netherlands	Inducing factor
F3 Knowledge Development	Unclear data/parameters for the necessary analyses for the development and diffusion of eMobility	Blocking factor
F3 Knowledge Development	The rise of inductive charging as additional charging infrastructure development (though still in the Knowledge Development phase)	Inducing factor
F4 Knowledge Diffusion & Networks	Publishing reliable data on EV sales and charging infrastructure	Inducing factor
F4 Knowledge Diffusion & Networks	The presence of partnerships between multiple stakeholders	Inducing factor
F4 Knowledge Diffusion & Networks	Collaboration between relevant actors	Inducing factor
F4 Knowledge Diffusion & Networks	National and local consultations with OEMs, increasing the feeling of trust and ownership	Inducing factor
F4 Knowledge Diffusion & Networks	Unclear division of roles between collaboration State, provinces and municipalities	Blocking factor
F5 Entrepreneurial Activities	Leading market parties and consumers that are stimulating EV	Inducing factor
F5 Entrepreneurial Activities	Car2Go as one of the frontrunner initiatives in EV	Inducing factor
F5 Entrepreneurial Activities	Tesla, Schiphol, Taxi as frontrunner and example	Inducing factor
F5 Entrepreneurial Activities	Creation of a snow ball effect by the marketing of EV	Inducing factor
F5 Entrepreneurial Activities	Starting small with the Proeftuinen project	Inducing factor
F5 Entrepreneurial Activities	An entrepreneurial spirit	Inducing factor
F5 Entrepreneurial Activities	The initiative ELaad building trust and the realization of charging infrastructure	Inducing factor
F6 Market Formation	An adverse business case for charging EVs	Blocking factor
F6 Market Formation	Niche market developments for EV (protecting the market)	Inducing factor
F6 Market Formation	Targeting the wrong audience with the wrong vehicle	Blocking factor
F6 Market Formation	A tax on electricity for EVs / a low tax on electricity for EVs	Blocking factor
F6 Market Formation	CO2 emission reduction certificates	Inducing factor
F6 Market Formation	Free parking for EVs	Inducing factor

F6 Market Formation	"Green" taxi stands	Inducing factor
F6 Market Formation	Favorable tax (BMP) regulation for electric taxi's	Blocking factor
F6 Market Formation	Subsidies for the purchase of EVs	Inducing factor
F6 Market Formation	Subsidies on smart grid developments	Inducing factor
F6 Market Formation	EU integration projects	Inducing factor
F6 Market Formation	High price for charging your vehicle	Blocking factor
F6 Market Formation	The regulation is not suitable for EVs and poses restrictions to its diffusion	Blocking factor
F6 Market Formation	To little top-down demands for the EV technique and emissions	Blocking factor
F6 Market Formation	Fiscal policy, tax benefits, 0% additional tax	Inducing factor
F6 Market Formation	Having the same stimulating fiscal measures for PHEVs and EVs	Blocking factor
F6 Market Formation	Too little stimulant of native Dutch economy/parties	Blocking factor
F6 Market Formation	CO2-tax (*future, not based on current practices)*	Inducing factor
F6 Market Formation	Regulation for free charging	Inducing factor
F6 Market Formation	An environmental zone within cities (downtown)	Inducing factor
F6 Market Formation	Problems with understanding the energy regulations for charging infrastructure	Blocking factor
F6 Market Formation	Obligation to accommodate 10% of all parking places of a charging point *(future, not based on current practices)*	Inducing factor
F6 Market Formation	Including EVs for business and public transportation in tender procedures	Inducing factor
F7 Creation of Legitimacy	Lobby stemming from the oil sector	Blocking factor
F7 Creation of Legitimacy	Lease companies were not supporting EVs	Blocking factor
F7 Creation of Legitimacy	Large incumbent companies are too slow and too big to follow the developments of EV	Blocking factor

Annex V Input of the online survey

To assign a weight to the individual preconditions and to validation the identified preconditions, an online survey was set up through the online software of Survey Gismo (www.surveygismo.nl). 21 experts in the field of electric mobility participated in the survey (see Table 15). The correspondents are not directly linked to the outcomes or comments of the survey to create a certain level of anonymity.

Name	Function and company
Geert Wijnen	Senior consultant EVConsult
Roland Steinmetz	Managing director EVConsult
Remco Mur	Senior consultant Royal Tropical Institute of the Netherlands
Debashish Bhattacharjee	Human settlements officer at the UN Habitat
Dominic Patella	Infrastructure Finance Specialist at the World Bank
Fleur Elfrink	Consultant EVConsult
Tom de Groot	Junior Project leader at Natuur & Milieu
Julia Williams-Jacobse	Independent consultant on electric mobility and former project leader EV at ministry of economic affairs of the Netherlands
Gert-Jan de Graaf	Consultant EVConsult
Joeri Wesseling	Post-doctoral researcher at CIRCLE (Lund University) focusing on innovation strategies
Sture Portvik	Project leader eMobility at the agency for Urban Environment, City of Oslo
Suzan Reitsma	Program coordinator eMobility at the Dutch Enterprise Agency (RVO)
Peter Hoogeveen	Consultant EVConsult
Sonja Munnix	Senior advisor at the Dutch Enterprise Agency (RVO) and experienced in innovation theory
Rob de Jong	Head of the transport program of UNEP
Yossapong Laoounal	President of the EV association of Thailand (EVAT)
Roos van der Ploeg	Senior consultant EVConsult
Tom Meeuws	Belgian advisor on eMobility and former director Antwerp at deLijn
Laurens van Mourik	Consultant EVConsult
Tim van Beek	Managing director EVConsult
Tom Turrentine	Director of the Plug-in Hybrid & Electric Vehicle Research Center (UCDavis)

Table 16 Overview of participants of the online survey

The participants were asked to rank the preconditions per system function in the right order, from most important to least important, taking into account the baseline situation without EV. It was not possible to give the same weight to different preconditions. Additionally, they were provided with the option to comment on each system function. These comments were taken into account with the identification and operationalization of the preconditions, contributing to the validity of the tool.

The online survey automatically scored the preconditions: the most important precondition received a score of 1, the least important precondition received the score of the total amount of preconditions of that system function (N). This gives a reversed image of the weight that will be given to the preconditions. The preconditions were therefore ranked manually using the outcomes of the survey.

The scores per precondition were added and divided by the total number of respondents (21) to get the average weight per precondition.

Below an overview of all the outcomes of the survey as well as the manually calculated weight per precondition are given and the comments, made per system function.

F1 Guidance of the Search

The following preconditions were ranked for F1:

F1.1. A long term ambition for sustainability (national level)
F1.2. A national plan for sustainable mobility, focused on EV as main method
F1.3. A local plan for sustainable mobility, focusing on EV as main method
F1.4. The presence of local sustainable mobility and/or EV targets
F1.5. The presence of national government divisions/institutes which can enable sustainable mobility
F1.6. The presence of local government divisions/institutes which can enable urban mobility and EV implementation
F1.7. The appointment of someone/ a team to move EV forward
F1.8. The presence of civil society actors (NGOs) driving/supporting the EV introduction
F1.9. A high level of willingness to change of potential actors of the EV value chain
F1.10. A high level of willingness to change of the consumer

During the research, it was decided (see Chapter five) that the presence of local targets is not seen as a separate precondition. It was not possible to adapt the survey. Therefore, F 1.4 (weight of 8) has been removed from the survey results and the remaining final weights of the preconditions have been adapted (which scored higher than F1.4).

Furthermore, the presence of civil society actors has been removed from the system function as well, as this was thought to overlap with the system function Creation of Legitimacy and the actors driving for eMobility. It also ranked lowest at Guidance of the Search. Therefore, F 1.8 (weight of 1) has been removed from the survey results. As it had the lowest weight of all preconditions in F1, the final weight of the preconditions has been decreased with 1.

F1 Guidance of the Search								
Precondition/ Respondent	**F1.1**	**F1.2**	**F1.3**	**F1.5**	**F1.6**	**F1.7**	**F1.9**	**F1.10**
1	6	1	5	2	3	10	8	9
2	1	6	9	10	4	8	3	7
3	10	9	3	6	5	1	2	7
4	1	2	3	4	5	7	8	10
5	1	4	5	2	3	6	7	10
6	1	4	6	3	5	7	10	9
7	9	6	5	10	8	4	2	1
8	5	1	2	8	3	9	6	10
9	1	2	8	4	3	6	5	9
10	7	9	1	8	6	2	5	4
11	2	3	4	8	5	9	10	7

12	2	1	8	10	6	5	4	7
13	10	8	9	7	6	3	4	1
14	1	2	9	7	4	6	10	5
15	3	4	2	6	10	5	9	1
16	4	5	7	2	3	1	9	8
17	3	1	2	5	6	7	9	10
18	2	1	4	5	6	8	3	10
19	3	4	5	7	8	9	2	1
20	8	9	2	6	3	7	5	4
21	6	5	1	7	4	3	10	9
Total score	4,1	4,1	4,8	6,0	5,0	5,9	6,2	6,6
Outcome survey	1	2	4	7	5	6	8	9
Final weight per precondition	**8**	**7**	**6**	**3**	**5**	**4**	**2**	**1**

Table 17 Outcome of the survey for the system function Guidance of the Search

Comments Guidance of the Search:

- the policy should be long term.
- In the study I mentioned earlier, I also found that EV targets are not realistic or seriously pursued by policy makers. Their level may instead reflect the (in)ability of technology forecasters or simply a political tool. Again the indicators include input and output indicators, which I do not understand from a research design point of view.
- The targets and plan should be long term
- For this system function all preconditions are very important, especially the first 9, so I found it very hard to make a ranking. The number 1 does not deserve to have 9 times more value than the number 9. But besides that, I think that for this function it is, in the end, the goal to guide the technological search in such a way that consumers and producers are willing to adopt EVs over of other competing technologies. Therefore I ranked the preconditions about willingness and competition highest. I think that the guide is stimulated firstly by a broad national support, and secondly by local regulations about the practical implementation of EVs. However, both must be present for a successful implementation of EVs. The organizational structures within governments are in my opinion less important for guiding the search.
- Very difficult to score the order!
- Policy makers need to align many different stakeholders behind a common objective (e.g. power suppliers, local govt., various national govt. institutions). This requires a strong policy framework and a competent team to manage it's implementation

F2 Resource Mobilization

The following preconditions were ranked for F2:

F2.1. The presence of international funding
F2.2. The presence of national financial resources for the development and diffusion of EV
F2.3. The presence of consistent energy (supply)
F2.4. The presence of renewable energy (supply)
F2.5. Availability of complementary technology (which could support EV)
F2.6. The availability of suitable electric vehicles
F2.7. The presence of people with knowledge about EV
F2.8. The ease to get a loan for a new technological innovation such as EV
F2.9. A supporting geographical and climatological environment for eMobility
F2.10. Insight in the different modes of transport used in the urban region
F2.11. Awareness amongst potential actors of the EV value chain about the financial resources

F2 Resource Mobilization											
Precondition / Respondent	**F2.1**	**F2.2**	**F2.3**	**F2.4**	**F2.5**	**F2.6**	**F2.7**	**F2.8**	**F2.9**	**F2.10**	**F2.11**
1	8	4	6	10	2	1	5	9	11	7	3
2	6	2	1	8	10	4	7	11	9	3	5
3	1	5	6	10	7	8	9	2	4	11	3
4	1	2	3	4	5	7	10	11	9	8	6
5	11	6	5	7	4	8	1	10	3	2	9
6	9	1	3	10	7	2	8	11	5	6	4
7	4	5	2	1	7	6	8	9	3	10	11
8	3	2	5	8	10	6	1	4	9	11	7
9	2	1	10	11	5	6	3	7	8	9	4
10	9	7	11	10	2	1	3	8	6	5	4
11	6	1	3	7	10	4	8	2	9	11	5
12	11	1	2	7	6	5	3	10	4	9	8
13	10	2	5	4	9	1	3	6	8	11	7
14	5	2	3	8	7	4	9	1	10	11	6
15	9	3	5	6	7	1	2	8	4	11	10
16	11	1	7	8	9	2	4	5	6	10	3
17	3	4	1	11	9	2	5	10	6	7	8
18	4	1	9	3	8	2	6	11	7	10	5
19	7	5	3	11	2	1	4	6	9	10	8
20	9	1	5	8	10	2	3	11	4	6	7
21	2	1	4	11	10	3	8	9	7	5	6
Total score	6,2	2,7	4,7	7,8	6,9	3,6	5,2	7,7	6,7	8,2	6,1
Outcome survey	6	1	3	10	8	2	4	9	7	11	5
Final weight per precondition	6	11	9	2	4	10	8	3	5	1	7

Table 18 Outcome of the survey for the system function Resource Mobilization

Comments Resource Mobilization:

- Finance is not really a constraint. The market for private vehicle financing is generally robust across the world.
- In my opinion the availability of suitable EVs, a suitable charging infrastructure (assuming this is part of the complementary technology) and a consistent energy supply are the most important preconditions. However, these preconditions are only relevant for using EVs. All other preconditions are important for producing and implementing EVs. For the production side it is important to have access to knowledge and financial resources. The share of renewable energy in the energy mix of a country might only counteract a successful implementation of EVs, since it can be a threat for the energy security.

F3 Knowledge Development

The following preconditions were ranked for F3:

F3.1. Insights in the existing knowledge about EV (and sustainable mobility)
F3.2. The presence of R&D institutes performing research on sustainable mobility and/or EV
F3.3. The presence of actors from the potential EV value chain stemming from the automotive industry with knowledge about EV
F3.4. The presence of actors from the potential EV value chain stemming from the energy/ICT sector with knowledge about EV

F3 Knowledge Development				
Precondition / Respondent	**F3.1**	**F3.2**	**F3.3**	**F3.4**
1	1	2	3	4
2	3	4	1	2
3	3	2	1	4
4	1	4	2	3
5	1	4	2	3
6	1	2	3	4
7	1	3	2	4
8	1	2	4	3
9	1	3	2	4
10	1	4	3	2
11	1	3	2	4
12	1	4	3	2
13	3	4	2	1
14	1	2	4	3
15	1	4	3	2
16	3	2	1	4
17	1	4	2	3
18	4	2	1	3
19	1	4	3	2
20	1	3	4	2
21	4	1	2	3
Total score	1,67	3,00	2,38	2,95

Outcome survey	1	4	2	3
Final weight per precondition	**4**	**1**	**3**	**2**

Table 19 Outcome of the survey for the system function Knowledge Development

Comments Knowledge Development:

- I miss a pre-condition related to conduce policies and regulations. Another pre-condition is related to the urgency, i.e. the need to innovate / for change
- There is a large need for governments to have the right policy framework in place that enables but does NOT force the adoption of EVs
- The importance is likely system-specific and therefore cannot be answered in this way. It also is likely to depend on the policy goals.
- I think the government also plays a role in the development of this function, through programs and money.
- it does not make sense to separate knowledge and involvement from industry and non-industry as it is key to bring them together for a successful introduction of electric mobility
- In my opinion the presence of service providers and charging point operators is more important for a practical implementation of EVs than the presence of EV manufacturers.

F4 Knowledge Diffusion & Networks

The following preconditions were ranked for F4:

F4.1. Potential knowledge exchange regarding EV through events
F4.2. Possibility to access generated knowledge (presence of open access knowledge)
F4.3. Collaboration between R&D institutes and (local) government
F4.4. Collaboration between the (local) government and potential actors from EV value chain
F4.5. Collaboration between R&D institutes and potential actors of the EV value chain
F4.6. Collaboration between the potential actors of the EV value chains
F4.7. Collaboration between local and national government regarding sustainable mobility/EV
F4.8. Knowledge exchange within local governmental (departments) regarding sustainable mobility and/or EV

F4 Knowledge Diffusion & Networks								
Precondition / Respondent	**F4.1**	**F4.2**	**F4.3**	**F4.4**	**F4.5**	**F4.6**	**F4.7**	**F4.8**
1	5	1	2	3	8	7	6	4
2	1	3	4	6	5	8	7	2
3	8	6	5	4	2	1	3	7
4	2	6	8	1	4	5	3	7
5	2	3	8	6	7	5	4	1
6	8	2	3	5	4	7	1	6
7	7	2	6	5	8	3	1	4
8	8	7	4	1	3	2	5	6
9	4	8	3	1	5	7	2	6
10	8	7	2	1	5	3	4	6
11	1	4	3	6	7	8	2	5

12	8	3	7	2	6	1	4	5
13	8	5	3	2	4	7	1	6
14	7	6	4	3	2	1	5	8
15	4	8	2	3	7	6	1	5
16	5	6	8	7	4	1	2	3
17	8	7	6	1	4	2	3	5
18	3	6	2	4	7	8	5	1
19	8	3	7	4	2	1	6	5
20	6	1	8	2	7	4	3	5
21	6	7	2	4	5	8	2	1
Total score	5,6	4,8	4,6	3,4	5,0	4,5	3,3	4,7
Outcome survey	8	6	4	2	7	3	1	5
Final weight per precondition	**1**	**3**	**5**	**7**	**2**	**6**	**8**	**4**

Table 20 Outcome of the survey for the system function Knowledge Diffusion & Networks

Comments Knowledge Diffusion & Networks

- Knowledge of the international market for EV technology is critical - especially for smaller countries that will not be shaping the global market
- The concept EV value chain is not clear, while most of the elements contain this concept
- So many factors are difficult to score. Some might be equally important or should exist together to get maximum results.
- Most important is diffusion of knowledge and awareness with -potential - consumers.
- I think knowledge diffusion is very important, especially amongst different actors in the supply chain and between those actors and R&D institutes. The function of the government is only to support the knowledge diffusion when it is not functioning properly. The occurrence of EV events might be a nice indicator for the focus of a certain region on sustainable mobility, but is in my opinion not an essential precondition in itself.

F5 Entrepreneurial Activities

The following preconditions were ranked for F5:

F5.1. Insight in the potential actors from the energy industry
F5.2. Presence of actors from the established automotive sector with possible interest in EV
F5.3. The degree of entrepreneurship of the country (and the presence of start-ups)
F5.4. Presence of actors from the ICT-sector with possible interest in EV
F5.5. The possibility to create niche markets in the automotive sector
F5.6. A high level of innovation in the country

The preconditions “The possibility to create niche markets” (F5.5) and “A high level of innovation in the country” (F5.6) were reallocated from F6 Market Formation to F5 Entrepreneurial Activities (see Chapter five) after the survey was completed. Therefore, the weight of the two differs from the other preconditions in this system function and the weights of the total score of the Market Formation is now inconsistent with the final weight per precondition. To solve this problem the following method was used:

F5.5 ranked sixth out of 10 preconditions, having an average weight of 6/10=0.6. It was therefore placed between the 2d (2/4=0.50) and 3d (3/4= 0.75) ranked precondition of F5 (consisting of 4 preconditions). F5.6 ranked 4th out of 10 preconditions, having an average weight of 4/10=0.4. It was therefore placed between the 1st (1/4=0.25) and 2d (2/4=0.50) ranked precondition of F5 (consisting of 4 preconditions).

F5 Entrepreneurial Activities						
Precondition / Respondent	**F5.1**	**F5.2**	**F5.3**	**F5.4**	**F5.5**	F5.6
1	1	2	4	3	4	3
2	3	2	1	4	10	9
3	2	1	4	3	2	7
4	1	3	2	4	8	4
5	3	2	1	4	8	10
6	3	2	1	4	8	4
7	3	2	1	4	7	3
8	3	4	1	2	10	1
9	3	2	1	4	4	1
10	3	1	2	4	9	10
11	2	4	1	3	10	9
12	2	4	1	3	5	6
13	3	1	2	4	6	3
14	2	3	1	4	3	8
15	2	3	1	4	8	9
16	4	3	1	5	1	2
17	1	3	4	2	10	3
18	2	1	4	3	6	7
19	4	2	1	3	5	10
20	4	2	1	3	8	3
21	2	3	1	4	9	10
Total score	2,5	2,4	1,7	3,5	6,7	5,8
Outcome survey	3	2	1	4	X	X
Final weight per precondition	**3**	**5**	**6**	**1**	**2**	**4**

Table 21 Outcome of the survey for the system function Entrepreneurial Activities

Comments Entrepreneurial Activities

- Governments need to enable EV related business to develop but should be careful not to distort markets excessively with unsustainable levels of subsidies.
- I would focus more on the actual number of entrepreneurs and Entrepreneurial Activities in the EV sector, than on general entrepreneurship indexes.

F6 Market Formation

The following preconditions were ranked for F6:

F6.1. (Insight in) the presence of subsidies influencing the introduction of EV (+/-)
F6.2. (Insight in) the presence of taxes influencing (+/-) the introduction of EV
F6.3. Understanding of the regulation/ legislation influencing the introduction of EV regarding electricity
F6.4. Understanding of the regulation/ legislation influencing the introduction of EV regarding import
F6.5. Understanding of the regulation/ legislation influencing the introduction of EV regarding transportation
F6.6. Understanding of (environmental) standards present which could influence EV
F6.7. A high competitiveness of EV compared to ICE (taking into account efficiency, fuel type and prices)
F6.8. Competitive cost structure of EV compared to ICE vehicles (focus on purchasing price)

Two preconditions have been removed after the survey to F5 Market Formation. Therefore, the final weight of the individual preconditions from the survey is not consistent with the final outcome. They were assigned a weight of 5 and 7 in the survey, but as they were removed the weight of the remaining preconditions was reduced with 1 or 2 points depending on their initial weight.

Furthermore, during the research is was decided that environmental standards fall under the regulation and legislation and are therefore not included as separate precondition. It also scored the lowest weight in the system function (weight 1). F6.6. has therefore been removed out of the final weight of the preconditions. The other final outcomes have been adapted (decreased with one).

F6 Market Formation							
Precondition / Respondent	F6.1	F6.2	F6.3	F6.4	F6.5	F6.7	F6.8
1	2	1	10	6	7	5	8
2	7	8	6	5	4	1	2
3	3	1	5	9	8	4	6
4	6	5	1	3	9	7	2
5	3	5	9	7	6	1	2
6	1	5	9	6	10	3	2
7	1	2	6	5	4	10	9
8	4	5	7	8	9	2	3
9	5	2	9	8	7	3	6
10	3	4	7	6	5	2	1
11	4	5	7	3	6	2	1
12	2	1	4	10	8	7	3
13	4	10	9	7	8	2	1
14	4	5	6	10	9	1	2
15	1	4	10	6	7	3	2
16	3	4	5	7	6	9	10
17	1	2	9	5	8	4	6

18	1	2	4	5	8	9	3
19	3	4	8	9	6	1	2
20	2	1	10	5	6	9	7
21	8	7	6	5	3	2	1
Total score	3,2	4,0	7,0	6,4	6,9	4,1	3,8
Outcome survey	1	3	9	6	8	4	2
Final weight per precondition	**7**	**5**	**1**	**3**	**2**	**4**	**6**

Table 22 Outcome of the survey for the system function Market Formation

Comments Market Formation

- I am not always sure whether one pre-condition is more important compared to the other: sometimes both need to be in place to make innovation work.
- There is an acute need to understand the cost structure of EVs vs. ICE vehicles as well as the differences in technical performance in order to choose the right set of enabling measures
- The reason I ask about the policy goals (i.e. EV diffusion or EV development), is because in a paper I recently wrote "explaining variance in national EV policies", I find that there are significant differences between countries aiming for EV diffusion or for EV development, in terms of policy and as well as industry structure. If you just want diffusion, you do not need an active industry (see Norway, the most successful in diffusion with almost no EV industry)
- Many factors! Some only matter if a government actively wants to stimulate them (i.e. competitiveness)
- I think that the most important precondition for the implementation of EVs is that normal consumers are willing to buy EVs. To achieve that, first the performance of an EV must be sufficient compared to an ICE, second the cost structure must be competitive compared to an ICE. The latter is stimulated by subsidies and tax benefits. Also the presence of niche markets is helpful since in these markets the performance and cost structure of EVs are less of an issue. The level of innovation in a country does, in my opinion, not contribute to this system function.

F7 Creation of Legitimacy

The following preconditions were ranked for F7:

F7.1. The presence of a strong lobby for EV
F7.2. The absence of a strong lobby against EV
F7.3. The level of certainty regarding the potential of EV
F7.4. The absence of powerful companies with high stakes in ICE vehicles and/or traditional fuels

F7 Creation of Legitimacy				
Precondition / Respondent	**F7.1**	**F7.2**	**F7.3**	**F7.4**
1	1	3	2	4
2	1	2	3	4
3	3	4	1	2
4	1	2	3	4
5	2	3	1	4
6	1	3	2	4
7	3	4	1	2
8	1	4	2	3
9	4	2	1	3
10	1	4	3	2
11	2	3	1	4
12	1	2	3	4
13	2	3	4	1
14	1	2	4	3
15	2	3	1	4
16	1	3	2	4
17	1	3	2	4
18	1	4	2	3
19	4	2	3	1
20	1	2	4	3
21	1	2	3	4
Total score	1,7	2,9	2,3	3,2
Outcome survey	1	3	2	4
Final weight per precondition	**4**	**2**	**3**	**1**

Table 23 Outcome of the survey for the system function Creation of Legitimacy

Comments Creation of Legitimacy

- It is essential for governments to be "honest brokers" and not to push EVs on people. Govt. needs to foster transparency about costs, performance, advantages / disadvantages and then let people take their own decision
- in addition to local government, a crucial role will be with national government

Annex VI Interviewees for the application of the GEM-tool

The following experts have been consulted for the illustrative case study, focused on the local innovation system in Delhi (India).

Name	Organization	Function	Date of interview
Saurabh Rohilla	Society for Manufacturers India (Siam)	Deputy Director - Responsible for the out roll of hybrid and electric vehicles	1st July 2016
Harshith Gokulendra	Delhi Dialogue Commission (DDC)	Project manager	22nd June 2016
Wybren van der Vaart	Asia Electric (partner of the Partnerships in Business program India)	Founder	20th June 2016
Debi Prasad Dash	Indian Energy Storage Alliance (IESA)	Manager	21st June 2016
Samir Kumar Sharma	Delhi Integrated Multi Modal Transit System (DIMTS)	Vice president, transport planning	15th June 2016