Department of Management and International Business

Three perspectives on the evolving electric vehicles innovation network of Finland

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For the reader

This report compiles the electric vehicle related work done in 2012 in the project: Future innovation and technology policy for sustainable system-level transitions: the case of transport (FIP-Trans). The project focuses on researching alternative and complementary socio-technical pathways and related policy options for sustainable transition in the Finnish transport sector. The project is financed by Tekes – the Finnish Funding Agency for Technology and Innovation. Analysis is continued in 2013.

In this paper we study the evolving electric vehicle innovation network of Finland. The analysis is built on combining the theoretical aspects of Strategic Niche Management and Technology Innovation Systems. Based on the literature we develop a framework for analyzing the development of innovation networks. The framework contains four steps. The first step is the identification and analysis of the main actors and their activities. The second step is the identification and analysis of the main events affecting the development of the industry. This step is based on the use of event structure analysis. The third step consists of the analysis of development of the architecture of the system while the fourth step deals with the description and analysis of the niche and innovation system development processes in a combined manner.

The data consists of interviews, policy and consultation papers, newspaper articles, press releases and other enterprise publications and of private databases containing financial information of the enterprises. Based on the theoretical framework, the four separate, but complementing qualitative analyses were made.

The electric vehicle niche has evolved through the interaction of private and public sector actors. The involvement of public sector affected strongly on the evolution of the system arenas and was an important event for the resource mobilization of the industry. As with other Finnish industries, the importance of the international dimension is highlighted by the analysis. The niche is connected through different channels to the international forums, regions and actors and the foreign activities affect on the development of domestic niche. The niche has been constructed through the conscious activities of enterprises, interest groups, researcher, consultants, electric vehicle activist and politicians. Furthermore, the use of framework also enabled us to study the profile of the system and the related process weaknesses.

Keywords: *electric vehicle, electrification of traffic, event structure analysis, niche, industry creation, innovation network, innovation system*

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1. Introduction

This working paper summarizes the recent development of the Electric Vehicles Innovation System (EV-IS) in Finland and compares these to the results of Lovio et al (2011) and Rinkinen (2009). This paper discusses especially the emerging - environmental technology related - industry from the industry development point of view. The historic development of the Finnish EV systems is presented in the Lovio et al (2011) and in this paper the historic content is mainly limited to the period from the winter 2008 to the spring 2012.

The main technology concepts of the studied innovation system are electric vehicles and the infrastructure concepts: smart grids and charging stations. Here, the electric vehicle term refers to any car, which uses electricity as its propulsion. The electric powered cars are often divided into three classes: battery electric vehicles (BEV), hybrid electric vehicles (HEV) and plug-in hybrid vehicles (PHEV). The battery electric vehicles are cars, which use only electricity stored in the car's batteries as the propellant. Battery electric vehicles are also often considered as synonyms for electric vehicles (EV). The plug-in hybrid electric vehicles are cars, which use both electricity and fuel from external sources. Moreover, the PHEV-cars are further divided into 2 classes according to the motor arrangements. There are PHEV cars, which use electric and combustion engines in parallel (parallel hybrid) and on the other hand, cars, which always use the electric motor only for driving. Cars of the latter type are called series hybrids. However, the hybrid electric vehicles (HEVs) use both electric and combustion engines to propel the car, but they are not always considered as electric vehicles as the electricity for the engine is not based on an external source, but is generated by the internal combustion engine and supported by a regenerative breaking system. Although the electric motors of hybrid electric vehicles (HEV) are not loaded from an external source (grid) are they considered in this research report as electric vehicles due to their electric motors and therefore from their role in the electrification of the traffic. Regarding more detailed presentation for the definitions, see for instance Nylund (2011).

From the innovation system development point of view, (lithium-ion) batteries are perhaps the most important technology of the different components of an electric vehicle (International Energy Agency 2009). Especially the price and performance development of batteries are important factors affecting the demand and performance of electric vehicles. The high price of batteries raises the price of cars and thus decreases the demand of electric cars: in 2010 the price of batteries of a small sized electric vehicle with a driving range of 200 km was estimated to be approximately €24000. However, the price of batteries is expected to decrease in the long run due to a technology development. The other aspect of affecting the demand of electric vehicles is the current state of the main parameters of batteries describing the performance of batteries and therefore the performance of electric cars. For instance, energy storage capacity of batteries is only mediocre and therefore it is a limiting factor for the driving range of electric cars. However, on the other hand the parameters of batteries are expected to be improved in the long run as a consequence of technology development. (Nylund 2011.) Batteries are mainly embedded into the electrics cars, but also an alternative business model has emerged. Instead of owning batteries of the electric vehicle, vehicle owners can rent fully loaded batteries and when the batteries are nearly exhausted, change them with new batteries. (IEA 2009.) However, currently the battery swapping systems are still on a pilot stage and face several downsides. For instance, swapping systems are very expensive and it is unlikely that car manufacturers reach an agreement regarding the standardization of battery system, which is needed for running the swapping business. (Nylund 2011.)

Thus, the efficient use of plug-in hybrid and battery electric vehicles demands also the development of a charging infrastructure for the loading of batteries of the cars. This indicates that charging stations, and also for instance due to increased loading of the grid, a power grid suitable for electric vehicles needs to be developed. Regarding the power grid element in the electric vehicles context, a one generally proposed solution has been the introduction of smart grids, which generally refers to the integration of information and communication technologies to the power grid and thus generating new features to the power grid system. Massoud Amin and Bruce Wollenberg were first to present the term and idea of smart grid in energy production in 2005, but currently, there are no unanimous definition for the term. However, as presented in Nylund (2011), the smart grid term can be defined from a functional point of view. One such definition has been presented by the National Energy Technology

Laboratory (NETL) of the United States Department of Energy (2009) referring smart grids as “transactive agents” allowing different types of transactions to be made between the parties and components of the power grid system. The transactions in the system can cover financial, informational and electrical activities.

As presented by the NETL (2009), with the smart grid technologies the power grid is considered to have seven features, which improve the functionality of the power grid. The characteristics are: an active participation of the consumers for electricity transactions is made possible due to information transmission in the network; smart grids accommodate all the different ways to generate and store electricity to the system; new products, services and markets are created as the buyers and sellers are linked together over the transactive grid; quality of the produced power is enhanced; smart grids optimize production assets and operate more efficiently than traditional power grids; the grid is capable of self-healing measures by, for instance, detecting and analyzing information flows and taking corrective actions; and also, smart grids are more resilient against natural and cyber-attacks than traditional power grids.

Regarding the benefits for electric vehicles, with the smart grid technologies power grids can be constructed so that the overloading of the power grid during the peak hours of electricity consumption is avoided. Also, as mentioned above as one of the features of smart grids, with the new grid technologies electric vehicles can be considered to have dual roles in the energy system. Besides charging and consuming electricity, electric vehicles can feed in to the grid the excess electricity stored in the batteries of the cars turning the owners of electric vehicles as sellers of energy. (Nylund 2011 and MEC 2011.)

As the electric vehicles have a more limited driving range than internal combustion engine cars, the electric vehicles need in practice comprehensive charging station networks for the spreading of the technology or for the actual charging even to take place. The charging can be based on either slow or rapid technology, where the slow charging lasts between 6-10 hours, while with the rapid charging technology electric car is fully loaded in minutes instead of hours. However, intelligence can also be added to charging stations enabling the communication of the information systems of the electric vehicle with the charging station - and on the other hand - enabling also the communication between the charging station and smart grid. The intelligent charging station network allows for example the

loading of electric cars and paying the loading by using mobile phones. *The intelligent charging stations are part of the smart grid and thus complete the electric vehicle technology system*. (Nylund 2011.) From the technology point of view the spreading of the use of electric vehicles is connected and also partly dependent from not just of the technologies internal to electric vehicles, but also from the infrastructure technologies external to the cars.

Electric vehicles can be considered as environmentally friendly technology when compared with internal combustion engine cars. This is based on the many direct and indirect environmental benefits of electric vehicles. For example, electric vehicles produce no or only a limited amount of carbon dioxide due to the electric motors used to propel the vehicles. The carbon dioxide emission levels can be decreased, if the electricity is produced using renewable energy sources as water, solar or wind power, or even with nuclear power. With the renewables as the energy source for (battery) electric vehicles it is possible to create a carbon neutral traffic system and especially in that sense electric vehicles can be considered as a "clean technology". Another environmental benefit of the electric vehicles is that the electrification enhances energy efficiency of cars: electrification enables the use of regenerative breaking system, which makes it possible to collect and utilize the energy generated while braking the car. Also, the electric motors are more energy efficient than internal combustion engines, when measured with the so called tank-to-wheel –rate, which refers to the share of the thermal energy of the fuel that is turned into mechanical energy propelling the car. Especially, the battery electric vehicles do not produce any local emissions, including fine particle emissions, and they create a lower noise level than cars with combustion engines. (Nylund 2011.)

The recent interest for electric vehicles is evident from the way and volume how the technology is discussed in media. Below in the figure 1 is presented the frequency of the term electric vehicle published in articles of the leading Finnish newspaper Helsingin Sanomat between the years 2000-2012 (Rinkinen 2012). The data indicates a clear rise in the reporting of events covering electric vehicles in the 2008 (frequency 124) and peaking in 2009 (frequency 208), while reporting staying at slightly lower level in 2010 and 2011 (frequency 157 in both years).

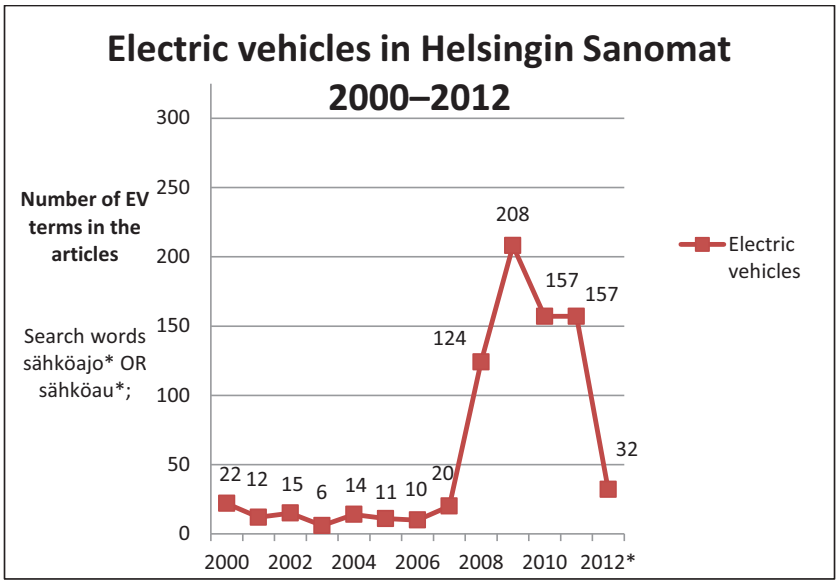

Figure 1 Frequency of electric vehicle terms in Helsingin Sanomat in 2000-2012
***Note: The 2012 data refers to the end of first quarter of the year**

According to various policy and consultation reports (e.g. Nylund 2011) and newspaper articles (e.g. Tuulilasi and Auto Bild in the winter 2012) the global supply of electric vehicles is expected to increase rapidly as the large car manufacturers have started investing in the development of electric vehicles. For instance, International Energy Agency (2009) has estimated, that in 2012 approximately 0.05 million PHEVs and 0.03 million BEVs will be sold, while in 2020 the corresponding figures are already 4.7 and 2.5 million totaling over 7 million sold electric vehicles. For the regional dimension, IEA expects the OECD countries to be the early adopters, followed by China and then India.

Regarding the Finnish context, the Ministry of Employment and the Economy of Finland (2009) has set as the objective that by 2020 25% of all of the sold new cars should be electric vehicles chargeable from the grid and 40% of these should be battery electric vehicles. This means that there should be approximately 177000 electric vehicles in Finland. However, also more conservative estimates have been presented where the minimum number of cars would be 11000 and maximum 140000, and the most probable scenario would approximately contain 35000 electric cars by the 2020. (Nylund 2011.) Even if the number of electric vehicles would increase significantly, it would not have a very strong impact on the electricity production as it has been estimated that, one million electric vehicles would consume less than 5% percent of the total electricity consumption level of the year 2010. Furthermore, as mentioned above, with the smart grid

technologies the electric vehicles can be loaded flexibly and thus avoid any threats regarding overloading. Thus with smart grids any extra power capacity for securing the functioning of the power infrastructure is not needed. Regarding the environmental technology aspect, the smart grids will also allow an efficient use of renewable energy sources for electricity production for electric vehicles. (Nylund 2011.)

In this research report, we will tell the story behind the sudden rise of interest towards electric vehicles by describing the recent development of the Finnish electric vehicles innovation system and discussing the decisions and activities of the different players of the innovation system, which have led to the current state of affairs. The analysis is done by integrating two different, although related, analytical process frameworks forming an integrated process model for emerging industries. The combined analytical process frameworks are the technology innovation system –model (TIS-model) and the niche-model containing the multilevel perspective aspect. The developed integrated process framework is utilized on the data collected during the research project and while in the analysis we use several angles for grasping the main features of the evolving complex innovation system, in the latter part of the report the framework is utilized to explore the data from a strategic policy-making perspective. In this paper the terms of complex system, innovation system and niche are mainly used as synonyms to refer to the studied evolving research object. However, exceptions to this are the sections where the differences between the concepts are discussed. The term complex system is used to refer to the object's multifaceted nature and it is not used in a strict system theoretic sense. This paper reports the recent short run developments in the Finnish electric vehicle industry through the following research questions:

1. How the Finnish electric vehicles industry was institutionalized? And more specific: through what kind of events the industry building took place?
2. How the architecture of electric vehicle innovation network has evolved? And more specific: what are the main features of the network?
3. How the niche and technology innovation system models describe the industrial development and how does the development look like when it is studied by integrating the two models into single framework?

The paper is structured as follows. The next chapter presents the build-up of the theoretical framework used for the analysis and the third chapter contains a description of the collected data and used methodology. The results of the analysis are reported in the next three chapters. Chapter four presents the institutionalization process of the electric vehicles niche while the fifth chapter studies the development of the innovation network. The chapter six contains the analysis of the processes behind the formation of the electric vehicles trajectory. A number of enterprise cases are shortly described from a longitudinal perspective in the seventh chapter in order to highlight the enterprise perspective of the development and the results of the research project are discussed in the Chapter 8.

2. Development of theoretical framework

The theoretical framework of the analysis is based on the integration of two different – but closely related explanations of innovation development and related policies. First, based on recent review articles we describe the concepts of niche and innovation system and compare how the explanations relate to each other. Second, we develop an analysis framework and integrate the two theoretical models into one analysis phase of the developed framework. This *integrated process model for emerging industries* will then be used as a heuristic device in the analysis of the electric vehicle activities and TIS and niche models' isomorphism from an empirical results point of view.

2.1 Concepts of niche and technology innovation system

The strategic niche management (SNM) refers to the creation and cultivation of protected spaces, or niches, for the development of new technologies needed for a sustainable transition of an economy (Kemp et al 1998 and Schot and Geels 2008). Niches are considered as places for exploring and experimenting with emerging technologies in a close collaboration with producers, users and social and regulative structures. This technology experimentation is considered to be a bottom-up process of private players, and if successful, leading to changes in the sociotechnical environment and eventually leading to a more widespread use, adaptation and replacement of the dominant technology. Finally, as the niche's technology spreads through the markets, the whole technology regime is expected to change - for instance - on more sustainable direction. (Raven et al 2010 and Schot and Geels 2008.) However, even as niches are not considered to be established by top-down policy decisions, the policy actors can play a role in niche development. For example, policy administrators can influence endogenously on the niches` development by affecting the processes from inside the niche. (Schot and Geels 2008.)

The SNM research states that the circumstances needed for the emergence and successful development of a technological niche depends from a three (3) niche internal structural processes. First, the successful development of a niche depends from *the articulation of expectations and visions* for the legitimization and directing of activities. Second, *social networks* need to be created in order to facilitate interaction and combine and deliver resources. And finally, actors of the niche need to *learn* from the taken actions and changes in the business environment in order to adapt to the changes. The success of the three processes has been further characterized by several hypotheses. For instance, the articulated expectations need to be shared by a wide range of actors; the expectations should be detailed and refer to actual or observable activities. Furthermore, wide and heterogeneous networks enhance the development of niche, especially, if the network members are able to mobilize resources for the tasks. Regarding the learning, it needs to influence the niche actors in a manner that they question and change their actions on the basis of the new information. (Raven et al 2010 and Schot and Geels 2008.)

Originally, SNM focused on endogenous processes of the niche. However, recent research has shown that also external or – exogenous – factors play an important role in the niche development. The external factors approach is contributed by the results of multi-level perspective (MLP) school. The MLP school claims that, instead of a single level or environment for activities, technology development and societal transition is based on the interaction of processes between three (3) levels: niches for radical novelties (micro-level), socio-technical regimes (meso-level) and socio-technical landscapes (macro-level) (Geels 2002 and Schot and Geels 2008). The main contribution of MLP research for the niche literature is the inclusion of multiple level processes affecting to niches development: niches are influenced and they feedback to the environment surrounding the niches (Schot and Geels 2008).

The literature on Technology Innovation Systems (TIS) forms the other theoretical dimension of the framework. Innovation system refers to a set of structural components or elements interacting with each other. The components refer to the structural units forming the system - actors, networks and institutions – that interact by developing, diffusing and utilizing products and technologies (e.g. Jacobsson and Bergek 2011). According to Berkeg et al (2008) technology innovation systems are: *"socio-technical systems focused on the development, diffusion and use of a*

particular technology in terms of knowledge, product or both." The concepts of innovation systems are primarily used as analytical tools for policy decision-making for studying the current status and weaknesses of the elements of the systems. Also, the concept can be used for analyzing innovation systems of different geographical coverage, industrial sectors or systems in different phases: both emerging and mature innovation environments can be studied within the innovation system framework. (Bergek et al 2008.)

Innovation systems are considered to emerge due to four interdependent and intertwined structural processes of the components: *entry of organizations*, *formation of networks*, *alignment of institutions* and *accumulation of knowledge and artefacts*. The entry refers to the process of engagement of enterprises and R&D related organizations to the emerging system, while the network formation means the creation of social, political and learning platforms and connections for users-suppliers, academics and their industrial partners. Moreover, the alignment of institutions is the process of formation of regulative factors for interaction: the development of norms and the settings for expectations and decisions. Furthermore, the accumulation of knowledge and artefacts refers, for instance, to the creation of codified knowledge and the concrete products and technologies. (Jacobsson and Bergek 2011.)

The analysis of the weaknesses of an innovation system is done by utilizing the concept of sub-processes. The sub-processes are also called functions of the system. These functions are defined as *intermediate variables* between the structure of the system (consisting of components) and the performance or outcome of the whole system. (Jacobsson and Bergek 2011.) Thus, the performance of the innovation system in some specific point of time can be characterized in simplified heuristic terms with the function $f(u_1, u_2, \ldots, u_n)$, where the intermediate variables $u_i (i = 1, \ldots, n)$ are functions of variables $x_j (j = 1, \ldots, m)$, which refer to the structural components of the system. The functions of innovation systems are considered as analogous to the functions of different technical systems where the system components contribute to the overall performance of the whole system (Bergek et al 2008).

Furthermore, with the intermediate variables it is possible to assess and therefore manipulate the system performance. The assesment of the state and quality of functions is based - for instance - on a judgment of the performance and improvement regarding the development state of the

technology innovation system; this can be complemented with a benchmark studies with similar systems in other regions or countries (Bergek et al 2008). However, according to Jacobsson and Bergek (2011) the actual policy interventions should focus on the activities taking place on structural level as the processes merely reflect the outputs of the structure.

On the basis of extensive literature review Bergek et al (2008) has defined seven (7) subprocesses for describing the functional pattern of innovation systems. See table 1 below. Six of the seven subprocesses assess directly the strength of the system. However, the seventh function - development of positive externalities – is a function for especially supporting the development of the other functions and thus the whole system. The positive externalities are the benefits for the whole technology innovation system originating from the emergence of pool of educated employees, information and specialized employee flows and knowledge spillovers, which stimulate the overall development due to the interconnections or feedback loops. (Bergek et al 2008.)

Table 1Functions of the technology innovation system

Functions	Description
Knowledge development and diffusion	Is the process of strengthening the breadth and depth of the knowledge base and how that knowledge is developed, diffused and combined in the system
Entrepreneurial experimentation	Is the process of strengthening the testing of new technologies, applications and markets whereby new opportunities are created and a learning process is unfolded
Influence on the direction of search	Is the process of strengthening the incentives and/or pressures for organizations to enter the technological field. These may come in the form of visions, expectations of growth potential, regulation, articulation of demand from leading customers and crises in current business.
Resource mobilization	Is the process of strengthening the extent to which actors within the TIS are able to mobilize human and financial capital as well as complementary assets such as network infrastructure.
Market formation	Is the process of strengthening the factors driving market formation. These include the articulation of demand from customers, institutional change, changes in price/performance. Market formation runs often various stages, e.g. nursing or niche markets in the form of demonstration projects, bridging markets and eventually mass markets.
Legitimation	Is the process of strengthening the social acceptance and compliance with relevant institutions. Legitimacy is not given, but is formed through conscious actions by organizations and individuals.
Development of positive externalities	Is the process of strengthening the collective dimension of the innovation and diffusion process, e.g. how investments by one firm may benefit other firms as free of charge. It also indicates the dynamics of the system since externalities magnify the strength of the other functions.

Sources: Bergek et al (2008) and Jacobsson (2011)

The functions of the TIS paradigm are somewhat abstract and clearly contain both quantitative and qualitative attributes. Thus, the relations have to be characterized with several indicators, which contribute to the strength and performance of each function. The practical assessment and use of suitable indicators depends besides from the available information, but also from the development state of the system – it is possible that there does not exist suitable indicators for describing market development or positive externalities in emerging systems. Due to the number of indicators and combination of qualitative and quantitative data, the functions of innovation system are not considered as fully unambiguous measurements of system. For instance, the assessment of the state and strength of the legitimation function is mainly based on qualitative evidence and the assessment relies heavily on the subjective interpretation of the available qualitative data. Nevertheless, the seven functions and indicators suggested by Bergek et al (2008) for the measurement of the performance of technology innovation systems are presented in the table 2 below.

Table 2 TIS functions and their accompanying indicators

Functions	Suitable indicators
Knowledge development and diffusion	• Bibliometric indicators • Number of relevant patents • Number of R&D projects • Size of R&D projects • Orientation of R&D projects • Number of professors relevant to the system • Assessments by managers and other relevant players
Entrepreneurial experimentation	• Number of new entrants, including diversifying enterprises (new to the field) • Number of different types of applications • The breadth of technologies used and the character of the complementary technologies employed
Influence on the direction of search	• Stated beliefs in growth potential • Incentives from factor/product prices (e.g. taxes) • Extent of regulative pressure • Articulation of interest by leading customers
Resource mobilization	• The volume of invested capital (in general) • The volume of invested seed and venture capital • Volume and quality of human resources
Market formation	• Assesment of the development phase of the market (nursing, bridging or mature markets) • Assesment of the market size • Identification of the customers or users of the products of the TIS • Qualitative data relevant for describing actors behavior: strategies, standards and their significance, purchasing processes
Legitimation	• Analysis and assesment of the strength and legitimacy of the TIS in relation to current legislation the value base of the industry and society • Analysis and assesment of legitimation activities influence on demand, legislation and firm behavior • Identification and analysis of players or things involved in the legitimation process (who or what and how)
Development of positive externalities	• Identification and assesment of the strength of emergent of pooled labor markets • Identification and assesment of the strength of emergent specialized intermediate goods and service providers • Identification and assesment of strengths of information flows and knowledge spill-overs

Source: Bergek et al (2008)

2.2 Comparison of models

The niche and TIS-models have both common and distinct attributes. Although both of the models can be used to analyze environmental innovations, they have their own angles based on their academic research traditions. The main attribute shared by both of the models is the objective of research. Both models study the performance and development of innovation in an area or space characterized with either the concept niche or system. However, the models also differ in this respect. The applicability of the TIS-model is broader than the niche-model: The TIS is not only for sustainability transitions nor is it limited for studying the spreading of innovations as such.

The main differences between the models are in the structural assumptions and parameters and in the way the models present these. For instance, in the TIS model the structural elements are explicitly listed whereas in the niche-model the structural components are included, but are not in the focus of the analysis. The reason for this is that the TIS-model builds the whole analysis upon the state and functioning of the elements, but the niche-model emphasizes more the structural processes in the analysis. This difference is further elaborated in the hypotheses and propositions of structural processes. In addition, although both models have two similar structural procesess, they differ regarding the total number and content of one of the processes. The TIS-model emphasizes the significance of institutions whereas the niche-model explains the development with the articulation of expectations and visions. Furthermore, the TIS-model explicitly states the significance of the entry of relevant players for the development of the system.

However, the models also share attributes, where the models both differ and share features at the same time. For example, the niche-model emphasizes the direction of development processes - even if the current research tradition incorporates both top-down and bottom-up processes to the research agenda. The TIS-model does not emphasize the directions of development processes in a same way as the niche-model, although activities from both process types are included in the analysis. Another feature of the models is the way they deal with policy analysis. Both of the models aim for delivering an analytical framework for policy-making, but due to the models structures the niche- and TIS-model differ significantly. As the niche-model builds on case-by-case policy solutions, which are based on the structural processes the TIS-model aims for a systematic treatment

of policy problems and solutions. In addition, TIS does not build on the structural processes, but on the structural elements of the model, which are represented by the functions or sub-processes on the system level. The differences in the models' structures is further elaborated how they can be used in policy analysis: the niche-model is suitable for ex post analysis of historical events, but the TIS-model is intended for contemporary analysis based on historical data. Due to the systematic approach the TIS model can be considered as a more forward-looking –model than the niche-model.

The differences and shared attributes of MLP and TIS frameworks have been discussed in recent papers (Lovio & Kivimaa 2012, Markard & Truffers 2008 and Geels 2010) where especially the frameworks' individual explanatory capabilities and ontological differences have been in the spotlight of the academic discussion. For instance, MLP research has been criticized for missing "the roles and strategies" of actors in the innovation processes and on the other hand, focusing mainly on niches as the source for innovations (Smith et al 2005, Markard and Truffers 2008). However, also TIS-research has been criticized for considering the success of innovations to be mainly dependent from the factors endogenous to a system (Markard & Truffers 2008). Furthermore, the MLP research has been criticized from its dominating ontological position in social scientific sustainability research (Geels 2010). Nevertheless, regardless of the structural and ontological differences, or academic traditions, both frameworks have been developed for similar purposes: both models aim for describing and developing practical solutions to complex innovation related societal problems. Also, as presented shortly above the models share features, which build common ground for the two approaches. This common ground encourages the further development of the two approaches. The comparison of the attributes of the two models are presented below in the Table 3

Table 3 Comparison of attributes of niche- and TIS-models

Attributes	Niche-model	TIS-model
Academic tradition of the model	An effort to integrate constructivist sociological research with technology studies and evolutionary economics	Industrial and evolutionary economics, management science and sociology
Objective of the model	The study of the facilitation of sustainable innovation journeys through directed selection experiments in protected niches	The study of processes affecting innovation, industrial transformation and economic growth (also from sustainability point of view)
Structural elements of the model	Considers at least actors: enterprises, users, societal groups and governmental organizations	Actors (firms, R&D organizations) Networks Institutions Technology
Emergence of the object	Niches emerge mainly through collective enactment of structural processes	Systems emerge through the structural processes
Structural processes in the model	1 Articulation of expectations 2 Building of networks 3 Learning	1. Entry of organizations 2. Formation of networks 3. Alignment of institutions 4. Accum. of knowledge and tech.
Hypotheses and propositions regarding the processes	Niche's development is enhanced if there exists: 1. Broad and deep networks 2. Second-order learning process 3. Articulation of robust, specific and high quality expectations	Procesess are: 1. Interdependent 2. Intertwined 3. Weaknesses in any of the structural elements weaken the development of the system
Development direction of the structural processes	Both top-down and bottom-up processes (due to MLP research)	Direction of the structural processes is not on the focus
Origin of the models' factors	Focus is primarily on the niche endogenous factors, but also incorporates linkages (procesess) exogenous to the niche (due to MLP research)	Systems acknowledge both endogenous and exogenous factors affecting the development
Methodology of analysis	Qualitative and quantitative methods	Qualitative and quantitative methods
Targets of policy analysis	Identification of policy dilemmas related to the structural processes. Clear-cut recipes for dealing with the dilemmas are not possible	Identification of structural weaknesses and the related mechanisms in a systematic way and formulation of policy advises
Tools for policy analysis	The analysis of the above mentioned three structural processes	TIS utilizes the seven sub-processes or functions
Direction and nature of the analysis	Mainly ex post analytical framework for historical events	Analytical framework for historical and contemporary processes especially for future development of the system

Sources: Schot and Geels (2008), Bergek et al (2008), Jacobsson and Bergek (2011), Lovio & Kivimaa (2012)

2.3 Integrated process model

The integrated process model is an analytical framework for the analysis and description of emerging technology industries from an innovation process point of view. The integration of the system and niche approaches into one comprehensive framework is also an experiment for studying the empirical similarities of the models and an effort to increase the accuracy (reliability) in the analysis of niche or system development. The integrated process model enables the analysis of innovation processes from both actor and structural point of view by making explicit the ways actors promote the technology, how the system structures are formed and what kind of interaction is between the structural elements and structures.

The integrated process model for emerging industries contains actors, networks and institutions as the structural elements. The structural processes of the studied system or niche are the three niche processes, although, for this project the seven sub-processes of TIS research highlighting the functioning of a system, are embedded in the three niche internal structural processes. The hypotheses of niche literature for structural processes apply, as do the hypotheses of TIS literature. However, the hypotheses of the TIS literature are not in the focus of the framework or in its use. The allocation of functions into the corresponding main processes is based on the definitions of the functions and their a priori compatibility with the structural niche processes.

As the TIS-functions are not structural processes as such, but more like complementary pieces to the analysis of the innovation system structure, are the functions in this research effort considered also as complementary to the niche internal processes. This is considered regardless of the differences between the models' structural processes. The entry of organizations process of the TIS-approach is considered to be included in the three main processes through to the inclusion of entrepreneurial experimentation sub-process. *Therefore, the integrated model consists of the niche model completed with the TIS-functions and with the emphasis on the structural elements of actors, institutions and networks, and their development and interaction both endogenously and exogenously for the development of the niche.* Here, the niche refers to the studied evolving technology innovation system. The niche internal processes and the integrated subprocesses are presented in the table 4 below.

Table 4 Processes of the integrated process model for emerging industries

Niche processes	Sub-processes (functions)
Network	Resource mobilization
	Development of positive externalities
Learning	Knowledge development and diffusion
	Entrepreneurial experimentation
	Market formation
Articulation of expectations	Influence on the direction of search
	Legitimation

The model has an eclectic ontology. It is based on the inter-ontology cross-over of MLP and TIS-research, which although have different academic traditions (Lovio and Kivimaa 2012, Geels 2010), share a common ontological ground through the evolutionary aspect of economics and science and technology focused sociological research. The main ontological aspects of MLP research (see Geels 2010) – evolution and interpretivism – with the economics and science and technology study dimensions, form the main building block for the ontology of the integrated process model. The ontological cross-over emphasizes the holistic nature of the activities in an evolving niche. The ontological base is not all-inclusive, but instead, it builds on the social aspect of agency of strategic management in conjunction with the technology development and evolutionary aspects of economics.

The integrated process model is used by analyzing four consecutive steps, where each of the steps builds on the previous steps. As the integrated process model is considered as a general framework, the different steps utilize models and concepts developed in other research domains, but which are in line with the ontological assumptions of the framework. As the framework is for studying the development or evolution of a system, the analysis demands longitudinal data of the researched subject. The analysis begins from the identification and analysis of individual actors and ends to the identification of functional pattern of the system. The introduced steps are an effort to solve the shortcomings of the individual models as presented by Markard and Truffer (2008). The steps are:

1. *Identification of key players and their innovation activities from the current technology point of view*. In the first step the technology and related innovation processes are studied from an actor point of view. This allows increasing the understanding regarding strategic motives, activities and roles of organizations and even individual people in the system. This initial step also highlights the importance

of agency of actors for affecting to the system by reaching or failing to reach set objectives and the roles of actors in the overall development or change in a system, for instance, into a sustainable direction.

2. *Identification and analysis of the main events affecting the evolution of the emerging industry*. The second step focuses on identifying the main events of the evolution by the types of actors and system processes. The second step describes the time structure or chronological order of the events of the system and how the events are connected by causes and effects. The chain of events can be studied with event structure analysis. The second step builds on the first step, but is also complemented by other collected data.
3. *Cross-sectional description of the activities in discrete time periods*. In the third step the longitudinal data is sliced into discrete time periods by using the results created in the two previous steps. The discrete time periods form the cross-sectional picture of the system at the chosen time periods. The third step enables the forming of the overall picture of the system and it also enables the identification of the dynamic structure(s) of the network(s) of the system. The third step includes the use of descriptive network analysis for describing the key acts, interactions, hubs and possible power and economic relationships. The second and third step together may also connect or identify how the system relates to regime and landscape type of "structural levels". Thus, through these steps the analysis of the system is connected to the wider, or even global, technological environment and it acknowledges both endogenous and exogenous factors of development of the system.
4. *Analysis of the processes and identification of the factors or mechanisms affecting the growth or blocking of the development of the system*. The processes are analyzed on the basis of the previous steps. First the analysis focuses on the main process and then complements the description with the details of corresponding functions (sub-processes). The analysis of subprocesses utilizes the indicators as presented in the table 2 above. Although the development of the system is very much described in the first three steps, *the process analysis enables the systematic assessment of the development of the system emphasizing both quantitative indicators and a social construction type of activity; for example, the process analysis enables the assessment of the state of hypotheses of the processes*. The results of the process analysis are

transferred to describing the functional pattern of the system. (See e.g. Bergek et al 2008.)

The four steps describe the emerging industry from two opposite angles. First, by analyzing the development of actors, institutions and networks from some specific starting point to the current state the changes in the system and its structures are covered. Second, the factors affecting to the development of the system are studied from the perspective of the current state to the initial starting point of the evolution in order to find and explain possible mechanisms for underdevelopment. By combining the two angles into the framework, the tool is considered to provide new information from the studied phenomenon; however, the second aspect of the framework has also a normative feature as it enables the framework's utilization in policy analysis.

3. Data and methodology

The report is based on five different types of qualitative data from three different time periods. The data types are policy papers, interviews of key actors, articles of newspapers and weekly periodicals covering or completely focusing on automobiles and related technology, and electric vehicles related press releases picked from the key enterprises of the emerging electric vehicles network. The fifth data type is the complementing background information studied from the organizations' web pages and from private data bases containing financial information. The research material consists of data collected in four different time periods. The oldest set of data is the set of newspaper articles of the year 2009, which were collected in 2009. The other older data set is the interviews of key individuals done in 2010.

The most recent major data collection effort took place during the winter 2012. During this period press releases of key enterprises and news from newspapers and weekly periodicals were collected and more interviews of key individuals were done. During the winter 2012 the discussions and news of several media were collected in real-time. The real time collection covered mainly articles published in paper, but in the case of Tekniikka ja Talous magazine the collection was done only from the news published in

the enterprise's web page. Furthermore, in the case of Kauppalehti, both the paper version and the web page were covered. The fourth data collection took place during the writing process and it happened mainly during the spring, summer and autumn 2012. During this period a number of interviews of key individuals were made. The number of collected pieces of data (or observations) is presented in the table 5 below. The data table lacks the information of policy papers and web page type of data.

The articles were picked by first reading the title and second studying the actual content. Even if the main focus of an article was not solely in electrical vehicles, but if it just explicitly referred in EVs – even with just one sentence – was the article included into the data set. These types of included articles are, for instance, benchmark studies of the automotive magazines comparing the performance of vehicles with different engines. In general, the articles collected during the winter discussed mainly three general topics: technology development of electric vehicles, development and views regarding the current and possible business environment and test drives of electrical vehicles.

The research team analyzed the whole data by reading the material and making notes of the key events. During the winter 2012 monthly summaries were composed from the real time news collection. The concepts were operationalized by combining the empirical observations with the theoretical concepts. Thus, for instance, the three main niche processes were operationalized by searching and selecting statements from the press releases and news describing either explicitly or implicitly events, which match the above described features of the processes. The selected statements were collected in MS Excel sheets and used in the analysis. Thus the collected statements are considered as evidence of the niche processes at some specific point of time.

Table 5 Number of observations by the type of data and time period – excl. policy documents

Press releases & news	**Time period**	**Nbr of observations (e.g. articles)**
ABB Oy	2009-2012	11
Ensto Oy	2009-2012	8
European Batteries Oy	2010-2012	5
Fortum Oyj	2008-2012	28
Helsingin Energia Oy	2009-2012	3
Nokia Siemens Networks Oy	2009-2011	6
Valmet Automotive Oy	2009-2012	29
Press releases total		**90**
Real time newspapers	**Time period**	**Nbr**
Helsingin Sanomat	2.1.-31.3.2012	19
Tekniikka ja Talous	2.1.-31.3.2012	23
Kauppalehti	2.1.-31.3.2012	35
Talouselämä	2.1.-31.3.2012	2
Auto Bild Suomi	2.1.-31.3.2012	13
Tuulilasi	2.1.-31.3.2012	23
Tekniikan Maailma	2.1.-31.3.2012	26
Real time newspapers total		**141**
Newspapers during the writing process	**Time period**	**Nbr**
Helsingin Sanomat	15.8.-18.9.2012	4
Kauppalehti	7.6.-2.10.2012	4
Total		**8**
Newspapers in 2009	**Time period**	**Nbr**
Helsingin Sanomat	2009	32
Kauppalehti	2009	19
Talouselämä	2009	7
Tekniikka ja Talous	2009	13
VihreäLanka	2009	3
Newspapers in 2009 total		**74**
Interviews	**Time period**	**Nbr**
Director, new technologies (Ensto)	17.9.2010	1
Ev activist (Sähköautot Nyt!)	29.9.2010	1
Development manager (Green Net Finland)	30.9.2010	1
Research director (Fortum)	16.9.2010	1
Research professor (VTT)	17.11.2010	1
Project manager (Aalto University)	1.3.2012	1
Adviser (Technology industries)	12.3.2012	1
Program director (Eera)	14.3.2012	1
Program manager (Tekes)	13.9.2010	1
Program manager (Tekes)	9.2.2012	1
R&D manager (Helsingin Energia)	8.6.2012	1
Interviews total		**11**
Total number of observations		**324**

3.1 Identification of key players

The project has studied activities of two types of actors: individuals and organizations. In this study the key individuals, although they represent organizations, are considered as the keystone actors of the evolving network. As in the end, it is the key individuals, who set visions, make and execute decisions and form relationships with other individuals, even if the individuals are subordinates to and represent organizations. The network builders have been identified from the data by selecting persons on the basis of interviews and policy documents. The policy papers refer to actual policy documents and Internet web pages for relevant programmes and events. When selecting keystone actors, weight has been put on the individuals' actual roles represented in the observed acts. These observations have been combined with the frequency of how many times keystone actors have been mentioned in the different sources, including in the conducted interviews as this was asked from a number of informants. The mappings of keystone actors lead to the creation of a list, which consisted of representatives of enterprises, research organizations, consultants and agencies.

However, also enterprises as such are important research subjects in the case of emerging industry. Although individuals are the actual decision-makers, they use enterprises technologies, contracts, connections and other resources in promoting the goals of the organization. And even if individuals change work tasks, retire or leave to work for other organizations, the original organizations do not cease to exist but continue to fulfill commitments. Thus, for this study also a number of enterprises relevant for the field were identified from a previous research project, the news, public research and development programmes and from the interviews. The result of this mapping was the creation of a long list of organization actors. The long list contained different types of players such as small, medium and large size enterprises, domestic and foreign-owned enterprises, players of different industries as well as ministries with their relevant agencies.

From the long list a number of enterprises were selected for a more detailed study. The selected enterprises were defined as the key organizations whose actions – with factors emerging from the business environment – influence on the direction and quality of the evolving industry. The selection for the short list was not done randomly, but it was based on the information provided by the informants who named the main enterprises that were

active in the field. The short list was used for the creation of a number of case studies of the main players. *These are presented in the Chapter 7.*

The identification of key organizations and individuals were basically done at the same time. The lists and the cases along with the other collected information were used in the analysis as they made it possible to ask who did what, when the activities were done and even ask what were the motives behind the activities. *The key actor analysis was the first step in the use of framework.*

3.2 Methodology of event structure analysis

Event structure analysis (ESA) is an inductive methodology developed by David Heise (1988 and 1989). The method is used for mapping cause and effect relationships in a sequence of events in order to find an explanation for an outcome of particular process. Basically, the event structure analysis is conducted by first identifying the relevant events of the area of interest and then the implicational relationships of the events are studied. The methodological foundations of event structure analysis are in rational choice theory and in cognitive anthropology (Griffin 1993), where the rationality is based on the assumption that people aim to do rational actions based on a reasoning in the specific point of time - even if the actors would not understand perfectly the surrounding material or social reality (Heise 1989). Thus, the event structure analysis assumes that actors try to rationalize the world even if the outcomes of the actions would be from some perspective irrational or at least unexpected. Furthermore, Heise (1989) has defined five theoretical and six methodological principles for modeling the event structures of incidents. These are presented below in the following sections.[1]

The *first* theoretical building block is the theory of production systems for describing action. Although the scientific roots of the production systems theory are in cognitive science, the theory has been further developed in the areas of psychology, sociology and in computer science. Heise presents that *"action is governed by if-then rules: if a certain configuration of conditions arises, then a certain production occurs."* Also, the outcomes or productions affect back to the conditions and can create a new

[1] The texts of David Heise (1988 and 1989) are seminal pieces of the methodology and these texts are referred in this paper for the following sections dealing with the event structure analysis.

configuration of conditions, which then can lead into an evolving process. When conditions for several productions take place simultaneously, Heise recommends that the product with the highest priority should be considered. Furthermore, Heise states that the main benefit of the theory of production systems is that it allows the *"representation of knowledge about verbally defined events in models."*

The *second* theoretical building block is the way event-event structures are modeled. Heise proposes that event-event relationships are presented with implications where the actualization of a conjunction of prerequisite events maps into a consequent event. Thus multiple events may map into a single event, but also any single event may map to multiple other events (Heise 1989.) The graphical presentation of the event-event mapping is done with a directed graph where source nodes are events, which are necessary conditions for the events to which they branch and target nodes are events implying the events branching to it. The implications are included into the model as branches between nodes. (Heise 1989.)

The *third* assumption deals with the priming of events. In order for events to happen, all (conjunction) of the preconditions have to be fulfilled: events cannot happen without the happening of prior events. However, Heise (1989) states that although the conjunction assumption is emphasized, there can be cases where events are disjunctively connected to the prerequisites. The *fourth* aspect of the theoretical framework deals with the depletion of event's prerequisites and the *fifth* aspect with commutative implications. The depletion assumption means that the occurrence of an event consumes the related prerequisites. Thus, the assumption eliminates the emergence of loops into the model and prevents the system of getting stuck. Therefore, the event structure models are primarily built as acyclical. However, cyclical event sequences can be present in data and they can be included to acyclical models by marking the events, which deplete each other, as commutations. (Heise 1989.)

Heise (1989) presents six methodological principles when using event structure analysis. First, experts of the studied area should be used for defining events and identifying the related prerequisites and consequences. Second, the analysis should focus on specific and time-ordered incidents. Thus, not all the events need to be included in the analysis, but instead, the focus should be in the relevant ones. Also, the events selected for analysis *"should be equally significant or relevant"* and *"multiple events can be pooled"* up. Third, the analysis should build on short chains of inference instead of long chains as the truth-value of long chain of inference is easily

distorted due to the limits of human thinking. Heise calls the third assumption as the *"principle of local logic"*. Fourth, the analysis of implication chains is shortened when syllogism (transitivity) is utilized in the deductions of prerequisites and consequences. Fifth, observing a particular piece of a fallible data is not a reason to reject the developed model as the event structure model is based on *"patterns in data along with assumptions about the event system"*. With this principle, Heise contrasts event structure analysis's qualitative models with quantitative models. Sixth, the events are prioritized on the basis of objective observations. (Heise 1989.)

Event structure analysis has been used to analyze different types of organizational and social processes. For instance, Valorinta et al (2011) use the method for analyzing dynamics of competition in a period of over 40 years in the Finnish retail market. In the context of administrative decision-making the method has been used to analyze connections of events in a planned social change by Stevenson et al (2003), while Griffin (1993) utilized the event structure analysis on the analysis of a racial conflict, which happened in Mississippi on 1930. Although the method is general regarding the scope of applicability, the use of the event structure analysis demands in-depth understanding of the local physical and social contexts in order to understand the rationales of actors' decision-making and thus the connectedness of unfolding actions (Griffin 1993). Thus, it is the corresponding researcher's responsibility to assess the causal relationships of events.

In this project the event structure analysis was used to analyze the developments of the Finnish electric vehicle technology system. By combining the event structure analysis on the innovation system processes, it was possible to utilize the combination in three ways. First, the event structure analysis was used in its original purpose for analyzing the main development process of the whole technology system. Second, the collected annual information of the events highlighted the periodical build-up and interaction in the system complementing the plot of the main development path. Third, as the events convey information of actual, relevant happenings and when the events were coded to represent different types of functions - a time-series type of event data emerged for each of the processes. This made it possible to probe both the periodical and cumulative profile of the system. With the third consequence it was possible to analyze the process weaknesses for identifying blocking mechanisms in the system and make policy observations. However, this kind of analysis was done carefully as the sheer number of events did not necessarily tell the

whole truth of the development. The event data also contains negative information for the processes, or events, which have limited significance for the system. Also, the recorded events are multifaceted and an event can be interpreted to convey information from more than a one type of function. This is recognized in the analysis of processes. Nevertheless, when these kinds of risks were acknowledged the described approach could be used to approximate the system development.

First, it was decided that for this study the events would be defined as actual historical happenings, which were observable primarily from public sources or which were described in the private interviews. It was acknowledged that many of the observed events or sources for events, such as press releases, contained information of actually several different actors, or information of several and not just of one event. For identifying the activities of these kinds of multifaceted events, the first interpretation was to emphasize the main message reported in the source in order to describe the main activity for this project. The second option for the interpretation of the multifaceted events was to divide the information to different events, if it made sense in chronological context and if it was considered to be in line with the earlier or simultaneous activities.

Second, a chronological event list was built by utilizing all the data collected for the study. This resulted in the creation of the long event list. See the appendix 1. Instead of writing a full narrative for the analysis of the development process, it was decided to focus the analysis on the descriptive event listing. In addition, it was acknowledged that the listing is not complete, as it does not fully cover - for instance - the relevant investment data of private enterprises. However, it was decided that this kind of uncertainty would be acknowledged for the conclusions, but it would not prevent making the analysis. The time period for the exercise was first the interval from the January 2008 to the spring 2012, but it was later shortened to the end of the 2011.

Third, based on the described activities of an event, the individual events were coded and allocated into the subprocesses and then aggregated into the three broader niche processes. As described above, some of the events were multifaceted. These are a source for uncertainty when they are considered from the process coding point of view. Also, the event list contains some international events characterizing the market formation function. These were included to this analysis as the international

dimension of the Finnish electric vehicle innovation system has a rather important role on the domestic development, as will be later shown.

The breakdown of the individual events of the electric vehicle system is presented in the table 6 below. Totally 122 observed events were recorded for this study. In 2008, there were only few events, but already in the next year there were 29 events and in 2010 41 events. From the happenings of 2011, totally 16 are included into this study as events. Regarding the three niche processes, the learning (67 events) and articulation of expectations and visions (42 events) processes are the strongest while the creation of the social network is represented only by 13 events. From the subprocesses angle, the positive externalities function is the weakest process: there were only 2 events in the studied period. Also legitimation (4 events) and entrepreneurial experimentation (9 events) can be considered as weak processes. On the other hand, influence on the direction of search (38 events) and knowledge development and diffusion (30 events) are the strongest subprocesses.

Table 6 Number of events allocated on niche and TIS-processes in 2008 – April 2012

Niche processes	2008	2009	2010	2011	2012	Total	Sub-processes	2008	2009	2010	2011	2012	Total
Articulation of expectations and visions	5	9	14	7	7	42	Influence on the direction of search	5	9	13	5	6	38
							Legitimation	n.a.	n.a.	1	2	1	4
Learning process	5	19	21	5	17	67	Knowledge development and diffusion	1	7	15	1	6	30
							Entrepreneurial experimentation	2	2	5	n.a.	n.a.	9
							Market formation	2	10	1	4	11	28
Creation of social networks	1	1	6	4	1	13	Development of positive externalities	n.a.	n.a.	1	n.a.	1	2
							Resource mobilization	1	1	5	4	n.a.	11
Total	11	29	41	16	25	122	Total	11	29	41	16	25	122

The collected long list was used to make a more compact presentation of the development dynamics, as it was evident that the long list emphasized for instance public enterprises over private players. The pooling of activities was done separately for each of the events represented in the model in such a way that it described the main steps and activities of key players with

approximately similar weights. Although there is *"no general theory about how to choose relevant events"* (Heise 1989), for this project the pooling was based on the assessment of actors motives and events consequences. The abstracted list was iterated several times before it was used in the computer analysis. The list is in the Appendix 2.The actual event structure analysis was conducted with the aid of online process analysis software Ethno. The result of the prerequisite analysis was tested with Ethnos test procedures for comparing the match between the result and Ethno's theoretical syntax for events. The program suggested some changes, but the result of the analysis was maintained.

The result of the qualitative analysis is a simplification of a complex process of short run industrial evolution. In the result, the aggregated events are presented in chronological order with figures and the implicational relationships of events with arrows. As most of the events included to the analysis are pooled from several incidents the aggregation has affected the timing of the events. However, based on the available information the time order of events is such that it does not affect the assessed implicational relationships. *The use of the event structure analysis was based on the second step of the framework and the results are visualized and discussed in detail in the Chapter 4.*

3.3 Analyses of networks, structures and processes

In this paper the concept of network is used as a metaphor for describing the structure of distributed social system of Finnish electric vehicles cluster. The network approach is used mainly in two sections. First, the networks are used to describe the structure of the innovation system in different, but consecutive time periods as presented *in the step 3 of the theoretical framework* in Chapter 2.3. In that context, networks refer to the identification of clusters of key actors and their relationships or major acts in the studied periods. *The result of this step is presented in the Chapter 5.* The changes in the innovation network's architecture are visualized in three pictures. Besides identifying certain main actors, a number of activities are presented in the visualizations. Basically two types of activities are included: acts (or interaction) and ownership (or funding) relations. The division between major acts and interactions is somewhat artificial as basically most activities generally are reciprocal interactions (transactions). The approach does not cover all activities, but it was selected in order to highlight the

main happenings in the system. The ownership relation describes funding, investments and ownerships between actors. Besides highlighting actual events related to, for instance, rising venture capital, the ownership relation presents actual and potential power relations between the different players. Furthermore, relations have been marked between groups by default, but also acts between actors are included in order to highlight events. The boundaries of groups are marked as open by using dashed lines.

When the network concept is used second time, it is used to discuss the niche internal structural process of network formation *as part of the fourth analysis step of framework*. In this second context, the emphasis is on the actions taken by individuals more than organizations when they are creating networks in the industry. The second approach focuses on discussing, what are the acts and roles of key individuals in the network. Related to organizations, the discussion focuses on the supportive measures that have been made to foster the evolution of innovation network. *This aspect is included in the Chapter 6*. Moreover, the three niche processes are discussed from a chronological perspective at a general level starting from the earlier steps of the processes. However, the development steps of an individual niche process are not assumed as causally connected within a process as the three social processes can be intertwined and they can feed each other. Therefore event structure analysis is not used for the individual processes, even if the collected and allocated events are used as a data of the analysis. Especially, the processes are studied in relation to the niche hypotheses. The TIS subprocesses are approached from a slightly different perspective. For the functions, chronological order in this study is not considered as the main factor, as the focus is on the rough estimation of the strength of each function based on the indicators (see chapter 2) and within the limits of the collected data.

Regarding ontology, in the first instance of use – in Chapter 5 –, the networks of the electric vehicles innovation system is discussed from an 'outsider' ontology point of view. In this case, the 'outsider' ontology means that the approach focuses on telling the story of the evolution or development of the structures of the network without commenting actions of key individuals. However, when the networks are discussed in the second time – see Chapter 6 – an 'insider' ontology or path creation aspect is being adopted referring to the active roles of the keystone actors inside the niche. (Smith and Raven 2012 and Garud et al 2010.)

4. Institutionalization of the electric vehicles niche

The Finnish electric vehicle industry has evolved due to the interaction of economic and political players. The development is characterized by the activities conducted by diverse type of players in 18 aggregated events in three periods - 2008, 2009-2010 and 2011 (-2012) - where the events 6., 17. and 18. turn out to be the focal points of the process. The 18 main events from the years 2008-2011 forming industry's development process, are presented below in the figure 2.

Already in 2007 Metropolia University for Applied Sciences of the City of Helsinki decided to develop an electric race car as a student project with the intention to participate in an international competition. The students did not build the whole car themselves, but instead, the project team started to contact players involved with cars, components and related technology development and the project gradually built a large network of supporters for the venture. The first press conference of the electric race car project was held in January 2008 (1.), informing the public of the bold mission. Soon a totally separate project (2.) emerged due to an opportunity seen by a number of private investors. The group of investors established the European Batteries - a manufacturing enterprise for electric vehicle batteries with the intention to seize the opportunity from the growing awareness of the climate change and the simultaneous distress of the global car industry.

However, during the spring 2008 another separate venture was launched when the Finnish utility company Fortum reestablished its electric vehicle business and started promoting the idea of electric vehicle industry (3.). The reestablishment emerged from the company's Swedish subsidiary where it was contacted regarding a project dealing with smart grids and electric vehicles. For promoting the idea of developing electric vehicles in Finland the Finnish parent company started building networks to the relevant stakeholders and, for instance, contacted the City of Espoo - the municipality forming the home base of the company.

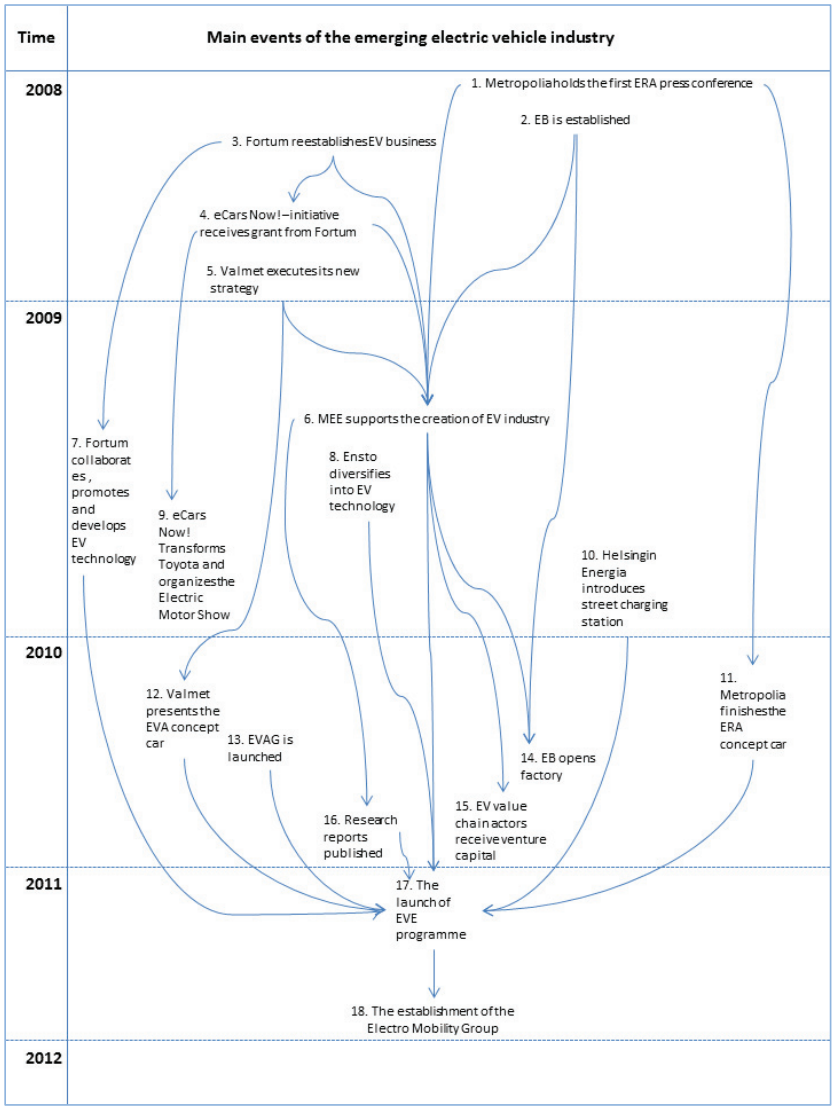

Figure 2 Institutionalization of the Finnish electric vehicle industry

The idea of developing electric vehicles was not developed solely by enterprises or Metropolia. Also the ordinary people representing the civil society were very much interested of the topic. Already in the summer 2007 a number of interested people established spontaneously a loose network organization, eCars Now!, for fostering the electric vehicle development. The eCars Now! -initiative had a close relationship with the Electric Vehicle Association of Finland (EVAF) – an organization for electric vehicles, which was established already in the early 1990s. The members of the eCars Now! –initiative formed an idea that private persons could foster the EV development in Finland for instance through promoting the topic to the

public and to the main civil servants, and also by transforming combustion engine cars into electric cars and offering the transformations to the users. The first transformation was made possible when the initiative managed to negotiate Fortum to fund the transformation: in 2008, the initiative received €30000 funding from the company. (4.).

Furthermore, the Finnish contract manufacturer for cars, Valmet Automotive, had formed a new strategy, at least partly based on the changes taking place in the global car industry, which included focusing on the building of electric cars. Thus, in the Fall 2008 and in the January 2009 Valmet announced contracts covering cooperation with Fisker (Fall) and Garia (January). (5.).

Thus, there were a number of ongoing projects and personal ambition for launching electric vehicles in Finland in the year-end of 2008. The development in the electric vehicles field was taken into account by the Ministry for the Employment and the Economy (MEE) and in the January 2009 the Ministry initiated a work group for investigating the prospects for creating an electric vehicle industry in Finland. One of the reasons for initiating the work group was to develop a strategy for the industrial policy to respond to the global crisis threatening the domestic electric industry. As the work group finished in the August 2009 (6.) it supported developing electric vehicles industry into Finland: the work group set up a vision and objectives for creating the industry and for the electrification of the Finnish traffic. The decision to support the industry creation, as manifested in the form of the report, enabled the public sector organizations to conduct a number of activities during the next few years. As a consequence for the political decision, research and consultation projects for monitoring the domestic strengths and global business opportunities were conducted (see event 16.). Also, venture capital and private equity investments were made in the Finnish electric vehicle value chain by Finnish Industry Investment – the private equity tool of the MEE (see event 15.). Research and development projects were also funded after the affirmative decision.

Since reestablishing electric vehicle business in 2008 Fortum was consistent in promoting electric vehicles (7.). Besides promoting, in the years 2009-2011 the company collaborated with relevant stakeholders and developed electric vehicle related technology. For instance, the company collaborated with Ensto in the fall 2009 in a project for developing a charging station for electric cars and with Valmet in a project for developing

the Finnish concept car EVA. Furthermore, Fortum developed test beds, for instance in Kurikka, for charging of electric vehicles.

A new player emerged in the fall 2009. During the fall Ensto, a family owned enterprise, initiated its electric vehicle business (8.). The company focuses especially on charging stations and collaborates in the development with Fortum and Helsingin Energia. One of the main events for the company took place in the fall 2009 when the enterprise won a procurement organized by the City of Oslo for the delivery of charging stations for the City. Later, in October 2010, Ensto continued internationalizing in the EV business and the company acquired the French NOVEXIA. Since initiating its electric vehicle business Ensto become one of the enterprises driving the development of the industry along with Valmet and Fortum.

With the aid of Fortum's grant the eCars Now! -initiative managed to finish the transformation of the first car (Toyota Corolla) in the Fall 2009 (9.). Furthermore, at the same time the actors participated organizing the first Electric Motors Show in Helsinki, which functioned as a temporary networking platform and created some visibility for the cause. However, the individuals participated in organizing the event mainly on a voluntary basis and the members considered that the task had been a very time consuming project for volunteers. Nevertheless, another Show was still organized later in the fall 2010, but since then the project has been on hold. Regarding the car transformation, the eCars Now! –initiative managed to transform another car, but it soon became evident that transforming is not a competitive method for the electric vehicle breakthrough due to the associated high costs and accountability issues of transformation. Although the civil society players had a role in the emergence of the industry, their significance diminished when government started to act and the enterprises become aware of the business potential related to electric vehicles.

Another new player, Helsingin Energia –the utility company of the City of Helsinki, came public in the industry in the fall 2009 (10.). Helsingin Energia had a long history in electric vehicles and it had restarted to generate interest towards the electric vehicles business already in 2008. However, it was until December 2009 when the utility company introduced the first public street charging station in Helsinki. The first station was delivered by Ensto. Since restarting electric vehicles business Helsingin Energia has been a strong advocate for the vehicle and infrastructure development.

Since initiating the electric race car project, Metropolia collaborated and developed skills, knowledge and know-how in the building process. As a result, the institution managed to put the race car first time on wheels in February 2009 and in October 2009 it was accepted on the final of the Progressive Insurance Automotive X PRICE competition. Metropolia finished the race car prototype ERA in the spring 2010 demonstrating learning and entrepreneurial attitude of not just of the students, but also of the involved stakeholders (11.). Furthermore, later in the year the ERA car reached second place in the international XPRICE competition demonstrating the high quality of the work done and acting as a motivational event for the involved stakeholders. Besides the success story of ERA, Metropolia was active in the development projects of the period.

Also Valmet Automotive continued executing its plans for electric vehicles. For instance, in August 2009 the company announced having signed a letter of intent with Think Global AS for manufacturing Think City electric cars. Basically at the same time with Metropolia, Valmet managed to finish with the aid of partners the Finnish concept car EVA (12.). Regarding the company's electric vehicles trajectory in 2009-2011, Valmet encountered both high profile accomplishments, but also difficulties. Valmet Automotive managed to deliver for example Think Citys, although soon after starting the manufacturing process, Think Global AS went out of business. In addition, the manufacturing of Fisker Karmas was postponed several times and it was not until in the early 2012 when the company delivered the first Fiskers.

Another initiative for the electrification of Finland was launched: Electric Vehicle Action Group (EVAG). In the spring 2010 the EVAG initiative for promoting the rapid development of EV infrastructure was launched (13.) The EVAG initiative was a predecessor for the upcoming PSL-consortium of the Electric Vehicle Systems research and development programme (EVE) of the Finnish Funding Agency for Technology and Innovation (Tekes) and it was coordinated by the consulting company Eera. The initiative was formed by a handful of companies whose interest collided with the infrastructure development. For instance, Fortum was a member of the Group.

As soon as the company was established, the investors behind the European Battery continued with the plans to supply batteries for electric vehicles. Regarding that, the company decided to build a factory and apply funding

for the complex. In a while, the company managed to raise the funding, tens of millions euro in total, and open the factory in the summer 2010 (14.). The factory is located in the town of Varkaus and a large share of the funding came from public sources. Regarding the operations' connection to the administration, the factory venture was well recognised project in the MEE's decision to support the industry creation in 2009 and the public funding was critical for the venture to take place.

Regarding the consequences of MEE's decision to support industry creation, Finnish Industry Investment made three venture capital investments in 2010-2011 (15.). Finnish Industry Investment invested in February 2010 in Nordic Mining SA - parent of the Keliber, which is a mining company for lithium in Western Finland. Few months later, in October 2010, Finnish Industry Investment invested in Valmet Automotive and in January 2011 the company participated in an investment round organized by Electric Batteries. Although Electric Batteries was able to build the factory and raise capital, the company could not establish a foothold in the car industry as a supplier of electric batteries. In the spring 2012, Electric Batteries had to enter in reorganization programme and the enterprise decided to focus on other segments than electric vehicles in the battery manufacturing.

After the decision to support the industry creation a number of research and consulting reports were commissioned by the authorities in charge (16.). The reports were published between the August 2010 and February 2011 and the reports mapped the local strengths, opportunities and market potential for electric vehicles, electrification of work machines and impacts of wide spread use of electric vehicles on the grid. The report Hypätään kyytiin of SWOT Consulting was commissioned and published by Tekes in the August 2010 while in the November of the same year Finpro published research results covering global business opportunities. In December 2010 VTT Technical Research Centre of Finland delivered a report Scenarios of large-scale deployment of electric vehicles and their power system impacts, which was partly done for in-house purposes and partly for the Cleen and Tekes. In the February 2011 the Ministry of Transport and Communication published a broad and detailed report dealing with the prospects of electric vehicles in Finland. Although the Ministry's report was published in 2011, it was commissioned already in 2010. Although the reports gave information for planning, the reports highlight the different views and estimations of the various experts for the future development of the industry.

Finally, the main research and development initiative for the electric vehicles, the EVE-programme of Tekes was launched consisting of €80 million investments from Tekes and private enterprises for the years 2011-2015 (17.). The administrative decision for the programme was published in the late December 2010, while the programme started running in the 2011. However, the launch of the main subprograms of EVE, took place at the end of the year, and the actual execution of the programs right after the turn of the year. The MEE's decision to support industry creation allowed directly the build-up of the program, although the actual planning was done in conjunction with the main authorities, agencies and investing enterprises. The content of EVE program is thus based on the various reports, experiences, interests, negotiations and power relations of the players holding stakes in the industry's success. The enterprises Fortum, Valmet, Ensto, Eera, European Batteries and Helsingin Energia are all involved with various positions in the management or execution of the programme. Furthermore, the programme attracted a number of new entrants from other industries such as ICT or construction field.

In October 2011 the Electro Mobility Group was established leading to the institutionalization of the industry (18.). The Electro Mobility Group is a multilateral platform for coordinating the further development of the industry (a coordination mechanism); the establishment of the mechanism was outlined already in the MEE's report. Although the industry continues to evolve, the structures of the industry have been found in the form of political support, investments, committed enterprises and their stakeholders and a mechanism for sharing information and searching support and resources for future activities for the electrification of Finland and on the creation of successful industry for exports. It is unlikely that the Electro Mobility Group would have been established without the launching of EVE programme.

The focal points 6., 17. and 18. of the process seem to follow each other in a linear fashion. However, in truth, the development process included also accomplishments, challenges and failures of the actors, which created movement inside the process. For instance, in the fall 2009 the Fisker Karma project of Valmet and the factory project of European Batteries were considered as important and expected to be sources for added value for the Finnish economy. However, as later turned out, both projects faced setbacks. At the same time as the car and component manufacturing seemed to fail the importance of infrastructure solutions grew.

5. Developments in the architecture of the innovation network

Next, the development of the architecture of the innovation network is discussed. The discussion on the structure is divided into three consecutive periods: the year-end 2008, years 2009-2010 and the period of 2011-spring 2012. The analysis consists of the horizontal description of the main actor groups and their main activities and the development of the institutions, subnetworks or arenas, which are the main elements of the innovation system. The focus is on the growth in the number of activities and the international dimension of the electric vehicle innovation system.

5.1 In 2008 the network emerges from multiple sources

The Finnish electric vehicles cluster started to evolve strongly between the years 2007-2008. There was not any single driver, but instead the evolution started almost simultaneously from different sources. Although Finland had a short history in electric vehicles in the period 1980-1990s (see Lovio et al 2011), the activities were fragmented, of very small scale and actors were disconnected when the electric vehicle activities started to re-emerge in 2007.

The international development of the global car industry and the increased environmental awareness and the related climate change discussion created a window of opportunity for the domestic players. For instance, Valmet Automotive – a contract manufacturer of premium sports cars and a subsidiary of Metso Group – revised its strategy and started focusing its activities on the electric vehicles, which were expected to triumph due to the changes taken place in the global business environment. Regarding this, the enterprise received its first contract from the American electric vehicles supplier Fisker Automotive. The deal involved the delivery of Fisker Karmas, premium plug-in hybrids. However, another signal to the domestic system came from Stockholm, Sweden. The Swedish subsidiary of the Finnish Fortum, a mainly state owned public utility company, was involved with developing a smart grid infrastructure for the electric vehicles in one of the districts of Stockholm. Thus, due to the development steps taken in Sweden,

Fortum re-launched its earlier electric vehicles research and started promoting the idea in Finland. Furthermore, the looming opportunity was perceived by European Batteries, a start-up manufacturer of large lithium-ion battery systems, and it started building a production facility into Varkaus, a town in Eastern Finland. The Finnish system received an investment from Norway as Nordic Mining acquired Keliber – an enterprise operating in the mining of lithium in Western Finland in the winter 2008. The situation of the innovation network in 2008 is presented below in the figure 3.

Due to the actions of Fortum and European Batteries two municipalities were connected in the early phase of the development to the innovation network: Espoo and Varkaus. When European Batteries sought a location for its plant from Varkaus, Fortum initiated collaboration with the City of Espoo. Varkaus sought better employment opportunities for the inhabitants of the town, while Espoo was motivated by the opportunity to develop the local high quality innovation environment even further with electric vehicle test beds. Also the City of Helsinki started to interest of electric vehicles in 2008. However, regarding the role of the Finnish Government, the State was mainly involved through the ownerships connections to Fortum and Valmet Automotive, as the State owns approximately 10% of the Valmet's parent Metso.

There had been few electric vehicle traffic related projects, before the described activities were established. For instance, Tekes funded fuel cell research and Kabus Oy – a subsidiary of Koiviston Auto Group – had led a Tekes funded consortium, which developed a hybrid bus for the company. VTT was one of the main partners of project.

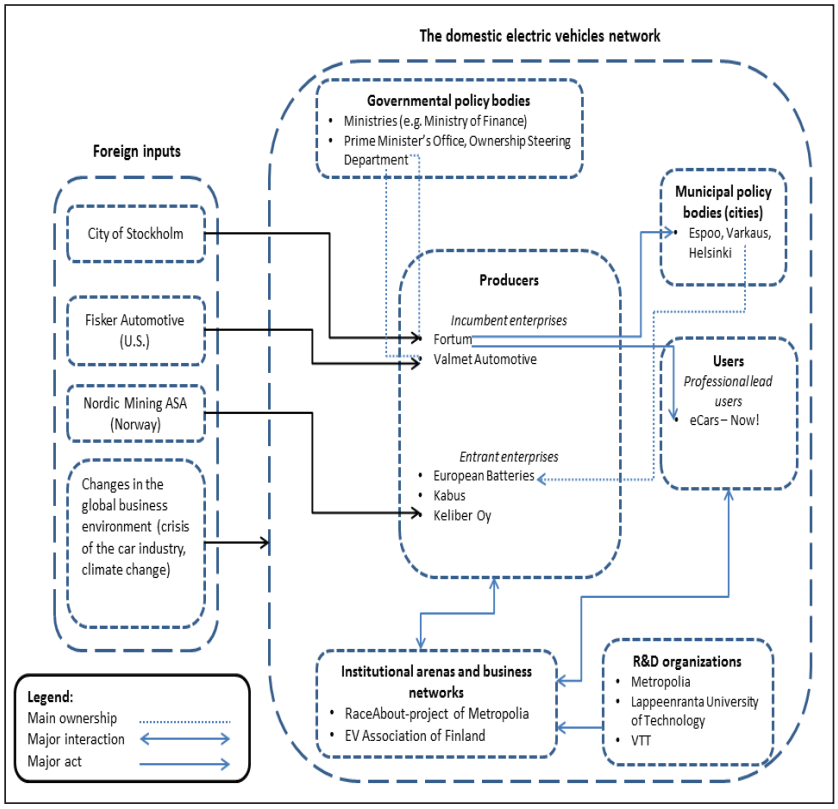

Figure 3 Emerging electric vehicles innovation network in 2008

The institutional arenas of the innovation system started to evolve already in the 2007. The most notable single electric vehicles venture was initiated by the Metropolia University of Applied Sciences when they launched in September 2007 a project for developing a fully functional electric race car: the Electric RaceABout –project (ERA). Although the ERA was an educational student project with an ambitious goal aiming for developing the electric car, the project started soon to attract partners. In May 2008, the RaceAbout-project had already 26 enterprise, R&D and funding partners. Among these were Valmet Automotive and Lappeenranta University of Technology, which developed the electric motors for the ERA. (ERA 2008).

Another group also promoted the awareness and widespread use of electric vehicles. The Electric Vehicles - Now! –initiative was established by a number of self-motivated private persons in summer 2007 with the objective of promoting the wide spread use of electric vehicles by lobbying the cars to the public and Finnish administration. In order to demonstrate electric vehicles, the members of the initiative started transforming combustion engine cars into electric motor cars. As the group operated on a

voluntary basis it did not have the funds for the transformation. However, the first transformation car was made possible by the funding from Fortum in November 2008, when the company granted €30000 to the initiative. In addition, the eCars – Now! (Sähköautot – Nyt!) -group had close ties with the EV Association of Finland (Sähköajoneuvoyhdistys) – an organization established in 2002 for promoting electric vehicles.

The initial steps of the development of the electric vehicles innovation network were driven by enterprises operating in the different sections of the value chain and representing infrastructure, components and contract manufacturing. However, also self-starting individuals demonstrating entrepreneurial spirit and ambitious goal setting played major roles for attracting stakeholders and initiating discussion on the possibilities for electrifying the domestic traffic.

5.2 Ministry of Employment and the Economy as the strategic enabler in 2009-2010

Between the years 2009-2010 the innovation network evolved. These two years were the period for researching the global market potential for the domestic industry and planning and resourcing the research and business development activities. During the period the innovation network attracted a number of municipal, enterprise and research and development actors. The years marked the growth of business and research and development networks and international interaction. The situation of the innovation network in 2010 is presented below in the figure 4.

From a structural point of view the Finnish Government played the strategic role. In the winter 2009 the Ministry of Employment and Economy set a work group for finding out the possibilities to develop a domestic electric vehicles cluster. The work was motivated by the global recession affecting severely to the domestic industry severely in addition to the simultaneous troubles of the global car industry. The work group finished its task in the following summer and set the measures and goals for the development of the domestic electric vehicles cluster. Regarding the objective, the ministry stated that by the year 2020 the electric vehicles cluster would be a significant exporter of finished products and services based on the renewing of the existing domestic industrial players of electric infrastructure, car manufacturing and engineering services. Also, in 2020 the industry is expected to generate a total turnover of €1-2 billion and

employing directly several thousands. In addition, the vision included a statement regarding the use of electric vehicles: by the 2020 one quarter of all of the cars sold should be plug-in hybrids and 40% of those should be full electric vehicles.

The ministry's subordinates started executing the commands. Finnish Industry Investments - a state-owned private equity company, which is a subordinate to MEE - invested in the electric vehicle manufacturer Valmet Automotive and in Keliber of Nordic Mining (9.2.2010) while Tekes – the R&D policy tool of MEE, started funding electric vehicles related projects. In addition, the sectoral research organizations of the ministry – VTT Technical Research Centre of Finland and GTK Geological Survey of Finland were involved in research projects related to the cluster while Finpro - the organization for promoting Finnish exports – conducted foreign market research for finding out the state and opportunities on the key markets.

From a regional and municipal point of view, the domestic innovation network spread out to new areas. The City of Espoo continued fostering the local collaboration motivated by the mitigation of climate change and the development of innovation environment while the neighbouring City of Helsinki engaged publicly in developing its electric vehicle infrastructure with motives similar to Espoo. Already in the fall 2009 the first charging station was opened in Helsinki. However, Lahti Energia, the utility company of the town of Lahti, started promoting electric vehicles by establishing in the summer 2010 the first parking places and charging stations near the company's establishment (Lahti Energia 2010). Furthermore, other centers emerged in the fall 2009 in Tampere and in the winter 2010 in Rovaniemi, located in Northern Finland. The activities of the Tampere region were organized under the ElectriCity-project aiming for developing a local center of expertise of electric vehicles while in Rovaniemi the activities focused on developing an electric snowmobile for tourism purposes. Besides the ledge, there was another pilot project in the Northern Finland. A consortium consisting of University of Oulu, AMC Motors and Chinese enterprises developed a concept car Sanitec for AMC.

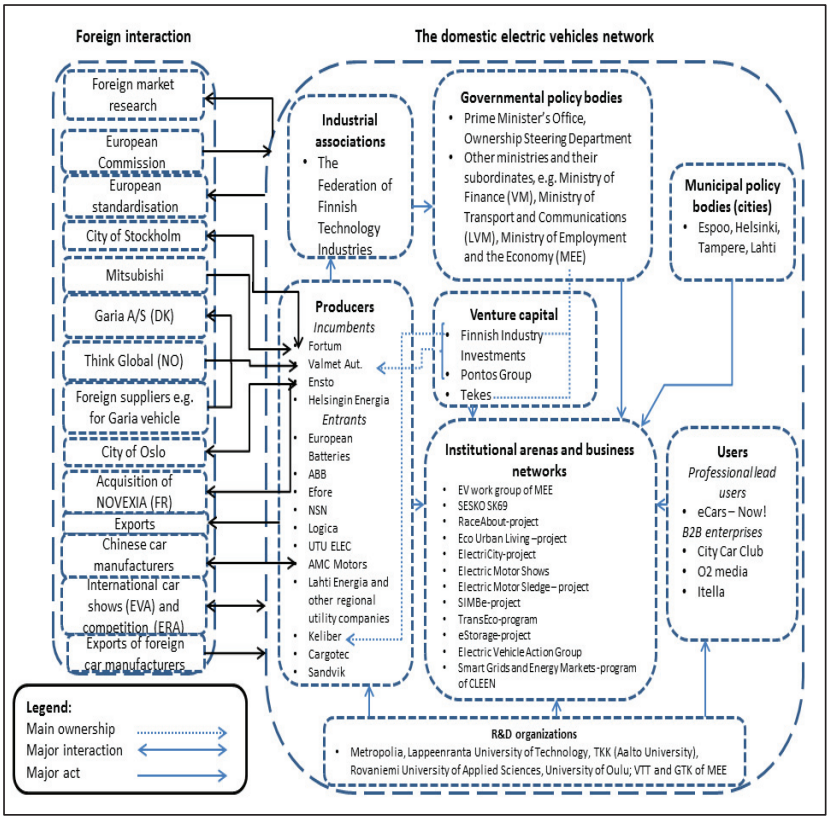

Figure 4 Electric vehicles innovation network in 2010

As mentioned, several research institutes participated in research projects and programs for smart grids and electric vehicles. The most notable players were the Technical University of Helsinki (TKK), which is part of the current Aalto University, and VTT. Especially the researchers of VTT initiated TransEco program, a broad consortium focused on developing energy efficiency and emission reduction technologies for transport. One of the topics of the program was to foster the creation of electric traffic technologies. As did the number of research players grow, so did the number and scope of business and R&D networks. For instance, when Metropolia's electric racecar (ERA) was finished in the fall 2010, the development network had grown from 26 to approximately 60 partners. Later that year Metropolia's racecar reached second place in an international race. Similar network creation took place with Valmet Automotive when it contacted both domestic and foreign partners and suppliers for developing and manufacturing electric vehicles. Furthermore, two Electric Motor Shows demonstrating electric vehicles to the wide public were organized, first one in 2009 and the other in the next year.

The evolving network attracted more enterprise actors. For instance, Helsingin Energia – the utility company of the City of Helsinki, ABB Oy – a subsidiary of the global ABB Group and the private company Ensto started contributing to the innovation network. The incumbent enterprises played multifaceted roles in the network: besides manufacturing and research and development activities, the enterprises strongly promoted the use of electric vehicles and the development of test environments. It was estimated that in 2009 there were 40 enterprises active in the cluster (Biomeri 2009). The players, which contributed or diversified to the field, were such as Nokia Siemens Networks, Logica, Efore, Vacon, Utu and utility related companies. Also work machine manufacturers interested of electrifying their products showed interest of the research and development done in the area.

The period saw a number of internationalization activities. For instance, besides contributing to the domestic test beds Ensto won a procurement contract from Oslo - the capital of Norway, concerning the delivery of charging stations. After the initial delivery Ensto exported also to other cities in the Northern Europe and acquired the French NOVEXIA. Regarding Fortum, the incumbent continued its operations in Stockholm, but in Finland the company collaborated with Mitsubishi in an endeavor of promoting Mitsubishi's iMiEV vehicle for potential Finnish customers. Valmet Automotive received in the summer 2009 a new customer from the Norwegian electric vehicle provider Think Global and the company delivered its first electric vehicles: Think Citys and Danish Garias. However, the manufacturing of Fisker Karmas was postponed several times. Regarding the other international activities, Valmet displayed the developed concept car Eva in an international car show held in the spring 2010 in Geneva. The Eva car was not a commissioned work, but instead it was Valmet's own venture for demonstrating electric vehicles competencies of the company. However, the innovation system received inputs from the foreign car manufacturers as they exported hybrid vehicles to the domestic consumers and also European Commission's automotive regulation favoring electric vehicles was published in 2009. On the other hand, the Finnish representatives participated in the international standardization forums through SESKO organization's standardization committee SK 69.

5.3 In 2011-2012 the Finnish industry forms the Electro Mobility hub

The Government's involvement enabled the development of the innovation network. The Government's continued actions covered investments, car

taxation reform, and research and platform formation. Finnish Industry Investment of the Ministry of Employment and Economy invested in European Batteries while Tekes allocated €40 million research and development funding to the EVE – Electric Vehicle Systems –programme running from 2011 to 2015. In the spring 2012 the new car taxation came into effect favoring electric vehicles.

Regarding the institutional arenas and networks two central platforms emerged in 2011. The EVE-programme of Tekes funds the different projects aiming for renewing the industrial capabilities and fostering the creation of new electric vehicle related technologies. The program contains several projects, which aim for developing regional test beds and collecting user experiences of the use of electric vehicles. However, after the Government directed the resources and created the platform for the industrial players, the initiative and responsibility of the cluster's development passed into the industrial players. Under the Federation of Finnish Industries in October 2011 the second platform was established, the Electro Mobility Group, a hub organization for the different industrial and research players interested of developing the domestic electric vehicle business environment and supporting the international business operations of the Group's 57 members (The Federation of Finnish Technology Industries 2012).

Due to the injected R&D funding a number of enterprises entered the network from different industries and for instance players from ICT and construction industry were represented. However, some of the already entered firms quitted from the industry and some players faced severe setbacks. For instance, Think Global – a customer of Valmet Automotive, faced financial difficulties and had to quit the industry. The event caused the closing of the production of Think City car. Another setback came through European Batteries, which had to focus more its operations on other segments of the cluster than electric cars, also due to a financial distress. This happened regardless of the collected venture capital from several private equity players in January 2011.

However, the Finnish system continued internationalizing and, for instance, both Efore and Valmet Automotive increased their international operations. Also, in the spring 2012 new vehicles came to the domestic market and the introduction of Nissan Leaf, a battery electric vehicle was preceded by the technology development project of Fortum and Nissan for developing a charging station usable by households. The Finnish system received also other inputs as the Polish hybrid bus manufacturer Solar S/A entered the

markets and when the Swiss Power Engineering Group, a private equity provider with Russian background, injected in the European Batteries.

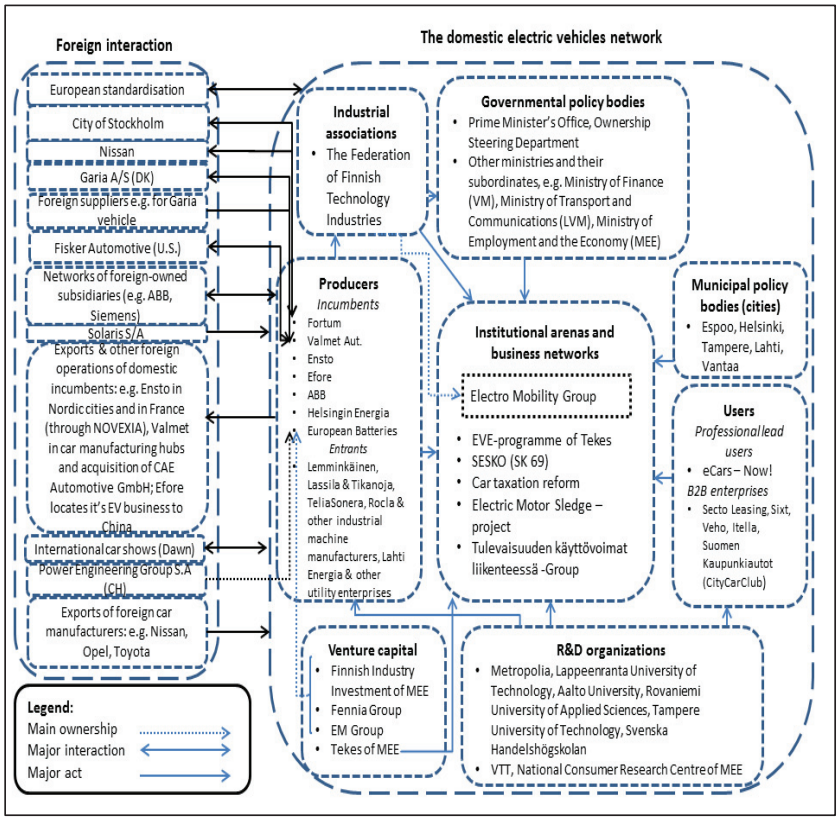

Figure 5 Electric vehicles innovation network in April 2012

Regardless of the setbacks concerning Valmet Automotive and European Batteries, the Finnish electric vehicles cluster continues evolving. The emphasis is more on the infrastructure aspect than in the car development. As the business and R&D networks have been initiated and the innovation network has received funding, the activities are more organized and focused than before. Thus, the direction is towards developing the domestic markets and regions in order to develop competencies and references for the competition in international markets. These are motivated for instance by the fine example shown by the ERA-project of Metropolia University of Applied Sciences, as mentioned, the car developed by students reached in 2010 the second place in the Progression Automotive X PRICE, which is a demanding international car development competition. However, due to the emerging structure, the significance of a volunteer based activity has diminished.

6. Analysis of the development process with niche and TIS aspects

Next, the three niche processes are studied in conjunction with the allocated TIS subprocesses. First the focus is on the role of the articulation of expectations and visions for creating an electric vehicle industry into Finland. After the expectations and visions -process has been presented, the focus changes on the initiated learning processes as the activities start to unroll. These two processes are accompanied by the creation of social networks when the arenas - for example - for research and development cooperation are created. The analysis builds on the information presented in the previous chapters.

6.1 Articulation of expectations and visions for electric vehicles

The articulation of expectations and visions started soon after the separate electric vehicle projects were found in 2007 and 2008. Straight from the beginning, the creation of expectations and visions had two directions or audiences. First, the main actors exercised the articulation either directly with the selected decision-makers or in the collaboration arenas such as the initiated R&D projects and programs. These kind of activities represented efforts for influencing on the insiders of innovation network in order to build and share expectations of the future development of the Finnish electric vehicle niche. Second, the articulation reached a wider audience through the various channels of the different media organizations, which informed the media consumers - or outsiders from the development process point of view – and which thus had an opportunity to become aware of the ongoing articulation process.

Both dimensions of the articulation process were present already in 2008 when the main actors such as Metropolia, Fortum and eCars Now! – initiative started contributing to the niche. For instance, the members of the eCars Now! started contacting the relevant civil servants in order to present their visions. Also, as soon as Fortum had re-established its electric vehicle operations, the company scanned for an opportunity to collaborate with the City of Espoo. On the other hand, the race car team of Metropolia used

other type of strategy as it decided to hold a press conference and inform the public of their intention to develop an electric racecar.

Although the private activities had gained attention of the media in 2008, the topic became a source for a major interest in the next year when the different private projects attracted attention of the high level political decision-makers. The risen interest of the media is evident for instance in the articles of Helsingin Sanomat. The number of terms referring electric vehicles rose from 124 of 2008 to 208 in 2009. The high level involvement resulted in the establishment of the electric vehicles work group of the Ministry of Employment and the Economy in the January 2009, which in the August made the decision to support the electrification of the traffic and creation of a domestic electric vehicle cluster. The decision of the work group contained a detailed vision for the Finnish cluster and since then the details of the decision have been referred in many electric vehicle events.

During the next two years the expectations concerning electric vehicles and electrification of the traffic became shared by an increasing number of actors as new enterprises became interested of the industry and more organizations became involved with the innovation network. The expectations became also more specific and started to converge. For instance regarding the specificity, it was suggested (e.g. Nylund 2011) that the electric vehicles should be piloted by forming large test fleets. This idea was accepted as part of the Electric Vehicle Systems technology programme of Tekes (EVE-programme) and later, in the winter 2012, a demonstration for electric vehicles suitability for winter condition was held in Helsinki by the participating organizations. Furthermore, the launching of EVE-programme signaled the convergence of expectations. The planning of the program took a rather long time, but finally the program was launched with notable media publicity in the December 2011. The Minister of the Economic Affairs played a prominent role in the launch. After the launch of EVE the articulation of expectations continued in 2012.

6.1.1 Influence on the direction of search -function

The main authors influencing the niche are the Government, European Commission, and entrepreneurs, researchers, activists and consultants launching ventures or having special know-how of the topic. Furthermore, the evolution of the electric vehicle niche has been fostered with a number of activities: by the use of domestic or European steering mechanisms; policy visions set by the administration, by delivery of influential research

and consultation reports and by public performances of high level politicians, businessmen, lobbyist, and specialists of the topic.

Table 7 Main decision and consultation publications

Publications and regulations	Year
MEE work group for electric vehicles in Finland – report	2009
European Commission: Regulation No 443/2009	2009
European Commission: Directive 2009/28/EC	2009
European Commission Communication: European Strategy on Clean and Energy Efficient Vehicles	2010
Biomeri: Electric Vehicles in Finland – report	2009
SWOT Consulting: Hypätään kyytiin –report	2010
Finpro: Ajoneuvo- ja työkoneteollisuuden sähköistymisen kansainväliset liiketoimintamahdollisuudet	2010
Ministry of Transport and Communication: Future of electric vehicles in Finland. Electric vehicles in the transport and climate policy context -report	2011

The Ministry of the Employment and the Economy and the European Commission made three influential decisions in 2009. Also, five reports were published in 2009-2011. See the table 7 above. The decisions consisted of the ministry's visions for creating electric vehicle industry and of the European Commission's regulation and directive for cleaner traffic.

One of the published reports was a communication of the European Commission for delivering the high level European strategy for clean and energy efficient vehicles - an important document for the administration and main enterprises and policy organizations. All the rest four reports analyzed the prospects of creating an electric vehicle cluster in Finland and electrifying the domestic traffic from various angles. The reports covered the identifying of the local value chain and ongoing projects, identifying strengths, weaknesses, opportunities and threats for domestic specialization and for international business operations, and also scenarios for the future development regarding electrification. The domestic reports were done for the administration or done by organizations of the administration.

Furthermore, electrification has been fostered with two incentives offered by the Finnish administration: change in car tax and grant of energy subsidies. The energy subsidies were part of the EVE-programme and designed as incentives for reducing the cost of acquiring electric vehicles for the participating organizations. The car tax reform came into force in the beginning of April 2012 and the new law lowered the taxation of electric vehicles.

The expectations in the electric vehicle industry have been supported with several statements of enterprises and public presentations of high-level politicians. For instance, the Ministers of Economic Affairs have participated in the inauguration of the factory of European Batteries and in the launching of EVE-programme. Also the incumbent firms have actively promoted the development of electric vehicles industry, for instance in press releases and in various public events.

6.1.2 Legitimation -function

The legitimation process is closely related to the influencing function. Some of the direction of search events contribute or aim to contribute on the legitimation of the electric vehicles as well. However, only few events were interpreted of being directly dealing with legitimation. These activities are mainly major public promotions by the leading politicians or lobbyist in events with high media visibility. Also the establishment of an open coordination mechanism for the interested electric vehicle actors can contribute on the industry creation's legitimacy.

The conscious decisions of administration and the promotion done by the interest groups form the basis for legitimation. Therefore, the decision to create the industry and the offered incentives also contribute on the legitimation. Besides the administration, the electric vehicle industrialization venture is for some extent considered legitimate by those enterprises that have joined in the niche's arenas as demonstrated by their actions. However, the fact that only a limited number of battery electric or plug-in hybrid vehicles have been bought by households undermines the legitimacy from consumers' point of view.

6.2 Learning processes regarding electric vehicles

There were two types of learning processes in the niche. First, there were several individual learning processes based on the private projects. For instance, after establishing their projects Metropolia, European Batteries, Valmet Automotive and eCars Now! –initiative, were all involved with knowledge and technology creation. Metropolia's ERA-project's main purpose was to educate students by creating a demanding race car while European Batteries venture for the battery manufacturing factory demanded understanding of the car manufacturing business. Also, Valmet's decision to diversify into electric vehicle segment required the development

of new competencies for the new technology, and the eCars Now! initiative was involved with learning while transforming the combustion engine car into electric car. Second, learning also took place at a more collective – or policy-making – level represented in the choices and decisions for stimulating the niche.

However, the private projects launched in 2008 continued or were finished in the following years. For instance the niche actors presented several concept cars. eCars Now! -initiative managed to finish the conversion car and AMC Motors its Sanitec concept car in 2009. Metropolia finished its electric race car with great success in 2010 and Valmet Automotive finished its concept car EVA practically at the same time as Metropolia finished its car. On the other hand, also problems emerged with the development of electric cars. The transformation of combustion engine cars into electric cars turned out to be more expensive than expected - in addition to the problems related to insurances, repair services and accountability. Although Valmet was successful with EVA and the cars Think and Garia, the company had to delay several times the manufacturing of the premium hybrid car Fisker Karma. In order to overcome the difficulties regarding Fisker Karma, Valmet Automotive invested in knowledge development and was able to deliver the premium car in 2012.

Although the development of concept cars demonstrated success, also disappointments emerged. For instance, European Batteries was not able to develop sustainable business model for supplying for electric vehicles and the firm faced financial distress. Thus, the enterprise decided to focus on other than electric cars with its battery manufacturing business.

The learning process for the policy choices emerged when the MEE's work group was established and it made the decision to support the industry creation in the August 2009. As a consequence of the decision several consultation and research reports were commissioned for identifying the features of the domestic industry and estimation of the international business opportunities. The report phase signaled the need of the various actors to gather intelligence for detailed decision-making. Although the industry creation started in 2009 with a specific goal and with the intention to electrify the traffic, later in 2012, the activities in the niche emphasized especially the development of the infrastructure aspect of the industry as a necessary step for the creation to succeed. Thus, the stressing of the infrastructure demonstrated the learning among the involved niche actors.

6.2.1 Knowledge development and diffusion -function

Knowledge and technologies have been developed in private, bilateral and multilateral R&D-projects. Most of the projects with public funding have been initiated after the Ministry of Employment and Economy made the support decision. The focus of the projects and programmes has been – basically – in all major aspects of electric vehicles: from electric car development to charging, storing and to smart grids. See Table 8 below for the list of main projects.

Table 8 Main public electric vehicle research and development projects

Project	Starting year
ERA-development project of Metropolia	2007
TransEco-programme of VTT	2009
SIMBe-consortium of Aalto University	2009-2010
Smart Grids and Energy Markets-programme of Cleen	2009-2010
Electricity-development project in Tampere	2009
Syöksy -development consortium of Metropolia	2010
Eco Urban Living consortium	2010
eStorage project of VTT	2010
EVE-programme of Tekes	2010-2011

Sources: Metropolia, VTT, Aalto University, Cleen, Eco Urban Living and Tredea

The Smart Infrastructure for Electric Mobility in Built Environments (SIMBe) –consortium was a Tekes funded project for accelerating the introduction of electric vehicles in Finland from the sustainable development point of view. The Business, Innovation and Technology Centre of the Aalto University School of Science led the consortium. However, the Smart Grids and Energy Markets –programme of the Cluster for Energy and Environment (Cleen) focused on developing smart grid solutions, which took account also electric vehicles. The Electricity-development project's objective was to develop an environment for fostering the skills and know-how for working with electric vehicles and work machines. Besides the ERA-project, Metropolia led the Syöksy consortium for developing models for sustainable traffic solutions to be piloted in the Marja-Vantaa and Aviapolis districts of the City of Vantaa. The Eco Urban Living consortium focuses on developing demonstration platforms for electric vehicles while the eStorage of VTT defined the needs and requirements of storing research infrastructure and related support services for the industry.

In addition to the major R&D-projects, a number of development projects have been carried out by the enterprises. These have covered the development of concept cars, electric vehicles for the international

customers (by Valmet Automotive), charging stations and even charging station testbeds. Furthermore, the transformation of internal combustion engine cars into electric motor cars by eCars Now! –initiative has increased understanding of the ways to electrify traffic. The incumbents have not done the technology development only by themselves, but in close cooperation with domestic or international players. Although the number of R&D projects has risen, it has not affected strongly on the demand of technology developers, scientists, researchers or other highly skilled professionals.

6.2.2 Entrepreneurial experimentation -function

Entrepreneurial experimentation is closely related to the knowledge development and diffusion –function. Experimentation is characterized by the entrant enterprises consisting of start-ups and diversifiers, and by their different development projects aiming to generate technologies and business. Also part(s) of the R&D-projects of the public research institutes have entrepreneurial features.

The niche has attracted more diversifiers than start-ups. Although the business potential of the niche raised interest among a number of firms after the MEE's support decision, the entrepreneurial development has mainly been driven by the few incumbent enterprises. Also, most of the incumbents are diversifiers to the niche. Regarding the start-ups, the most notable is European Batteries. The entrepreneurial projects have consisted basically of the knowledge development projects for concept and transformation cars, test beds for charging stations and of the related technology development.

6.2.3 Market formation -function

The markets of the technology innovation system consist of five main markets. Markets for the electric vehicles (full and hybrid cars) consist primarily on the enterprises (supplied as company cars) and household segments. The main segments of the electric buses are transportation enterprises and the organizations of the public sector. Moreover, the main segments of the infrastructure solutions markets (charging stations) are public sector organizations, enterprises and households. The electrified work machines are supplied for other enterprises and public sector organizations. The markets for intermediate outputs, or components, build on the supply of the finished products in the four other markets.

Markets for the products of the electric vehicle technology system are still waiting to emerge at full scale. Especially, only a limited number of electric vehicles have been bought in Finland since the electric vehicles activities emerged in 2007-2008 and the cars sold in Finland are mainly of foreign origin. There is only a handful of registered electric cars and for example in the first half of the year 2012 (January-August), only 38 electric vehicles were sold in Finland. Most of the electric vehicles are owned by enterprises and other organizations – not by private persons. The full electric cars are exported by the enterprises Nissan (Nissan Leaf) and Opel (Opel Ampera). Also the demand for charging stations has expanded only slowly.

However, the incumbent enterprises have managed to create especially international business in their own areas of specialization. Ensto, Valmet, European Batteries and ABB all have had international operations. For instance, in autumn 2010 Ensto had delivered 500 charging stations to Oslo and by the 2012 Valmet had delivered electric cars of Think City, Fisker Karma and Garia, which were all made for the foreign clients. Thus, the main objective of the incumbents is in the foreign markets.

6.3 Innovation network thrives from the keystone actors

An essential feature of the individual projects was the need to develop networks. As practically none of the actors was able to accomplish their projects alone, the actors started creating networks as soon as the projects were established. Also, in some occasion it is reasonable to conclude that the network building was a prerequisite for the launching or for the further continuation of ventures. Depending on the path creator, the network creation focused on seeking funding, political support or strategic knowledge. The networks were built as consortium projects, R&D programs or by establishing arenas for expectation and vision formation such as the standardization committee SK 69 or Electric Motor Shows.

Already in 2008 a number of networks emerged. Metropolia's venture for developing the electric race car (ERA) was one of them. The development project entailed the creation of a network in order to acquire support, complementing skills and components for the electric car, and the completion would not have been possible without the contributing members of the network. Besides that the success of ERA-project demonstrated learning and generation of positive expectations, ERA highlighted network creation. The network grew from 26 (May 2008) to

about 60 partners when the car was participated into the Progressive Insurance Automotive XPRICE competition in 2010. The other members of the ERA-network represented enterprises, funding organizations and educational organizations. However, a teacher of automotive electronics of Metropolia led the ERA-project and he has been credited for the success of the project.

In 2008 also three other ventures were occupied with the network creation. The members of eCars Now! –initiative had the goal of fostering the electrification of domestic traffic and they contacted actively the decision-makers of the administration. Also, the enterprises Fortum and European Batteries were on the move with similar motives. However, Fortum was interested of gaining political support while European Batteries needed to raise capital for its venture.

In 2009 several arenas emerged. The TransEco R&D program, MEE's work group, the establishment of SESKO standardization committee SK 69 and the organization of the first Electric Motor Show were all platforms for lobbying, exchanging information and forming visions for the electric vehicles. The insiders did affect on the launching of arenas. For example, the research professor of VTT orchestrated the large TransEco program while the activists of eCars Now! contributed on the organization of the Electric Motors Show. Regarding the network formation of incumbent enterprises, Valmet Automotive invested in networks in order to develop its supply chains for developing electric vehicles.

In 2010-2011 the niche experienced growth in the number of arenas. Especially three networks were essential for the niches development: Electric Vehicle Action Group (EVAG), Electric Vehicle Systems-programme (EVE) and Electro Mobility Group of the Federation of Finnish Technology Industries. EVAG was an enterprise consortium for lobbying the electrification of the traffic in Helsinki Metropolitan Area. The consulting company Eera led it, and later the initiative evolved as one of the major R&D sub-programs of the Electric Vehicle Systems –programme of Tekes. The launch of EVE in 2011 signaled a significant resource mobilization for the niche and it was a result of multilateral cooperation between enterprises, research organizations and administration. Moreover, the Electro Mobility Group was created for coordinating the industry's development. The group is set open to organizations interested of developing the industry, and the group has close connections with the EVE-programme. In the figure 6 below are depicted some of the main actors in four major arenas - MEE work group, EVE R&D-programme, TransEco

R&D-programme and Electro Mobility Group. The actors (keystone individuals) are presented by their main context and volume of involvement in the arenas.

Figure 6 Electric vehicle actors in major arenas

The processes of network creation started from the individual projects of the keystone actors. At first stage representatives of enterprises, consultants, activists and researchers built the networks, but later, as the networks institutionalized, they become part of organizations' assets. In the beginning, the networks were based on private relationships and initiatives, but later the networks became public as the R&D programs and arenas were launched.

6.3.1 Resource mobilization -function

In several cases the path creation resulted in successful resource mobilization. Even further, the development of the major arenas and growth projects would not have been possible without significant funding

decisions. There have been at least four major resource mobilization events: TransEco R&D-programme, the venture of European Batteries, Valmet Automotive's fund raising and the launching of EVE R&D-programme. The most obvious investments are presented in the table 9 below.

The happenings of TransEco and European Batteries demand more detailed attention. Regarding the TransEco-programme, it focused broadly on developing the energy efficiency technologies for traffic and only a part of the activities covered technology development for electric vehicles. In addition, the funding of the programme is not from a single source, but instead it is pooled from different public and private sources for various durations and for specific purposes. In addition, the entrepreneurs of European Batteries were very successful in raising capital. The representatives of the company had created strong networks with the administration and they participated in the MEE's work group for electric vehicles, management group of EVE-programme and in the board of Electro Mobility Group of Finnish Technology Industries.

The total amount of capital mobilized for the industry creation in 2008-2012 is at least over 130M€, but it can even be much more than 150M€. The higher estimate is based on two things. First, the entrepreneurs of European Batteries were able to raise approximately 30M€ of private equity from various public and private sources in addition to the public subsidies. However, the total amount of raised funding is unknown. Second, the table 9 contains the largest and most obvious events, but it does not contain all the investments made in the system. Many of the detailed private actions are not public as they can be for instance trade secrets. But, as pointed out by the event listing it is evident that many niche actors did initiate and engage into electric vehicle related projects involving investments in research and technology development.

Table 9 Volume of mobilized public and private capital on electric vehicles

Event	Year	Approximation of the investment
TransEco R&D-programme	**2009-2013**	Total funding in 2009-2011 approx. 8M€
- Including Tekes funding for Domestic EV research	**2009-2010**	*450 000€*
- Including Tekes funding for Nordic EV research	**2009-2010**	*Size not known*
- Including ST1s funding for biofuels and electric vehicles research	**2009-2011**	**130 000€**
- Including Fortum's funding for electric vehicles research	**2009-2010**	*60 000€*
- Including investment of Ministry of Transport and Communications for electric vehicles	**2010**	*80 000€*
Fortum's grant for eCars Now!	2008	30 000€
Finnish Industry Investment invests in Keliber	2010	765 000€
European Batteries raises capital and subsidies	2008-2011	At least 30M€, total size not known
-Including investment subsidies, loans and guarantees	*2008-2011*	*Total size not known*
- Including Tekes R&D funding	*2009-2011*	*Over 2M€*
- Including private equity from EM Group, Finnish Industry Investment, Fennia and Power Engineering Group	*2011*	*13.7M€*
Valmet Automotive raises private equity	2010	20M€
- Including investment of Finnish Industry Investment	*2010*	*10M€*
- Including investment of Pontos Group	*2010*	*10M€*
Tekes funds Electric Motor Sledge –project	2010	952 800€
Electric Vehicle Systems - programme	2011	Approximately 80M€ of public and private funding

Sources: Tekes, TransEco, Finnish Industry Investment, Fortum, European Batteries, Valmet Automotive

The increased interest of enterprises has affected on the niche's human resources. For instance, the expansion of Valmet and European Batteries increased the demand for skilled employees. However, due to the uncertainties regarding the demand of the enterprises finished products, the duration for the need of new employees has turned out to be uncertain.

6.3.2 Development of positive externalities -function

Although the niche experienced a rapid increase in the number of R&D projects due to the launch of e.g. EVE-programme, the impact of single projects on the generation of positive externalities is not straightforward. Even if the projects would be of large scale and they would develop new technologies and skills, the impact on positive externalities would depend from the way new technologies and know-how are transferred between the parties and especially how the results relate to the public domain. Thus, the generation of positive externalities raises the dilemma of how the property rights are organized.

Nevertheless, the network creation led to two projects, which can be considered as generating positive externalities. The first possibility is the ERA-project of the Metropolia. The ERA-project was a highly successful venture where students of a university of applied sciences built a fully functional electric race car and won a second place in an international demanding competition. The project developed new know-how, educated a number of students for the industry and increased cooperation between over 60 participating organizations. In addition, the success of the ERA-project acted as an inspirational example demonstrating that it is possible to compete in a carefully selected niche.

The second example, and possibly of smaller impact than the ERA-project is the project of the Electric Traffic consortium of the EVE-programme for the development of a free database containing all public charging stations. The charging station database can be a source for positive externalities for users and researchers of electric vehicles, but also for providers of charging stations and related services. However, the significance of database-project depends from the future development of the electric vehicle system.

7. Entrepreneurial activities in the niche

The activities of six incumbent enterprises are described next. Two of the cases are discussed by utilizing the three main niche internal processes, while the other four cases are shorter descriptions of the enterprises' roles and activities in the emerging cluster. Thus, the longer cases cover the activities of Valmet Automotive and Fortum, where Valmet Automotive is basically the only electric car manufacturer in Finland and Fortum is the leading electric infrastructure player. The shorter stories introduce the activities of ABB, Ensto, European Batteries and Helsingin Energia. The cases are mainly based on the published press releases complemented with news announcements of the companies.

ABB Oy

ABB Oy is the Finnish subsidiary of the global powerhouse for power and automation technology. The Finnish subsidiary descends from the local manufacturer of electric products Strömberg. The local company was bought in 1987 by the Swedish ASEA, which in turn merged with the Swiss BBC in 1988 forming the current ABB. ABB Oy is one of the leading industrial enterprises in Finland with over 30 offices in different locations throughout the country. The main industrial facilities are in Pitäjänmäki and Vuosaari districts of Helsinki, and in towns of Porvoo and Vaasa. The Finnish subsidiary has specialized, for instance, in the technologies of: motors and generators, switches, wiring accessories, process industry and transformers. The subsidiary plays an important R&D role in the group's value chain and in 2011 ABB Oy spent €163 million in research & development. The turnover of the subsidiary was €2.3 billion and the enterprise made operative profits of €342 million in 2011. ABB employs slightly below 7000 people in Finland.

ABB Group and its Finnish subsidiary are developing infrastructure solutions for electric vehicles. In 2010 ABB Group announced that it was globally involved in over 20 projects for researching the different aspects of smart grids and that it had signed a letter of intent with General Motors for a research and development project focusing on the use of exhausted

batteries of electric vehicles. In 1.9.2011 ABB Oy announced that it had developed Finland's first commercial rapid charging station, which allows the charging of electric vehicles in 15 minutes. The rapid charging station was delivered to the demonstration area of the Finnish utility company Fortum.

Regarding smart grid development, in Stockholm ABB has collaborated with Fortum in order to develop smart grids to Stockholm allowing the efficient utilization of electric vehicles. The companies have also continued collaboration with a smart grid project in Kirkkonummi. Regarding the domestic activities the Finnish subsidiary participates in the Tekes funded National Test Environment for Electric vehicles –project and in Helsinki, ABB Oy has been involved in the development of smart grids for the Kalasatama district. And most recently, ABB Group announced in 9.1.2012 that it will deliver 200 rapid charging stations to Estonia.

Ensto Oy

Ensto is a family owned company of the EM Group. Ensto was established by the engineer Ensio Miettinen in 1958. The company develops and manufactures utility networks, building technology and such industrial systems as switches. In the electric vehicles cluster, Ensto develops and manufactures charging systems. Regarding the financial indicators (of EM Group), the company had a turnover €252 million and operating profit €14.2 million in 2011. At the year end, the company employed 1574 persons. Approximately 25% of the turnover is from the domestic markets while most of the income is generated from the foreign markets. Ensto operates in 19 and exports to 80 countries. The main foreign markets are the other Nordic countries and France.

The charging station business started from the bidding competition organized by the city of Oslo and in 2010 there were approximately 500 charging stations in Norway. In the electric vehicles business, the focus of the enterprise is on international markets and especially on the exports to Central Europe. Also, by 2011 Ensto had delivered over 1000 charging stations to the different markets. The skills needed in the business of charging stations are based on the competencies developed in the area of building technology - although - In November 2010 Ensto announced of the acquisition of NOVEXIA – a French manufacturer of products for the control and automation of electric-power networks. With the investment Ensto strengthened its smart grid competencies and the acquisition also

gave access to the local customer base. However, Ensto is a strong advocate of smart grids and electric vehicles and has developed products in collaboration with customers. Ensto also participates in the Electric Traffic Helsinki Test Bed –project.

European Batteries Oy

European Batteries is a manufacturer of large rechargeable lithium-ion based prismatic cells and battery systems. The company was established in 2008 in order to supply batteries for the expected growing global demand of electric vehicles, which on the other hand was based on the increased global awareness of the climate change. The battery technology originates from the American K2 Energy Solutions and it came to European Batteries through Finnish Electric Vehicle Technologies – a current subsidiary of European Batteries –, which was established in 2003. The private company has a number of owners. The most notable are the Finnish EM Group and three private equity investors. The private equity is provided by the state owned Finnish Industry Investment, the Finnish Fennia Group and the Swiss Power Engineering Group S.A. European Batteries has received approximately €30 million equity funding from different public and private investors, in addition the enterprise has received public subsidies. The turnover of the European Batteries Oy (group) was approximately €1 million and the group employed about 65 persons in 2011. European Batteries has exported its products to over 20 countries.

The company has offices in Espoo and Tuusula and a production facility in Varkaus. The factory was opened in 8.6.2010 with the goal of fostering European Batteries development to one of the leading battery system providers in the industry. In order to develop the production, the company raised 13.7 million in directed share issue in January 2011. Besides production, the purpose of the fundraising was to enable the development of international client and partnership base.

European Batteries participates in the public R&D programs in order to share the firm's expertise and receive the latest research results for the support of technology development. The company is currently involved with the EVELINA – National Test Environment for Electric Vehicles – project. Also, in 14.2.2012 the company announced of the technology cooperation with the manufacturer of AC drives and inverters – Vacon Oyj. The collaboration focuses on the integration of battery systems and AC drives into same electrical systems.

Although the company aimed for the large global markets, it wasn't able to join in to the value networks of car manufacturers. Thus, European Batteries's business has been unprofitable and in the spring 2012 the company filed for reorganization of the debts. The current financial distress has forced the company to negotiate with foreign financial and industrial investors and the firm aims to collect €20 million from the international markets. European Batteries has stated that the company will seek new markets and change the focus from electric vehicle batteries to special vehicles, electric buses and even hybrid-powered ships.

Fortum Oyj

Fortum - the leading Finnish energy company - was established in 1998 in a merger of two Finnish energy enterprises: Imatran Voima and Neste. Fortum is a public company whose main owner is the State of Finland with slightly over 50% of the shares. The turnover of the company in 2011 was €6161 million with profits before income taxes €2228 million. Currently, the enterprise employs approximately 11000 persons. Besides the operations in Finland, Fortum has - for instance - expanded to the nearby regions and has numerous subsidiaries in Sweden, Norway, Russia, Poland and Netherlands.

The story of electric vehicles in Fortum predates to the time of Imatran Voima when the company had a pioneering role in the Finnish electric vehicles development. The main development steps took place in the 1980s and early 1990s, but after the merger with Neste, the electric vehicles project was cancelled. However, the topic started interesting the company again in 2008 and the project was relaunched. In 15.4.2008 Fortum announced that it had started collaborating with the City of Stockholm in an infrastructure development project aiming for the large-scale usage of electric vehicles. The initiative for the cooperation came through the Swedish subsidiary.

Fortum invests in economic and political networks. At the same time with the Stockholm project Fortum started scanning opportunities for a similar infrastructure project in Finland. Already in 16.7.2008 the company invited interested parties to visit the stand in the event Suomi Areena where Fortum presented a Toyota Prius - plug-in hybrid vehicle. However, the company continued networking and announced in 21.10 of the cooperation with the City of Espoo in order to develop an electrical vehicle test bed to

Espoo. Also, in 2008 the Finnish electric vehicle activities were still in the very margin and the development depended mainly on informal organizations. Fortum supported the Electric vehicles – Now! –initiative by announcing in 26.11, that the company had granted €30000 for the initiative in order to promote the public awareness for electric vehicles.

The company continued networking and engaged in public research consortiums aiming to accelerate the development. In the announcement 6.8.2009 the company reported of participating in the TransEco-program where it collaborated with VTT and Metropolia in projects focusing on the electric vehicles performance in low temperatures and the functioning of rapid charging stations. Also, the company announced in 3.6.2010 participating in the Eco Urban Living –project with the City of Espoo and Valmet Automotive. However, later Fortum left the project and joined in the Electric Traffic Helsinki Test Bed -project. Also the test bed development continued in 2010, as in 21.5 Fortum announced developing a testbed to Kurikka in cooperation with the town. The aim of the testbed project was to pilot a charging infrastructure and to facilitate the use of electric vehicles in Kurikka.

Besides testbeds and public consortiums, Fortum collaborates directly with research and development organizations, electric vehicle infrastructure developers and foreign car manufacturers. Regarding the Stockholm testbed, Fortum announced in 13.11.2009 developing with ABB smart grid technology for the testbed. Also, in 30.6.2009 Fortum initiated a marketing cooperation with the Japanese Mitsubishi in order to promote the Mitsubishi iMiEV to potential Finnish customers. The most recent joint project, announced in 2.2.2012, has been the development of a charging station with Nissan for the introduction of the electric vehicle Nissan Leaf for the Finnish markets.

Fortum is a strong advocate of electric vehicles. After the company diversified back to electric vehicles business, Fortum has consistently addressed the environmental benefits and the economic potential of the vehicles. For instance, the company referred in 22.7.2010 to the report published by the Ministry of Employment and the Economy stating that the domestic electric vehicles industry has potential to evolve into export industry. Furthermore, the company has promoted tax incentives for the electric vehicles in order to encourage the use of electric vehicles. Although the development of electric vehicles was encouraged by the City of Espoo, the electric vehicle niche initially lacked the support of the Government.

However, as the niche has evolved the situation has changed. This is evident from several factors: the public R&D funding allocated through Tekes's EVE-programme, from the high level public political support and from the changes in car taxation favoring electric vehicles.

The current electric vehicles project is part of the Solar Economy vision of Fortum. According to the vision the future energy system is built on renewable and clean solar-based energy emphasizing the flexible and efficient production of energy. In the Fortum's vision the future energy system enables the development of sustainable urban living consisting of a cleaner transport sector. However, Fortum is primarily a utility company and therefore electric vehicles are just one - although an important - business opportunity among the other business areas. Nevertheless, Fortum is a strong player and advocate of the emerging niche and the company researches business models accompanying electric vehicles with the focus on the business opportunities springing from the development of smart charging infrastructure technologies and the related customer services.

Helsingin Energia Oy

Helsingin Energia is a fully owned utility company of the City of Helsinki. The 1909 established company is one of the biggest energy players in Finland. In 2011 Helsingin Energia had a turnover of €876 million with the operating profit €287 million. Also, the company had 1419 employees. Together with partners, the company is engaged in developing the smart grid and charging station technology for the city. The activities are motivated by, for instance, the objectives of the climate policy of the city, and Helsinki aims to decrease greenhouse gas emissions by one third by the year 2030.

In order to enhance electric vehicles, Helsingin Energia develops city's capabilities for producing infrastructure for the vehicles. In 16.12.2009 the company announced that it had opened Finland's first street charging station for electric vehicles. In addition, in 26.3.2012 Helsingin Energia received Finland's first Opel Ampera plug-in hybrid and announced expanding the charging station network in order to respond to an expected increase in the electric vehicle traffic in the streets of Helsinki. In the infrastructure development project the company has collaborated with, for instance, Peugeot and Aalto University. Furthermore, Helsingin Energia plays a leading role in the Electric Traffic Helsinki Test Bed –project, which

aims for developing the electric vehicle infrastructure of the Helsinki Metropolitan Area and collects user experiences from the pilot fleets.

Valmet Automotive Oy

Valmet is the other key incumbent in the emerging electric vehicles niche. It is the most significant Finnish electric vehicle manufacturer with roots in the combustion engine cars. The enterprise was found in 1968 as a joint venture of the Finnish Valmet and Swedish Saab-Scania with the name Saab-Valmet. The production of combustion cars started next year in the town of Uusikaupunki. Since its establishment the enterprise has went through several changes consisting of, for instance, dismantling of the joint venture, other changes in ownership and changes in the strategy. The current main owner of the Valmet Automotive is Metso Group, which owns over 60% of the shares. The other owners are the state owned private equity enterprise – Finnish Industry Investment Ltd and the privately owned private equity enterprise Pontos Group. Both private equity providers own approximately 34% of the company in total. In addition, the State of Finland owns through Solidium, which is the State's tool for strategic investments, 10% of the parent Metso Group. Regarding the size of the enterprise, Valmet Automotive had 1705 employees (31.12.2011 figure) and turnover €72 million (in 2010). However, in 2010 the operations were unprofitable as the net profit of the fiscal year was -€3.7 million.

The story begins in the spring 2009 when Valmet Automotive announced its new strategy. In 4.3.2009 Valmet announced that it would focus on international markets with a new set of services, products and production technologies. Since its establishment Valmet has manufactured 1.1 million combustion engine cars, but now the focus had changed: even before the global financial crisis Valmet had made reanalysis of its strategies. The plan was to focus on three service areas: production and engineering related services and manufacturing of cars on a turnkey basis. The new strategy acknowledged the changes in business environment and in order to succeed in the competition, the enterprise should internationalize, have environmental awareness, healthy economy, continuous high quality production and the engineering services should form most of the turnover. The new strategy was preceded by the opening of an office in Frankfurt, and hiring contact persons in Stuttgart, United States, Japan and South Korea. By the 4.3 Valmet had already two electric vehicle contracts: one with the U.S. Fisker Automotive and the other with Danish Garia A/S.

Developing and manufacturing electric vehicles demands the development of networks. Although Valmet has a long history in combustion car manufacturing, diversification into new technology domain demands collaboration with players from different industries. For instance, in 8.12.2009 the company announced that the manufacturing of Garia - the Danish electric golf vehicle – was supported by approximately 70 component manufacturers, 30 of them were domestic suppliers. Also, the development of the concept car Eva required collaborating with organizations, whose competences complemented Valmet's. In the car exhibition of Geneva in 2.3.2010 the company announced that it had invited a number of enterprises and research institutions to the development project. Therefore Eva was the result of the cooperation between several complementing players; for instance Fortum, Vacon, Nokia, NAVTEQ, AXCO-Motors, Aalto University, Metropolia and Lappeenranta University of Technology were members in the consortium. Furthermore, Valmet Automotive is an active player in the domestic arenas. It participates in the Eco Urban Living –project with the City of Espoo, Aalto University and VTT in order to foster the creation of an electric vehicle test bed to Espoo.

As Valmet Automotive is a contract manufacturer of premium cars with only small domestic markets, the enterprise is oriented to foreign markets. However, before exporting the final product, Valmet Automotive utilizes its international subcontractors in the manufacturing process of electric vehicles: the manufacturing of Garia demanded the use of approximately 40 foreign suppliers. Most of the foreign components for Garia were imported from the other EU countries, but few components were imported from North America and Asia. Furthermore, regarding the international aspect of network building, the enterprise has increased its presence in the important foreign markets as it announced in 2.3.2012, that it had opened offices in Detroit and Shanghai and acquired a German engineering office. Besides outward internationalization, Valmet cooperates with an inward internationalizing enterprise: Solaris Bus & Coach S.A. Thus, in 13.2.2012 the company announced collaborating with the Polish manufacturer of hybrid buses with the intention to support the development of Solaris's business in Finland.

The case of Valmet Automotive highlights the fact that emerging niches do not evolve only by the endogenous processes, but take inputs or are influenced by exogenous factors. In the case of Finnish electric vehicle niche, all Valmet's main customers are foreign and the enterprise has

internationalized by tapping to the key centers of global automotive industry. In addition, already the start and even the primary focus of the activities in the domestic niche are directed towards foreign operations.

Although Valmet has progressed in the transformation process from a manufacturer of combustion engine cars into an electric vehicles supplier, the transformation has not occurred without challenges. For instance, one of the challenges was the ending of the production of Think City electric vehicle. Valmet announced in 27.8.2009 that it had signed a letter of intent with the Norwegian Think Global regarding contract manufacturing of the Think City electric vehicle. The manufacturing of Think City started in 10.12.2009. However, already in 23.6.2011 Valmet announced that the production of Think City was shut down due to the financial difficulties of the customer, Think Global AS. Also, the production of Fisker Karma plug-in hybrid sports car was delayed several times. The company announced in 4.3.2009 that the production of Fisker Karma would start at the end of the year. However, Valmet announced in 5.11 that production was rescheduled to the summer 2010, but in 2010, Valmet had to postpone the production yet twice. The Fisker Karma hybrid was put to production in 21.3.2011.

The case of Valmet Automotive highlights the need for competence development. The transformation of the enterprise into a new emerging technology field demanded the development of new skills and technology know-how, for instance, in the form of educated personnel. However, as there is only a small automotive industry in Finland, there are only few institutions of higher education offering the related education. Although the small size of the domestic industry can actually support the industrial transformation, at the same time, there is only very limited supply of training in the field of electric vehicles. Valmet has approached the problem by collaborating with research institutions and organizations having complementary knowledge. Also, the enterprise has constantly invested in engineering services, for instance, by hiring employees to the engineering services. In addition, the outward internationalization has been initiated with a knowledge-seeking motive: in 2.3.2012 the company announced of the acquisition of CAE Automotive GmbH, which is a German engineering office of R&D services for automotive industry.

However, the challenges and transformation process have affected Valmet and are evident from the financial indicators. For instance, although the turnover grew with over €7 million between the years 2010-2008, the operations were at the same time unprofitable as the enterprise made

annual losses varying between €3.2 and €8.2 million. Also, in the spring 2012 the company had to temporarily lay off several hundred employees from the manufacturing. Nevertheless, Valmet Automotive strongly believes that they will be successful in reinventing the firm and that in the end; the enterprise will be reborn as a supplier of electric vehicles for the emerging global electric vehicle markets.

8. Discussion

Institutionalization of the Finnish electric vehicle cluster

The Finnish electric vehicle industry was institutionalized as a consequence of the interaction of economic, political and civil society actors. The development of the institutionalization process, which took place in the years 2008 – 2011, is further characterized with three slightly overlapping, but still distinct time periods. The first period marked the emergence of individual projects, which led to the convergence of the idea for creating Finnish electric vehicle industry. The convergence became evident when the Ministry of Employment and Economy decided to support the idea for the new industry in the second period. The new interest for the industry led eventually to activities, which prepared the further focus areas of the industrial players. After several research and consultation projects, the main R&D programme was launched for building new capabilities and interested stakeholders established a common forum for the industry. Although some of the large enterprises would very likely have continued developing electric vehicle capabilities, especially the involvement of the ministry stimulated the development.

Various types of enterprise, R&D, public sector and interest group actors inhabit the Finnish electric vehicle cluster. One interesting feature of the Finnish system is that among the main incumbents there is only one functional car manufacturer, but a number of utility and infrastructure focused enterprises. This imbalance will affect on the development trajectory of the system when enterprises have to adjust their operations due to the changes in the global business environment.

Two geographical features characterize the development of the Finnish system. First, from the different local level projects the innovation network evolved rapidly throughout the country connecting the various stakeholders with specialist skills needed for developing the electric vehicle technology. Another aspect of the regional dimension of the innovation network is the role municipalities or cities play in the development. The cluster development is not only a matter of national level politics, but very much in the interest of cities and towns, which operate utility companies and which are keen to develop local innovation environments. Furthermore, the local urban and physical characteristics of the various locations have offered possibilities for developing different aspects of the technologies.

Second and more striking feature is the role international dimension plays in the development of the system. The significance of the international dimension is due to two factors: the connectedness of actors and activities and - even further - the systems dependency of the international development. The main actors of the Finnish system, domestic and foreign-owned enterprises and R&D organizations are in many ways connected to the global innovation networks and knowledge clusters. Especially many of the Finnish incumbents have increased international connections and presence in the key foreign markets and knowledge clusters. For instance, Valmet has increased its presence in the key foreign car markets, Ensto established presence in France and strengthened technology competence by acquiring NOVEXIA, while Efore reported in 2011 focusing its electric vehicle business in China where it has several offices. Furthermore, many of the global players of car manufacturing or electric vehicle related technology development have already a presence in the Finnish markets. In addition, the Finnish system has also attracted foreign enterprises such as the Polish Solaris, but also the Chinese electric vehicle manufacturer BYD has an office in Finland.

The connectedness creates room for interaction, although as a small, open economy type of country the Finnish system is also dependent of the development in the international domain. The dependency is characterized at least by the inputs to the system and the development of demand in the foreign markets. Regarding the inputs such as investments or deals, ideas and technologies, many of them are of foreign origin and even the emergence of the domestic system was largely influenced by the events taken place internationally. For instance, Valmet Automotive's electric vehicle contracts have been from Denmark, Norway and United States, and the hybrid and full electric cars for the Finnish consumers are imports from

the big foreign car manufacturers. Furthermore, from the global point of view, the large manufacturers of cars and components are the leading developers of the EV technologies and domestic players need to form business and technology alliances with them in order to create reference cases. Besides the business inputs, the guidelines and regulations guiding the technology development are determined in multilateral organizations and for instance standardization is de facto determined in either European or global level. Furthermore, the supply of the developed technologies is targeted especially for foreign markets and thus the success is also dependent how the foreign markets and societies develop. These observations concerning both the inward and outward internationalization of the system support the conclusion presented by the niche and TIS authors that the domestic niches or systems are in many ways connected and also dependent from the global technology development.

Academic observations

The development of the integrated process model was based on the existing literature of technology innovation systems and strategic niche management and it was experimented with the collected data. The framework is built on two syntheses. The first synthesis covers the combination of four analysis steps while the second synthesis is done inside the framework by integrating the TIS-processes into the niche processes in the fourth step. Due to the first synthesis, the studied object appears as multifaceted, but simultaneously, also very detailed. Each of the four steps can be considered as a lens or an optical instrument, which alone depicts only one – although somewhat sharp – dimension of the object. When the lenses are piled up for instance, like in a telescope, the whole picture emerges. This kind of research approach is common in quantitative research where a data can be analyzed with several complementing analyses in consecutive steps. The second theoretical synthesis describes the development of the industry from the social processes perspective and enables the making of policy analysis as presented by TIS researchers.

In the chapter four, as presented in the second step of the framework, event structure analysis was experimented in the analysis of the development process of the niche. The analysis resulted into a simplified description of the short run industrial evolution process. With the method it was possible to highlight the fact that there existed separate, private projects before the governmental decision-making, and on the other hand, several actions followed from the ministry's decision to develop the cluster. Among the

consequences were venture capital investments and market research and consultation reports for the decision-making. Furthermore, the event pattern highlighted, that incumbent enterprises continued with their own operations regardless of the administration, but later the actions of enterprises converged to the launch of EVE-programme. Although more specific information of the collaboration dynamics would have allowed the drawing of a more detailed event pattern, even the current level of information expands the understanding of niche's development.

As presented in third step of the framework, the snapshot mappings of the innovation network in chapter five complement the event structure analysis. Although also the snapshots are static simplifications of the dynamic activities, they also illustrate the innovation network's development. With the periodical mappings it is possible to depict, for instance, the growth in the number of actors, arenas and resource flows; it is also possible to present specifics of the international dimension of the network. Even though the mappings are not for example complete enterprise lists of the industry, they show that the niche or system consists of different types of organizations and they do contain actual and - through funding - potential policy actions affecting the niche.

The result of the second synthesis is in the chapter six. Although the first three steps describe actors, main events and development, they do not tell how the industry is constructed through the social action nor do they enable the making of policy analysis in a systematic way. Therefore the data has to be interpreted in the light of niche- and TIS-processes. Furthermore, the niche or the TIS-processes alone are not sufficient for both tasks at the same time and that is why the processes have to be integrated. The TIS concepts also create structure inside the niche processes and can thus introduce new angles for understanding the social aspect of development. However, the TIS-processes do not unambiguously add up to niche processes regardless of the theoretical definitions or empirical similarities; nor are the theoretical niche and TIS models a one same theoretical construct even if both processes are constructed or estimated from the same data set.

Based on all the collected data and analysis, it is therefore evident that niche processes constructed the niche and the hypotheses are maintained at various strengths. It is evident that expectations became more specific and converged in such a manner that a major R&D program was launched and it attracted not just the main incumbents, but also diversifying players.

Learning was demonstrated by the individual organizations, but also by a larger set of actors. This is demonstrated in the changed emphasis of infrastructure over vehicles. Essential part of the knowledge development was the formation of networks with specialist organizations and with the international domain.

With the framework it is possible to study the industry through the questions of who, what, why, how and even consider an estimation of what could be done next. Besides the analysis of causes and effects, the inclusion of a process analysis method makes it possible to assess strengths and weaknesses of the development. Due to the TIS-functions, the framework contains elements, which are usable also in business intelligence and not just in public policy work. For instance, when researching industry's attractiveness for entry in some specific region TIS contributes on identifying and assessing key organizations, incentives, costs, R&D-networks and markets and the related processes. Also, niche processes can contribute on the analysis due to the identification of network creators and estimation of visions in terms of the actual development phase of the industry's life cycle. The weakness of the framework lies in the nature of qualitative data. As the collected data has to be interpreted, the assessment of the functional profile and its development is dependent from the analyst's interpretation. Moreover, the inclusion of TIS-aspect is based on the definitions of functions and the current interpretation is dependent from the current allocation.

Policy implications

The study of the event-based profile of electric vehicle innovation system enables the discovery of inducement and blocking mechanisms. Especially the blocking mechanisms, or weak processes, become apparent with the methodology. Based on the combined niche-function profile of the system, the low number of projects contributing for positive externalities for the whole cluster is evident. As the positive externalities projects fuel the other subprocesses and therefore the overall development of the cluster, that kind of projects should be encouraged. From the observed events, positive externalities can be considered of being created by for instance the ERA project and by the introduction of freely available database containing the locations of charging stations. Depending on sustainability of the business model, the currently free charging stations and the Electric Mobility Operator –model for charging infrastructure can function as sources for positive externalities as well.

Only 11 events were interpreted to describe the resource mobilization function. However, the low volume of events covering resource mobilization does not necessarily indicate the low quantity of for instance invested capital: the EVE programme alone signals commitment of €80 million for the cluster. Instead of emphasizing overinvestment, the correct targeting and timing of the investments is more important. Regarding the human resources aspect of the function, it will strengthen when the technology matures and if the outputs of ongoing R&D programmes are successfully capitalized.

Entrepreneurial experimentation should be encouraged. Among the observed events, there are only few happenings covering directly entrepreneurial activities. The event data means two things. First, there are or there have not been many electric vehicle related start-up enterprises. Some of the ventures of the field are European Batteries and AMC Motors and the recently established Scarlet Motors. For the technology based start-ups the high costs of establishing operations are barriers to the entry. In addition, excluding the car leasing type of businesses, the system has not matured enough for the service-based enterprises to emerge, as the services will be built on the developed technologies. Second, the electric vehicle technology system has been estimated to hold business potential as it has clearly attracted diversifying enterprises especially for the infrastructure aspect of technology system. Although the diversification can renew existing operations, it does not necessarily lead to the birth of new enterprises. Therefore, it should be explored if there are opportunities for the creation of more stronger and profitable business ecosystems built on the one hand around the car and component -players and on the other hand around the infrastructure developers.

The influence on the direction of search –function can be estimated as the strongest sub-process of the system. The emphasis on articulation of expectations and visions for the need to develop the system and the related technologies has been necessary for the political and commercial decisions to take place. Furthermore, the articulation of interests has been supported by the administration by adjusting car taxation to favor electric vehicles and by granting subsidies for piloting with the vehicles. However, the other related function - legitimation – is considered as much weaker process. Although the industry creation has the support of the administration, legislative actors, large enterprises and enthusiastic people for the cause, the legitimate activities have not influenced enough on the demand of the

vehicles. Therefore it is legitimate to ask: have the actions been legitimate from consumers' point of view? The legitimation is connected to the technology neutrality of not favoring competing technologies. With the principle it is possible to avoid too early lock-ins for technologies, which turn out to be bad choices for the whole economy. Nevertheless, stronger legitimation would entail choosing a side.

The aspect of environmental policy is mainly connected to the evolution of electric vehicle cluster due to the basically emission free technology and its role in lowering emission levels of transportation. As shown in this study, the main players of the cluster have taken the initial steps for the electrification of the domestic traffic. However, the market and electrification development seems to be slower than presented in the scenarios of the various consultation papers. The slow development is especially due to the limited supply and high price of the available electric vehicles. As electric vehicles can be considered as luxuries with the current price level, it is obvious that consumers prefer internal combustion engine cars, which have more competitive prices and whose technologies are also developed to be more environmentally friendly. Furthermore, the path for the electrification of the domestic traffic is mainly dependent from the imported cars as there currently are practically no domestic suppliers for the domestic markets. On the other hand, the realized – slower than expected – development gives time for markets, households and infrastructure to adapt to the roll out of electric vehicles.

Accelerating the short run electrification of the domestic traffic would demand strong incentives for consumers to buy electric vehicles, which thus are manufactured by the big global players. These kinds of incentives can be criticized, that in addition to the benefits for the consumers, the subsidies would benefit mainly foreign car manufacturers and not the domestic players. However, not all of the benefits would go to foreign owned enterprises as also the domestic infrastructure players of the cluster benefit from the electrification regardless of the origin of the vehicles. If the objective is to combine industry creation and electrification of the domestic traffic, a strong policy mix for combining the objectives of exporting, infrastructure development and environment, should be developed.

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Appendix 1 Main events of the electric vehicle industry

The list of main events taking place in the Finnish electric vehicle industry 2008-2012 (spring)

Niche code: 1 = Articulation of expectations and visions, 2 = Creation of social networks, 3 = Learning process

Event nbr.	Date (month/year)	Description of the event	Niche code	Function of the event
1	January 2008	The Nordic Mining ASA from Norway acquired 68% of the stocks of the Keliber Oy (Lithium mining company in Kaustinen Western Finland)	2	Resource mobilization
2	February 2008	First ERA press conference in Helsinki Polytechnic	1	Influence on the direction of search
3	March 2008	European Batteries Oy is established; plans to build lithium-ion battery factory into Varkaus	3	Entrepreneurial experimentation
4	April 2008	Fortum announced of smart grid infrastructure development project with City of Stockholm	3	Knowledge development and diffusion
5	April 2008	Fortum announced promoting the electric vehicle issue in Finland	1	Influence on the direction of search
6	May 2008	Sales of cumulative world-wide Toyta Prius hybrid reached the 1-million vehicle mark	3	(Global) market formation
7	July 2008	Fortum displays the transformed plug-in hybrid Toyota Prius in the Suomi Areena -event and promotes electric vehicles	1	Influence on the direction of search
8	October 2008	Fortum announced the cooperation with the City of Espoo for developing infrastructure for electric vehicles	1	Influence on the direction of search
9	October 2008	Fortum sponsored eCars Now with €30000	3	Entrepreneurial experimentation
10	October 2008	Solidium receives the non-strategic investments of the Government of Finland (incl. 10% of the shares of Metso - parent of Valmet Automotive)	1	Influence on the direction of search
11	November 2008	Valmet announced the contract with the U.S. Fisker	3	Market formation
12	January 2009	Valmet announced the contract with Garia A/S	3	Market formation
13	January 2009	The joint venture of ABB and Ensto, Ensto Busch-Jaeger, is transferred to ABB in an acquisition	3	Market formation

14	Beginning of the year	GTK of TEM initiates a research program Hightech metals for investigating prospects for hightech metals such as lithium, which is needed in e.g. EV batteries	2	Resource mobilization
15	February 2009	Init GmbH (Init Innovation in Transportation) - a German developer of software and related technology for transportation establishes presence in Helsinki	3	Market formation
16	February 2009	Minister appointed a Working Group at the Ministry of Employment and the Economy to examine the prospects of electric vehicles in Finland	1	Influence on the direction of search
17	March2009	Valmet announced the new strategy	3	Market formation
18	April 2009	Regulation (EC) No 443/2009 of the European Parliament and of the Council for setting emission performance standards for new passenger cars	1	Influence on the direction of search
19	April 2009	Directive 2009/28/EC of the European Parliament and of the Council on the promotion of the use of energy from renewable sources	1	Influence on the direction of search
20	June 2009	Fortum initiates marketing collaboration with Mitsubishi in Finland and in Sweden for promoting electric vehicles	1	Influence on the direction of search
21	June 2009	Fortum announced developing a charging station network in Finland	3	Knowledge development and diffusion
22	August 2009	The report of the electric vehicle Working Group of TEM is published	1	Influence on the direction of search
23	August 2009	The report of Biomeri Sähköiset ajoneuvot Suomessa (Electric vehicles in Finland) is published in conjunction with the report of the Working Group of TEM	1	Influence on the direction of search
24	August 2009	Fortum and Valmet collaborate on developing the electric concept car EVA and the related charging technology	3	Knowledge development and diffusion
25	August 2009	Valmet announced the letter of intent with Think Global AS	3	Market formation
26	August 2009	SK 69 of SESKO (committee for electric vehicles standardization) was established due to the rapid international electric vehicle development and in order to secure the interest of domestic industry and society. Participants of the first meeting represented organizations: Ensto, Finnish Energy Industries, Tukes, Exide Technologies, European Batteries, Valmet Automotive, Nemko, SGS Fimko and SESKO. Also Fortum, Akkuvoima Oy, Ministry of Transportation and Communication announced participating to the committee	3	Market formation
27	September 2009	Fortum developed a charging station with Ensto, for the purpose of exporting the product	3	Knowledge development and diffusion
28	October 2009	Fortum is promoting the European-wide standard for infrastructure of electric vehicles	3	Market formation
29	October 2009	Ensto won the procurement from the City of Oslo. The deal covered delivering 150 charging stations to the city with an option to 170 more stations. Later Ensto expanded to other cities as	3	Market formation

		well and even later (2011) the company has announced selling over 1000 charging stations and plans to sell hundreds of thousands of charging stations		
30	October 2009	Volvo announces developing electric vehicle technology (BEV and plug-in hybrids)	3	Entrepreneurial experimentation
31	November 2009	ABB collaborates with Fortum on smart grids R&D in Stockholm	3	Knowledge development and diffusion
32	November 2009	Electric Motor Show demonstrating electric vehicles is organized in Helsinki	3	Market formation
33	November 2009	AMC Motors from Oulu demonstrated the Finnish electric vehicle concept car Sanifer in the Electric Motor Show, car was developed with the University of Oulu and 2 Chinese EV enterprises (Entrepreneurial experimentation);	3	Entrepreneurial experimentation
34	November 2009	AMC plans to sell 2000 cars annually	1	Influence on the direction of search
35	November 2009	Transformation of Toyota Corolla to eCorolla 1.0 finished successfully by eCars Now! -initiative	3	Knowledge development and diffusion
36	November 2009	Metropolia experiments with a Toyota Prius, which uses electric and ethanol as propulsion. Emissions are 15g/km	3	Knowledge development and diffusion
37	November 2009	Trans Eco -consortium, coordinated by VTT, is launched	3	Knowledge development and diffusion
38	December 2009	Valmet announced of the mass production of Think City (2300 cars) and Garia vehicles	3	Market formation
39	December 2009	Helsingin Energia announced of the first street charging station in Helsingin Kamppi, station was delivered by Ensto	1	Influence on the direction of search
40	December 2009	Fortum announced of the first publicly open charging stations in Espoo	1	Influence on the direction of search
41	Beginning of the year	SIMBe -consortium starts, led by Aalto University; the consortium finishes in December 2011	3	Knowledge development and diffusion
42	Beginning of the year	Launch of Smart Grids and Energy Markets programme of Cleen	3	Knowledge development and diffusion
43	January 2010	Sähkökäyttöiset pienajoneuvot matkailukäytössä-(Electric Motor Sledge) project of the Tekes Fuel Cell programme starts in Rovaniemi (University of Applied Sciences of Rovaniemi), Tekes finances the project €952800 in total (2010-2012)	3	Knowledge development and diffusion
44	February 2010	Launch of ElectriCity -consortium for developing electric vehicles centre of excellence in Tampere	3	Knowledge development and diffusion

45	February 2010	Finnish Industry Investment Ltd invest € 765000 in Nordic Mining SA - parent of the Keliber (mining company for lithium in Western Finland)	2	Resource mobilization
46	March 2010	Metropolia finishes the prototype ERA, over 60 organizations participated to the development of the concept car	2	Development of positive externalities
47	March 2010	Valmet presents the concept car EVA, a number of organizations participated to the development	3	Knowledge development and diffusion
48	April 2010	Syöksy-consortium coordinated by Metropolia begins; consortium finishes in August 2011	3	Knowledge development and diffusion
49	April 2010	European Commission publishes a European strategy on clean and energy efficient vehicles	1	Influence on the direction of search
50	April 2010	LVM decided to commission a research regarding the future of electric vehicles in Finland; the research project finishes in February 2011	1	Influence on the direction of search
51	May 2010	Fortum reports of developing a test bed to Kurikka	3	Knowledge development and diffusion
52	May 2010	Helsingin Energia announces of the smart grid development for the Kalasatama district of Helsinki, ABB announces participating into the project	1	Influence on the direction of search
53	May 2010	Electric vehicles are promoted by the launch of Electric Vehicle Action Group	1	Influence on the direction of search
54	June 2010	Launch of Eco Urban Living -consortium	3	Knowledge development and diffusion
55	June 2010	EB opens the battery factory in Varkaus, size of the factory investment was €40 million, €10 million is from the town of Varkaus and €10 million are public subsidies	2	Resource mobilization
56	June 2010	The first public and free charging stations for EVs are opened in Lahti, Lahti Energia supports the spreading of electric vehicles	1	Influence on the direction of search
57	June 2010	VTT launches eStorage research project; project finishes in January 2011	3	Knowledge development and diffusion
58	June 2010	Aalto University launches TopDrive - consortium; consortium finishes in March 2012	3	Knowledge development and diffusion
59	June 2010	GTK submits the results of the first lithium prospect investigation to TEM	2	Resource mobilization
60	July 2010	Fortum commented fuel taxation reform from electric vehicles point of view and promoted exporting of EV technology	1	Influence on the direction of search
61	August 2010	Valmet announced participating in Eco Urban Living	1	Influence on the direction of search

62	August 2010	Tekes publishes the report Hypätään kyytiin, which was commissioned from SWOT	1	Influence on the direction of search
63	September 2010	GTK submits the results of the second lithium prospect investigation to TEM	2	Resource mobilization
64	September 2010	Toyota announces that total sales of Toyota Prius reached 2 million units	3	(Global) market formation
65	September 2010	Metropolia's ERA is second in the XPRICE - competition	1	Influence on the direction of search
66	September 2010	Fortum announced researching and developing EV infrastructure and related services; the company has 39 charging stations in Finland	3	Knowledge development and diffusion
67	September 2010	Electric Motor Show is organized in Helsinki for the second time	3	Market formation
68	September 2010	eCars Now!-initiate delivers eCorolla 2.0 to the Mayor of Tampere	3	Knowledge development and diffusion
69	September 2010	The initiative understands the high costs associated with transformation process of internal combustion engine cars to electric vehicles	3	Knowledge development and diffusion
70	September 2010	Valmet participates in Electric Motor Show and displays Think City vehicles	1	Influence on the direction of search
71	September 2010	The ABB Group collaborates with General Motors on a project dealing the re-use of exhausted batteries and announces of the ongoing over 20 smart grid projects	3	Knowledge development and diffusion
72	October 2010	Fortum announced receiving investment subsidies with ABB from the Government of Sweden for the smart grid pilot project in Stockholm	1	Influence on the direction of search
73	October 2010	Valmet announced of the new leasing service for Think City	3	Market formation
74	October 2010	Ensto acquired the French NOVEXIA	3	Market formation
75	October 2010	The Finnish Energy Industries promotes electric vehicles (and presents how other EU countries support the use of electric vehicles) and suggests to include them into the agenda of the next Government	1	Legitimation
76	October 2010	Itella experiments the use of Electric vehicles in Helsinki Metropolitan Area and in Varkaus in a project with Valmet Automotive and European Batteries	3	Entrepreneurial experimentation
77	October 2010	Finnish Industry Investment invests in the Valmet Automotive along with the Pontos Group, the value of the investment is €20 million in total	2	Resource mobilization
78	October 2010	The standardization of electric vehicles raised interest in the annual standardization event FORUM 2010, which was held in Finlandia Hall	1	Influence on the direction of search

79	November 2010	Publication of the research results commissioned by Finpro: Ajoneuvo- ja työkoneteollisuuden sähköistymisen kansainväliset liiketoimintamahdollisuudet	1	Influence on the direction of search
80	November 2010	Nissan Leaf elected as the European Car of the Year by European car journalists	3	(Global) market formation
81	December 2010	VTT publishes report: Sähköutojen käyttöönoton skenaarioita ja vaikutuksia sähköjärjestelmään (Scenarios of large-scale deployment of electric vehicles and their power system impacts)	3	Knowledge development and diffusion
82	January 2011	Fortum announced recommendations for how to connect electric vehicles for the networks of residences	1	Influence on the direction of search
83	January 2011	The ABB Group invests in the electric vehicles infrastructure in the USA	3	Knowledge development and diffusion
84	January 2011	EB raises €13.7 million in directed share issues; main investors are: EM Group, Finnish Industry Investment, Fennia and Power Engineering Group (Swiss/Russian)	2	Resource mobilization
85	January 2011	Launch of the Electric Vehicles Systems Programme - EVE, €40 million of funding from Tekes, 40 million from enterprises; The launch of Tekes's EVE attracts lots of entrants from other industries e.g. ICT, construction and manufacturers of electric work machines are represented	2	Resource mobilization
86	January 2011	Efore reformulated its strategy and opened EV business in China	3	Market formation
87	March 2011	Fortum opened new charging stations in the shopping center Sello and announced the new business concept: Charge & Drive	3	Market formation
88	March 2011	Valmet announced that the production of Fisker Karma plug-in hybrid will start after summer	1	Influence on the direction of search
89	May 2011	Fortum announced the results of feasibility study of the smart grids project with ABB	1	Influence on the direction of search
90	May 2011	Fortum announced that its long run objective is CO2 emission free energy production	1	Influence on the direction of search
91	June 2011	Valmet ends the manufacturing of Think City due to the bankruptcy of the customer	3	Market formation
92	September 2011	Fortum demonstrated charging solutions for electric vehicles in Keilaniemi, Espoo	1	Influence on the direction of search
93	September 2011	Valmet seeks 200 employees for the production of Fisker Karma	2	Resource mobilization
94	September 2011	ABB supplies Finland's first commercial rapid charging station to Fortum	3	Market formation

95	October 2011	Establishment of the Electro Mobility Group of The Federation of Finnish Technology Industries for coordinating the development of EV industry	1	Legitimation
96	December 2011	Tekes organized a Sähköä liikenteeseen -day, a large promotional event in Narinkkatori, Helsinki; Minister of Economic Affairs promoted electric vehicles in the Sähköä liikenteeseen -day in Helsinki; PSL and EVELINA consortiums of EVE are lauched; incumbents announce joining consortiums	1	Legitimation
97	December 2011	Ministry of the Employment and the Economy granted €9.5 million as energy subsidies for the acquisition of electric vehicles	2	Resource mobilization
98	January 2012	The main global car manufacturers display electric concept cars in car shows; car manufacturers plan to supply new hybrid models in 2012 (e.g. Toyota, Ford, Lexus, Volvo)	3	(Global) market formation
99	January 2012	Rovaniemi University of Applied Sciences is about to finalize the eSled	3	Knowledge development and diffusion
100	January 2012	Toyota announces that it expects to sell 1000 hybrids in Finland in 2012	1	Influence on the direction of search
101	January 2012	Newspapers report that in 2011 the full electric vehicles did not sell globally as expected	3	(Global) market formation
102	January 2012	SESKO SK 69 published guidelines for charging electric vehicles in residential grids	1	Influence on the direction of search
103	January 2012	ABB Group builds 200 charging stations in Estonia	3	(Global) market formation
104	January 2012	Fisker Karma faces difficulties due to batteries and software related problems and the car does not sell well	3	Market formation
105	Beginning of the year	Ensto reports growth of turnover and profits; reports that new solutions for electric vehicle charging were well received	3	Market formation
106	February 2012	Fortum announced that it had developed with Nissan a home set charging station for Nissan Leaf	3	Knowledge development and diffusion
107	February 2012	SESKO participates in the IEC's new strategy group - SG6 Electrotechnology for mobility, which is e.g. for the coordination of EV standardization	1	Influence on the direction of search
108	February 2012	PSL-consortium organized an electric vehicle driving demonstration in cold weather in Helsinki	1	Legitimation
109	February 2012	LVM initiated a working group on intelligent traffic	1	Influence on the direction of search
110	February 2012	LVM initiated a working group on future motive power starts its work	1	Influence on the direction of search

111	February 2012	EB initiates technology collaboration with Vacon	3	Knowledge development and diffusion
112	February 2012	Valmet initiates collaboration with the polish hybrid bus manufacturer Solaris S.A and supports the inward internationalization of Solaris	3	Market formation
113	February 2012	The ABB Group collaborates with Nissan in order to study the use of batteries of Nissan Leaf for energy storage	3	Knowledge development and diffusion
114	February 2012	Oliivi Autot plans to initiate electric car sharing club and competes against City Car Club	3	Market formation
115	February 2012	Valmet temporarily lays of hundred(s) of people from the manufacturing of Fisker Karma	3	Market formation
116	March 2012	Valmet opens offices in Detroit and Shanghai and reports of the acquisition of the German CAE Automotive GmbH	3	Market formation
117	March 2012	Valmet presents the Dawn platform in car exhibition in Genev	3	Knowledge development and diffusion
118	March 2012	Helsingin Energia states the plans of expanding the charging station network; the goal is first to set 100 stations	3	Influence on the direction of search
119	April 2012	European Batteries reorganizes its debts and announces that it will focus its battery business on other vehicles than electric cars	3	Market formation
120	April 2012	Nissan Leaf electric vehicle is available in Finland	3	Market formation
121	April 2012	The new car taxation law (favoring electric vehicles) set by the Ministry of Finance comes into effect	1	Influence on the direction of search
122	April 2012	As part of the PSL -consortium, the locations of all public charging stations is downloaded into database (effort coordinated by BIT of Aalto)	2	Development of positive externalities

Appendix 2 Main events of the institutionalization process 2008-2011

Event nbr.	Event name in the EV industry model	Description	Included events
1.	Metropolia holds the first ERA press conference	Metropolia University for Applied Sciences decided already in 2007 to an electric race car as a student project and participates into an international competition. The school organized the first press conference of the project. Metropolia is mentioned in the report of Biomeri, Sähköajoneuvot Suomessa, as one of the ongoing projects. The Biomeri report was published at the same time (day) as was the TEM/MEE working group decision. Thus Metropolia's project was recognised.	Based on the events 2 and 23 of the long list.
2.	EB is established	A number of private investors established European Batteries - a manufacturing enterprise for electric vehicle batteries	Based on the event 3 of the long list.
3.	Fortum reestablishes electric vehicles business	This event combines several promotional activities of Fortum during the fall 2008. Fortum's Swedish subsidiary was contacted in Stockholm regarding smart grids and electric vehicles. The company started promoting extensively (in the Finnish context) the idea of developing electric vehicles in Finland. Fortum also started building networks. This is evident as the company e.g. contacted the City of Espoo.	Based on the events 4, 5, 7, and 8 of the long list.
4.	eCars Now! -initiative receives grant from Fortum	eCars Now! -initiative was emerged spontaneously in 2007-2008 as a number of persons formed the idea that electric vehicles are coming in the near future and that private persons could foster the development in Finland (e.g. due promoting the idea to the public and to the main civil servants). The initiative received €30000 funding from Fortum for transforming combustion engine Toyota to electrical car	Based on the event 9.

5.	Valmet executes its new strategy	Valmet Automotive had a strategy, which included focusing on the building of electric cars. In the Fall 2008 (Fisker) and Winter 2009 (Garia) Valmet announced contracts covering cooperation with Garia and Fisker.	Based on the events 11 and 12. Year 2008 ends.
6.	MEE supports the creation of EV industry	In the January 2009 the Ministry for the Employment and the Economy initiated work group for investigating the possibility for creating an electric vehicle industry in Finland. The establishment highlights the fact that there were already ongoing electric vehicle projects among enterprises, research organizations and the civil society (these were also represented as members of the work group). As the work group finished, it set up a vision and objectives for creating electric vehicle industry and for the electrification of the Finnish traffic. The report (as a guideline and a political decision) allowed a number of activities of the public sector to take place: research projects were funded, investments in the value chain were made; also private players developed their businesses; In addition, the international interaction grew.	Based on the events 16, 22 and 23.
7.	Fortum collaborates, promotes and develops EV technology	This event combines several Fortum's activities from the Summer and Fall 2009. For instance, Fortum collaborates with Ensto in a project for developing a charging station, Fortum also collaborates with Valmet in the EVA-project. Fortum also promotes the EV infrastructure standards. However, Fortum is active also in 2010 and 2011.	2009 events: 20, 21, 24, 27, 28, 31, 40.
8.	Ensto diversifies into EV technology	In the Fall 2009 (at the latest) Ensto initiates its electric vehicle business. The company collaborates with Fortum and Helsingin Energia and wins a procurement organized by the City of Oslo, which covers the delivery of charging stations. Later (in October 2010) Ensto keeps internationalizing its EV business and the company acquires the French NOVEXIA. Since initiating its electric vehicle business Ensto becomes one of driving organization in the industry (along Valmet and Fortum).	Based on the events 29, 39 and 74.

9.	eCars Now! transforms Toyota Corolla and organizes Electric Motor Show	The first Electric Motors Show is organized in Helsinki and the eCars Now -initiative (and the related Electric Vehicles Association) has a major role in organizing the event. Another Show is organized later in the Fall 2010. As the initiative received the grant form Fortum it was able to continue its operations and complete the transformation of the Toyota. The initiative transformed the engines of the car with the Fortum's grant. Later, the initiative transforms another car, but learns that transforming is not a competitive method for the electric vehicle breakthrough due to the associated high costs of transformation. The civil society players had a role in the emergence of the industry, but its significance starts to diminish as government starts to act and the enterprises become aware of the business potential related to electric vehicles.	Based on events 33, 35, 67, 68 and 69.
10.	Helsingin Energia introduces street charging station	Helsingin Energia had reestablished its electric vehicles business already in 2008 (before the start of working group of TEM), but the utility company introduced the first public street charging station in December 2009. The station was delivered by Ensto.	Based on 39, Year 2009 ends.
11.	Metropolia finishes the ERA concept car	Metropolia had created a large network of partners consisting of enterprises and research organizations for building the electric race car. Without the network, Metropolia would not have been able to complete the vehicle. The electric race, which was manufactured mainly by the students of Metropolia reaches second place in an international XPRICE competition demonstrating the high quality of the work done. Also, the accomplishment demonstrates learning, knowledge development and entrepreneurial attitude of the involved actors.	Based on the events 46 and 65.
12.	Valmet presents the EVA concept car	With the aid of enterprise partners Valmet finalises its electric concept car EVA. As with Metropolia, Valmet created a partner and subcontractor network for the task. In 2009-2010 Valmet continues to develop its electric vehicle business. However, challenges regarding the Think City and Fisker cars emerge in 2011.	Based on the events 24, 25, 26, 38, 47, 61, 70, 73.

13.	EVAG is launched	The electric vehicle action group (EVAG) is launched by Eera to promote the electric vehicle infrastructure development. Also e.g. Fortum is member of the EVAG. EVAG is a predecessor of the PSL consortium, which is part of EVE.	Event 53 of the long list.
14.	EB opens factory	The factory producing batteries for electric vehicles is opened in Varkaus. The size of the investments was €40 million, €10 is from the town of Varkaus and €10 million is public subsidies.	Event 55 of the long list.
15.	EV value chain actors receive venture capital	This event highlights (at least) three actions, which are consequences to the MEEs decision to support the industry building - actions (reactions) or feedbacks to the society. The Finnish Industry Investment (FII), the main venture capital and private equity tool of the Ministry made three investments in the Finnish electric vehicle value chain. In February 2010, FII invested in Nordic Mining SA - parent of the Keliber, which is the mining company for lithium in Western Finland. In October 2010, FII invested in Valmet Automotive and in January 2011 FII invested in Electric Batteries.	Based on the events 45, 77 and 84.
16.	Research reports published	Four research reports were done in the 2010 and January 2011, which mapped the Finnish strengths, opportunities and market potential regarding electric vehicles and work machines. The reports were done or were commissioned by the agencies in charge of the operations. The report Hypätään kyytiin of SWOT Consulting was published by Tekes in the August 2010, while in the November Finpro published research results of global business opportunities. In December VTT published a report covering scenarios regarding the wide-spread use of electric vehicles and in the February 2011 the Ministry of Transport and Communication published a report dealing with the prospects of electric vehicles in Finland. Although the ministry's report was published in 2011, it was commissioned in 2010.	Based on events 50, 62, 79 and 81. Year 2010 ends.

17.	The launch of EVE programme	Finally, the main development initiative, EVE-programme of Tekes is launched consisting of €80 million investments by Tekes and private enterprises in 2011-2015. The programme was made possible by the ministry's work group and the launch was preceded by a number of smaller R&D consortiums such as Eco Urban Living, which was later integrated to the EVE-programme. The EVE programme aims for developing capabilities related to electric vehicles and electrification of work machines. In addition, all the main organizations are represented in the EVE-programme. The administrative decision for the programme was made in December 2010 while the actual programme started running in 2011. The main sub-programmes were launched at the end of the year.	Based on the events 85, 96 and 97.
18.	The establishment of the Electro Mobility Group	As set by the work group a coordination mechanism for the electric vehicle industry is created. The mechanism is a multilateral platform called the Electro Mobility Group, which is for the further development of the industry. As the leading enterprises and science organizations are represented in the Electro Mobility Group, the voluntary activities of the civil society are in the margin. Although the industry continues to evolve, the structures of the industry have been found and the further activities are focused on the electrification of Finland and on the creation of succesful industry for exports.	Based on the event 95. Year 2011 ends.

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