A regional event analysis of electric vehicle technology development in the Netherlands

Master thesis	Utrecht, June 2010	30 ECTS

Coach:
dr. J.C.M. Farla — J.Farla@geo.uu.nl
Student:
ing. M.J. de Vries — M.J.deVries@students.uu.nl — 3126617

Science and Innovation Management

A regional event analysis of electric vehicle technology development in the Netherlands

Marijn J. de Vries

June 2010

Abstract

For the past 20 years battery electric transportation has frequently been assessed as the most desirable alternative for internal combustion driven cars. However widespread adoption has not yet been established. In this paper we studied the development trajectory of battery electric technology in the Netherlands using the “Functions of Innovation Systems” framework. Additionally a regional scope has been incorporated with which the effects of local policy and spatial proximity on BEV adoption in the Netherlands has been made more clear. Our research identifies three distinct periods starting with increased attention until 1999 followed by a strong decline. Since 2006, however, the technology is making a strong come-back. BEV adoption in the Netherlands seems largely dependent on foreign developments, which proved out to be more difficult to analyze using the functions of innovation systems framework. Combining a regional scope with the function approach, however, was relatively easy to accomplish. A strong influence of regional activities on the national TIS, was however, not found.

1. Introduction

Rising oil prices, growing dependency on a few suppliers and concerns regarding the environmental effects of carbon dioxide emissions (EU, 2008) have increased the search for alternatives for cars powered by means of oil based hydrocarbons. Many alternative energy carriers – such as compressed air (Creutzig et al.; 2009), liquid nitrogen (Knowlen et al.; 1998), hydrogen (Rifkin; 2003), ammonia (Metkemeijer and Archard; 1994) and bio-based fuels (Ragauskas et al.; 2006) – are under development for use in automobiles. The subject of our study – battery electric vehicles (BEV) – is one of these alternatives. BEV's can be charged via the existing electricity grid, which in turn can be fed by a wide variety of energy sources such as solar, wind, nuclear and various forms of fossil fuel. The BEV thus allows one to circumvent the problems regarding energy dependence and rising oil-prices. Additionally, when the primary energy source is a renewable energy source, the concerns regarding carbon dioxide emissions can also be escaped from. Perhaps these specific characteristics are the prime cause of what seems to be a renewed attention in BEV development (Ode, 2008).

Although BEV technology has received support from various politicians and environmental organizations in the past (see for instance Fogelberg, 2000 for an overview of “The Californian electric car controversy”). The BEV has not (yet) become a commercial success. Also in the Netherlands, where the Dutch government is introducing legislation to stimulate the adoption of BEV technology (for instance via tax-cuts (Volkskrant, 1996))

BEV vehicles remain a rare sight in the Dutch streets. Creating a better understanding regarding the process of innovation (related to BEV technology) is essential for both policymakers aiming to stimulate BEV adoption and for entrepreneurs attempting to commercialize the technology.

When we want to understand the entire process of innovation we must look beyond the actions of a few actors. Instead, our focus should lie on the entire “system of innovation” (Edquist, 2004), a system of organizations and institutions in which the creation and commercialization of knowledge takes place. Innovations are the products of a wide collaboration between various components within this innovation system that itself consists of components which are organizations such as firms and non-firm entities such as universities, ministries, and also institutions that regulate the relations and interactions between actors, “the rules of the game”.

The innovation system includes: “all important economic, social, political, organizational, institutional and other factors that influence the development, diffusion and use of innovations” (Edquist, 1997a). Several scholars have proposed to use a specific scope when researching the innovation system. Most familiar are: the technological [innovation] system (TIS) (Carlsson, 1995), the regional innovation system (Cooke et al., 1997; Braczyk et al., 2001; Asheim and Isaksen, 2002) and the national innovation system (Freeman, 1987).

For our research we have adopted a combination of the systems mentioned above. In addition to the focus on a specific technology (BEV) in a single nation (the Netherlands) we choose to also focus on region-specific developments. We have done so because various studies have shown the importance of regional influences on the development of the innovation system. Examples are influences of local preferences (Porter, 1990), local legislation (Fogelberg, 2000) and spatial proximity (Camagni, 1991). Because some large cities have initiatives to support electric cars, this added regional focus may give a better view of the TIS development in the Netherlands.

On the basis of a history event analysis we aim to provide a thorough overview of the development of the Dutch innovation system regarding BEV's since 1990. Such an overview with specific attention for regionally distributed innovation, allows for better understanding of the (development of the) system. Furthermore we aim to create insight in the applied method (with its focus on regions) itself. With these goals in mind we formulate the following research question:

How did the Dutch innovation system regarding electric automobiles develop from 1990 until 2009?

In order to provide guidance during our study we have formulated four sub-questions in addition to our main research question.

1. *What events have taken place regarding the electric automobile innovation system in the Netherlands between 1990 and 2009?*
2. *In what regions in the Netherlands have these events taken place?*
3. *How have regional organizations and institutions regarding electric automobiles aided the development of (regional) innovation systems in addition to national actors?*

4. *How does differentiation between events on different geographical levels aid our understanding of the build-up of the electric automobiles innovation system in the Netherlands as opposed to an approach without this differentiation?*

The paper is structured as follows. In section 2 a further overview of the theoretical background is given. The method itself will be further explained in section 3. Section 4 contains a quantitative overview of the events that have occurred between 1990 and 2009 and a corresponding narrative. A conclusion is given in section 5 including a discussion of the method and the results.

2. Theory

2.1 Innovation System

The innovation system approach has been widely credited for its specific strengths, Edquist (2004) addresses six: While (1) placing the learning process at the center of focus, thus emphasizing that technological change is not exogenous, it is still able to (2) hold a holistic and interdisciplinary perspective, hence incorporating (nearly) all important determinants of innovation. Furthermore (3,4), instead of relating to optimality and linearity, the approach recognizes mutual influences and relations between different factors on innovation and subsequently holds a more evolutionary perspective. Instead of focusing on a single type of innovation the aforementioned characteristics allow (5) the IS approach to be applicable to all forms – both product and process – of innovations. Finally, and for our study perhaps crucially, is (6) the emphasis the IS approach puts on the role of institutions, which are possibly one of the strongest influences on the innovation process (Edquist, 2004).

Despite the above mentioned strengths and the subsequent success of the innovation systems approach among scientists and policy makers, the approach has also received criticism. Carlsson & Stankiewicz (1991) for instance argue that the approach fails to explain why some technologies are more successful than others. A second point of criticism is the static perspective of the IS which makes it less suitable for analyzing the underlying innovation system of more dynamic (e.g. emerging) technologies (Suurs, 2009). For this purpose one needs to gain insight in the cumulative and historic interdependence of the development, diffusion and use of knowledge (Carlsson et al., 2002). In order to keep track of these aspects scholars have developed a set of system functions that allows one to keep track of the development of the IS trough time.

Various “sets” of systems functions have been constructed by a variety of different scholars, Liu and White (2001) for instance identify five “activities” while Johnson (2001) recognizes 8 “functions”, Jacobson et al. (2004) argue this set can be reduced to five. In general however, most sets display considerable overlap and differences between these individual methodologies are relatively small. Hekkert et al. (2007) argue that the appropriateness of a specific set can be confirmed (or falsified) by empirical evidence. For instance when a function analysis is carried out but a specific function remains unused it can be an indication that this function is less relevant to understand technological change. Opposed to this, when events are difficult to allocate to the functions of a set, this can be an indication that the set is incomplete. Based on these notions we choose the “(7) functions of innovation systems” developed by Hekkert et al. (2007), since this specific set has been successfully applied by scholars such as Negro et al (2006) and Suurs (2009) in studies that show considerable overlap with this study. Each of the seven functions is listed in Table 1 with a short elaboration of their meaning in the IS.

Table 1. Functions of the innovation systems approach (Suurs, 2009)	
F1: Entrepreneurial activities	Entrepreneurs are at the core of the IS. They perform the innovative market-oriented experiments necessary to establish a radical change. Entrepreneurs are usually private enterprises, yet they can also be public actors.
F2: Knowledge development	Research and development of technological knowledge are prerequisites. This system function is associated with the creation of variety in technological options. R&D activities are often performed by scientists, although contributions by other actors are possible as well.
F3: Knowledge diffusion	The typical organization structure of a IS is the knowledge network. One of its system functions is to facilitate the exchange of information.
F4: Guidance of the Search	Often, within an emerging technological field, various technological options exist. This system function represents the selection process necessary to facilitate the convergence in development. Guidance can take the institutional form of policy targets, but is often realized even more efficiently trough the expectations of technological options as expressed by various actors.
F5: Market formation	Often, new technologies cannot exceed incumbent technologies. In order to stimulate innovation, it is usually necessary to facilitate the creation of (niche) markets. This is especially the case in the energy sector, where external costs of fossil fuel based technologies are often unaccounted for.
F6: Resource mobilization	Material and human factors are a necessary input for all IS developments. Mobilization can be triggered by venture capitalists investments, movement support programmes, or entrepreneurial activities.
F7: Support from advocacy coalitions	The emergence of new technology often leads to resistance from established actors. In order for a IS to develop, some actors must raise a political lobby counteracting this inertia. Often, this is done by NGO's or industrial interest groups.

As has been mentioned in the introduction several more specific scopes can be adopted when researching the innovation system. Most notably the technological [innovation] system (TIS) (Carlsson, 1995), the regional innovation system (Cooke et al., 1997, Braczyk et al., 2001; Asheim and Isaksen, 2002) and the national innovation system (Freeman; 1987). When focusing on a specific technology (or sector) one usually applies a second (geographical) delimitation (Edquist, 2004). One of the most familiar (second) delimitation's is the nation-state, a combination that has proven its use in various other studies (Negro et al., 2006 and Suurs, 2009). It's straightforwardness and ease of use make the nation-state a popular demarcation. A focus on a lower geographical level does, however, allow for a more detailed analysis due to the specific characteristics of regionality on innovation. What are broadly considered the most important of those characteristics are elaborated below.

2.2 Local preferences

Within certain regions one can often discern shared preferences that are distinctive for those areas. By whatever means these preferences have come into play, they can lead to a particular demand. A shared culture for instance such as the Japanese perception of technology as a status symbol is one example. In Japan this particular cultural coherence has provided the local industry with a large (yet quality demanding) home market that ultimately aided in its international success (Porter, 1990). Local geography can also be of influence for local demand. The success of Swiss tunneling equipment suppliers for instance is hardly surprising given Switzerland's mountainous terrain. In combination with a strong cultural preference, the specific geographic conditions in Denmark (Denmark consist of several (windy) islands and peninsulae) has sprouted a thriving wind-turbine industry (Porter, 1990).

2.3 Legislation

Although legislation in democracies is (ideally) a result of a population's preferences it is highlighted here because one often forgets that legislation is not per sé nationally homogeneous. Local regulations can have a profound influence on technological development and use within specific areas. Related to our subject are the regulations that where introduced in California in 1990. These regulations forced car-manufactures to introduce zero-emission-vehicles in that state which led to a considerable boom in investment in BEV technology (Fogelberg, 2000). On a more local level, city municipalities can ban polluting vehicles from city limits (the Dutch “Milieuzones” for polluting trucks) or differentiate in parking fees (e.g. The German “Umweltzonen”) (Wichmann, 2008).

2.3 Spatial proximity

Despite the emphasis that often seems to be put on the global perspective, the importance of spatial proximity is well established in innovation science (Boschma, 2000). It is because innovations are not the outcome of independent actions of isolated actors but the outcomes of interactions between different components of the innovation system (OECD, 1992). For these interactions the geographical distance can be of significant importance. A few examples are listed below. Competition between industries operating in the same geographical area leads to a stronger drive for innovation. Furthermore strong competition provides a stimulus to expand beyond the traditional boundaries, both in a geographical and in a product sense (Porter, 1990). Supporting firms can have a strong influence on the innovative capacity of industries, especially via knowledge sharing. The proximity of supporting industries is far preferable as opposed to greater distances between actors. Delivering to nearby customers has a far greater impact on a firm's pride then far away clients. Furthermore the proximity of technical support along with cultural similarity tends to facilitate open information flows (Porter, 1990). Short distances between actors facilitate knowledge and information sharing (Camagni, 1991). In an area with a sizeable number of related and supporting industries specific “knowledge networks” are likely to come into existence. The relative free flow of knowledge within a relatively small geographical area enables firms to acquire new technology more easily as opposed to larger areas where knowledge is more difficult to transfer.

The importance of region-specific innovation has led us to adopt a regional scope when applying the function approach of Hekkert et al. (2007), see the Methodology section.

3. Method

As noted in the theory section the basis of our research is the mapping of activities that have occurred in the innovation system during the research period (1990-2009), this is the so-called “event analysis”. It provides us with insight in development of the TIS, via the disclosure of (mutually influencing) patterns of activities that have occurred during the research period. The first step in the event-analysis is the identification of events that occurred. For this purpose we used the LexisNexis (LexisNexis, 2010) database, which allows users to search the content of various periodicals. Since our research was restricted to the Dutch innovation system we have only incorporated Dutch periodicals. Most Dutch periodicals available via LexisNexis (both regional and national publications) have been searched for events. An overview of periodicals that we used is given in appendix I. We searched the LexisNexis database for events using the following (Dutch) seach-query:

*"ele*trische auto" OR "ele*trisch rijden" OR "ele*trisch tanken"*[1]

All articles that complied with this search-query where then read in search of one or more events. If appropriate the event would be classified and placed in the subsequent function category (see the theory section). Depending on the nature of the event (aiding the IS development, hampering the IS development or neither) a positive, negative or indifferent sign was allocated. Since our focus lies on the Dutch TIS all events that occurred abroad where classified as function four (Guidance of the Search).

In addition to the periodicals that we used from LexisNexis we have also incorporated a professional journal (“het Technisch Weekblad” and its predecessor “de Ingenieurskrant”), which is popular among Dutch engineers. This weekly newspaper contains short articles regarding a broad spectrum of engineering related events. We incorporated this extra periodical because of the specific focus this newspaper has on technical content. Therefore incorporating it in our study increased the likelihood of identifying technology-specific events that are not covered by regular media. This journal was not available in digital form, therefore we searched paper copies of all editions of the past 20 years manually. The process of classifying events is however, similar to those identified via the LexisNexis database.

When classified we administered several other tags in addition to function type and sign. Most important are: id number, date, description of the event, geographical level and (optional) type(s) of actors involved. This information was entered in a database that holds all events for this study.

Especially the geographical level is of importance given our special focus on region-specific innovation. We chose the following four geographical levels:

National level: For instance for national policy (**D**utch), but also for events that have foreign origin (**G**erman, **B**elgium, Other **E**urope, **O**ther) or when the geographical level is **U**nknown.

Provincial level: The Netherlands is subdivided in twelve provinces each with (limited) political authority and cultural background. The relatively small size of Dutch provinces also ensures relatively high spatial proximity between actors. Details of the individual provinces are given in appendix II.

1 Translated: *“electric car” OR “electric driving” OR “electric fueling”*

Agglomeration / Regional level: Several regions (not being cities) contain important actors in a limited geographical space. In some cases administrative activities (e.g. public transport, environmental regulations) are carried out on these regional levels, see appendix III. We have identified six regions:

- **R**andstad **N**orth: A metropolitan area including the city of Amsterdam.
- **R**andstad **S**outh: A metropolitan area including the city of Rotterdam, the port of Rotterdam and (in Delft) the largest technical University of the Netherlands.
- **Ei**ndhoven: A metropolitan area including the city of Eindhoven, a technical university and (in Helmond) a high-tech automotive campus.
- **Tw**ente: Area bordering Germany containing a technical university.
- **L**imburg **S**outh: A metropolitan area including the cities of Maastricht and Heerlen, it borders Germany and Belgium and houses several large chemical corporations.
- **N**orthern **N**etherlands: Large area containing two large cities but less densely populated than the rest of the Netherlands.

Municipality level: Although the 431 Municipalities in the Netherlands can vary considerably in size (CBS, 2010), they hold a considerable amount of political power, for instance regarding auto-mobility (parking permits, road construction, local environmental legislation, etc.).

Events were classified on the “lowest” geographical level they are known to have originated from, furthermore they are classified on geographical levels above that.
For example the event “city of Amsterdam introduces free BEV parking” would be classified on four geographical levels: national (the Netherlands), provincial (Noord-Holland), regional (Randstad North) and municipality (Amsterdam). The event “Dutch government introduces tax-cuts for BEV's” would only be classified on the national level (the Netherlands).

The use of a spreadsheet program to list all identified and classified events allowed us to create a quantitative overview of the events that occurred (see results). Although useful, this method has the disadvantage that the “weight” of the events is not incorporated in the results. For example, a tax-cut measure of the municipality of Schiermonikoog (pop. 1000) counts once, while the same measure in the municipality of Amsterdam (pop. 800,000) also only counts once. In order to (partially) circumvent this disadvantage we constructed a narrative based on the events that took place between 1990 and 2009. In this narrative we were able to give more attention to highly influential events and less to more insignificant events. Hence the narrative allows for a reconstruction of developments over time and identifying causal relationships between specific events.

4. Results

4.1 Quantitative results

A total number of 325 events have been classified for the years 1990 – 2009. See figure 1 for an overview the number of events per year. For comparison we also added figure 2, showing the number of “hits” for our search question in five important Dutch newspapers[2]. In both figures the increased attention for BEV technology in the mid-90's and after 2006 is

2 Het Financieel Dagblad, NRC Handelsblad, Trouw, De Telgraaf, De Volkskrant

clearly shown.

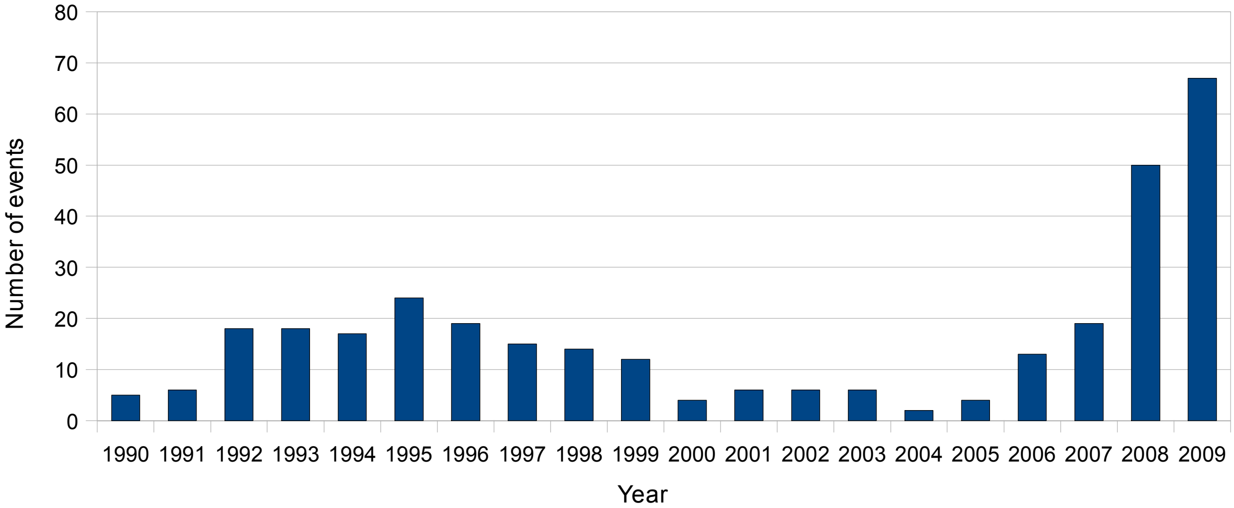

Figure 1: Events per year

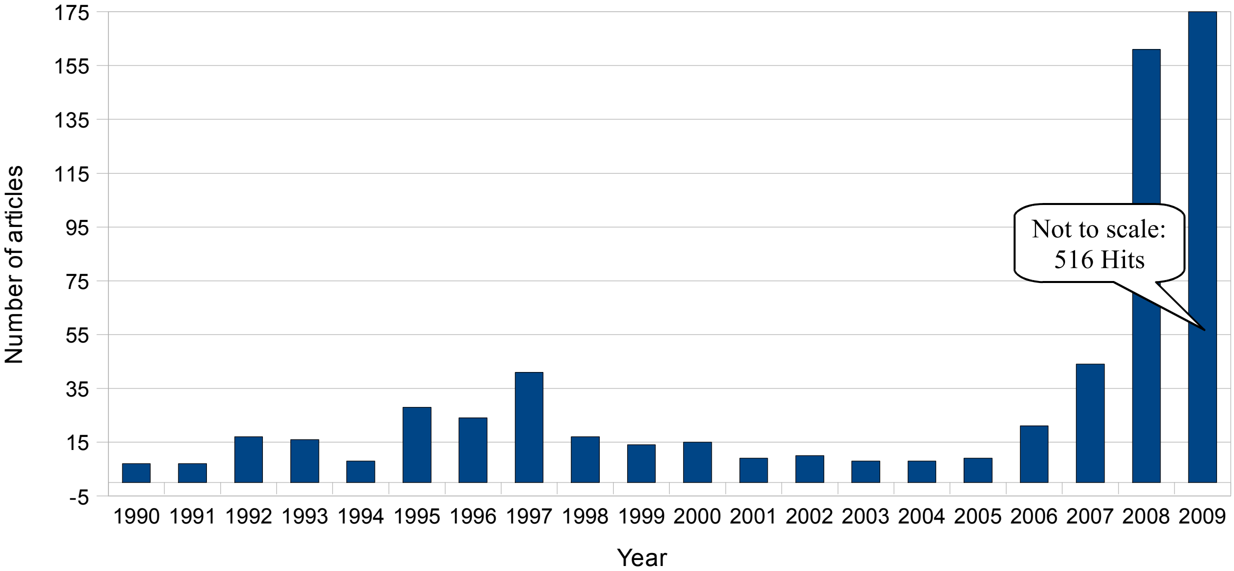

Figure 2: Number of "hits" per year

In figure 3 we have plotted the total number of events per function, apparent is the over-presentation of function 4 (guidance of the search) partially caused by our decision to classify all event from non-Dutch origin as function 4. Function 1 and 2 are also substantially present, most originate from (large) users who start “testing” BEV's (F2) or who start using BEV's (F1). Note that of the 265 classified events only 48 have a negative sign (12 indifferent).

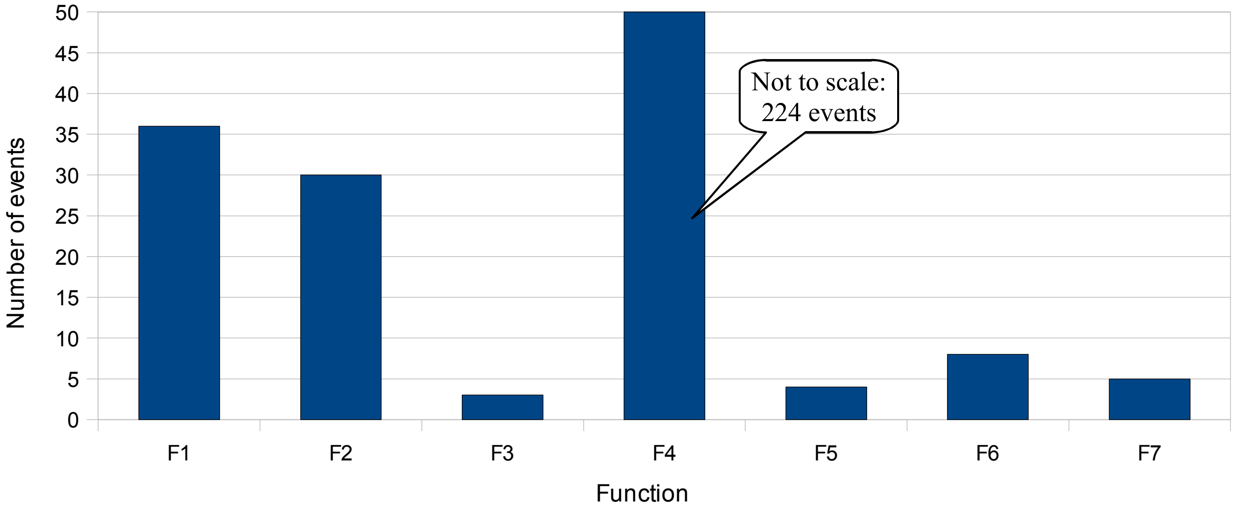

Figure 3: Total number of events per function

National events: Of the 325 events 147 originate from outside of the Netherlands (61 Europe, 86 other), from the remaining 178 events 85 are classified on a lower geographical level, only 93 events can thus truly be assessed as “national”.

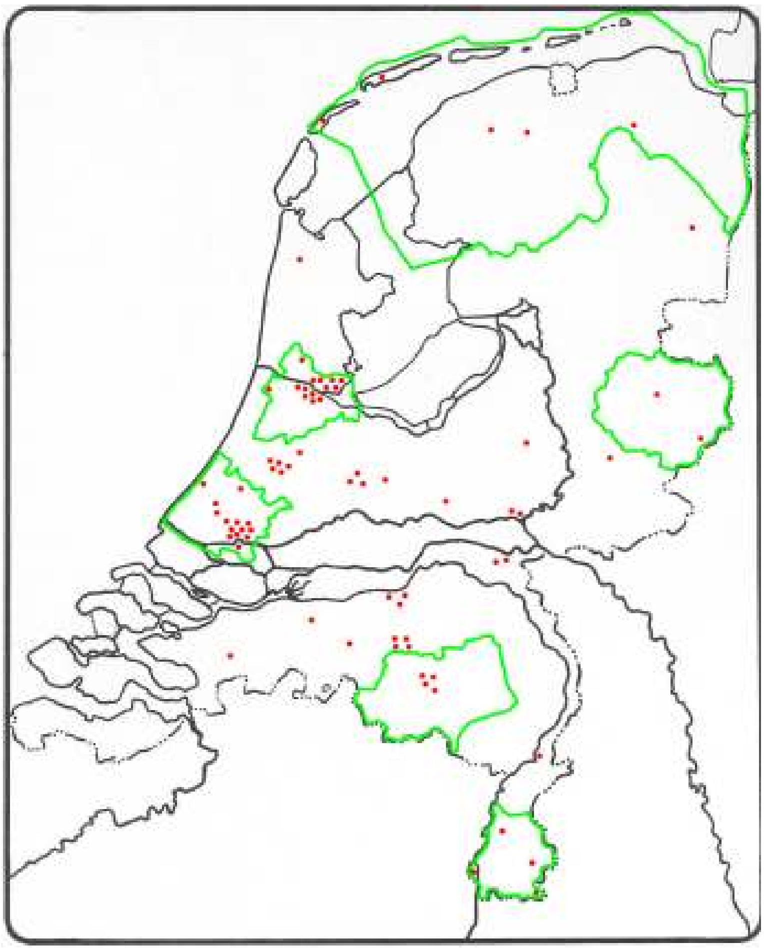

Figure 4: Distribution of municipality events

Provincial events: 85 events were classified on a provincial level. These data shows no surprises with 66 events taking place in the four most populous provinces (together containing 65% of the Dutch population): Zuid-Holland (20 events), Noord-Holland (13 events), Noord-Brabant (17 events) and Gelderland (16 events).

Agglomeration / Regional events: 45 events fell in one of the six pre-determined regional levels. Twenty-eight events took place in one of the two densely populated Randstad regions (13 North, 15 South), the remaining 17 are distributed over the other four regions. This distribution corresponds well with the populations in the regions.

Municipality events: The 75 events discerned by municipality show a wide spread, with the logical exceptions for the Netherlands' most populous cities Amsterdam (12 events) and Rotterdam (10 events). None of the other municipalities harbors more than 5 events. In figure 4 all events discerned by municipality are shown by a red dot, the green lines in the figure mark the borders of the six regions. The 36 Dutch municipalities that appeared in our research are listed in appendix IV.

4.2 Narrative

Analyzing the events of the past 20 years we have come to the conclusion that this period can roughly be subdivided in three characteristic periods regarding BEV development: first growing interest (1990 – 1998), second decline in interest (1999 – 2005) and finally renewed attention (as of 2006). To illustrate the difference in attention we have plotted the number of events of each period individually in figure 5. Clearly shown is that in period 3 a more even distribution of events is shown over the individual functions (note also that these periods are not equal in length).

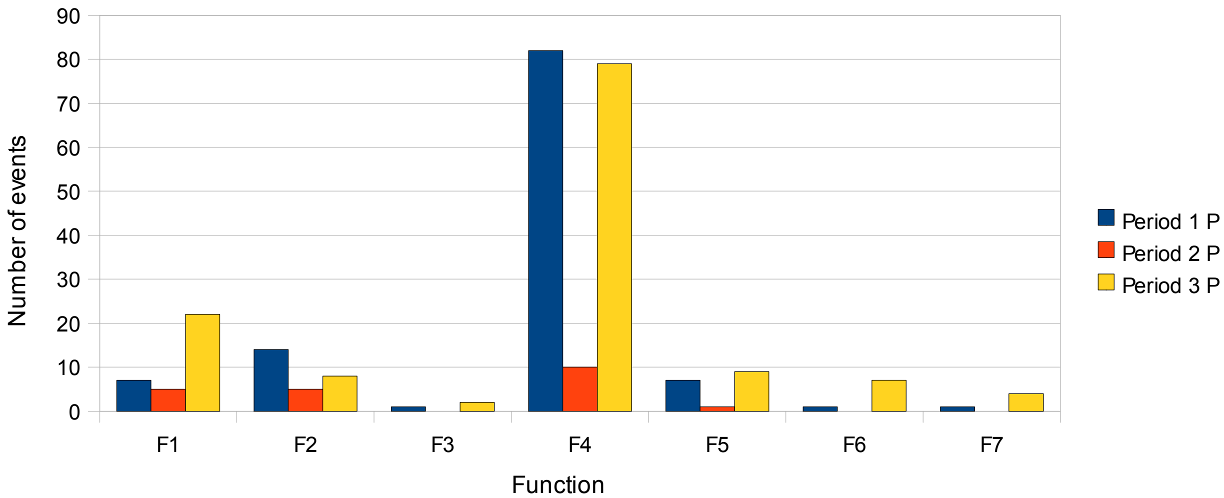

Figure 5: Number of (positive) events by period

The first period which is characterized by the growing attention for BEV technology is jump-started when GM introduces its BEV concept-car “the Impact” in 1990 (NRC, 1990a). Impressed by its specifications and general viability the California Air Resources Board (CARB) – a powerful subdivision of the government of California, that is allowed to introduce legislation to reduce air pollution – mandates car manufacturers by law to sell a specific percentage of their cars in California as zero-emission-vehicles (ZEV's). Since most automakers that operate on the (profitable) Californian market wanted to keep doing so they where in effect forced to introduce ZEV development programs. Given the technology available at the time and its perceived development, these programs initially focused on BEV technology. In our research we notice several events of foreign car manufactures developing BEV technology. The Californian attention regarding BEV technology seems to quickly find its way to the Netherlands since by the end of 1990 the Dutch government starts its own trials with BEV vehicles (F2)(NRC, 1990b). In 1992 the national government makes 10 million Guilders (4,5 million Euro) available (F6) for a trial with BEV minivans (NRC, 1992). In the subsequent years (1992 - 1999) 10 small BEV trials follow (F2). These trials range in size from a single vehicle for city inspectors to a small fleet of 6 vehicles for a regional utility corporation. Most trials are initiated by local municipalities, government research institutes or government owned utility corporations. The support some Dutch policy makers express towards BEV technology (F4) is therefore no surprise. However, apart from the relatively small trials the only concrete steps taken by policy makers is the road-tax-exemption for BEV's introduced in 1997 (F5) (ANP, 1997). By then, however, car manufacturers have set up a strong lobby for the repeal of the CARB legislation in the U.S. which is ultimately successful in 1998 (NRC, 1998).

The second period starts in late 1998 when the CARB legislation is repealed, dismissing car manufactures of their initial obligation to develop ZEV's / BEV's. In the following years (1999 - 2005) only a very limited number of manufacturers give notice of their progress in pure BEV development (hydrogen seems to be the new promising technology). Some BEV trials still occur, most notably in the city of Alphen (10 cars) (R&G, 1999), in the city of Rotterdam (7 cars) (AD, 2001) and in the city of The Hague (3 cars) (GC, 2003). An initiative with 5 BEV taxi's in the city of Utrecht in 2002 is unsuccessful and ends in the same year (UN, 2002). Overall however the second period is characterized by a lack of attention in BEV technology, although 1999 still experiences 12 events, between 2000 and 2005 the attention quickly dwindles with no more than 6 events in each of these years.

The third period starts early 2006 when U.S. president Bush states that BEV technology is the means by which the U.S. can reduce their dependency on oil (F4) (NRC, 2006). Whether induced by this statement or not, by the end of the same year General Motors – the largest U.S. car manufacturer – publicly announces it plans to introduce a (plug-in) BEV (AD, 2006). Unlike the first period no legislation is in place that forces GM to make this move. The renewed attention for BEV technology (again) travels from the U.S. to the Netherlands where policy makers (both national and local) and advocacy coalitions (again) speak out their support for BEV technology (F4/F7) on at least 17 occasions. Most notable is perhaps the announcement of the Dutch minister for transport that the Netherlands should be a testing grounds for BEV technology (NRC, 2009a). In the third period multiple BEV projects are started and although three events (F2) are designated as a “trial”, 22 other projects are started where the development of knowledge is not mentioned as the main objective. In most cases these projects originate from (semi-) commercial entities (for instance from the recently liberalized electricity corporations) and are thus classified as F1 (entrepreneurial activities). The large support of commercial entities is a striking difference opposed to the developments in the first period. The support of the joint electricity corporations for instance leads to the start of a large project that aims to unroll a nationwide BEV charging infrastructure (Telegraaf, 2009a). Other projects initiated by commercial entities are the frequent introductions of BEV's to the market, both by producers themselves or by importers. A second difference of the third period is the size of the projects, while in the first and second period projects did not exceeded more than 10 vehicles, in the third period projects are announced that aim to incorporate many more vehicles, for instance: City cargo, Amsterdam, 2006, 300 BEV's (Dagblad vh Noorden, 2006); TNT, Rotterdam, 2007, 50 BEV's (FD, 2007); Essent, nationwide, 2008, 200 BEV's (BN/DeStem, 2008); Prestige, Utrecht, 2009, 40 BEV's (AD/UN, 2009); Urgenda, nationwide, 2009, 3000 BEV's (NRC, 2009c). The most surprising characteristic of the third period is perhaps market development events and the availability of resources (F5/F6). Resources for BEV technology are made available more frequently (10 occasions, both in the form of direct subsidies and in the form of indirect support for instance in the form of tax-cuts for BEV users). Furthermore, allocated resources are substantially larger in size than in previous periods, e.g. Noord-Brabant, (part of) €75 million (Volkskrant, 2009); State, €10 million, (NRC, 2009a); Amsterdam, €10 million, (NRC, 2009b) 2009; Noord-Brabant (extra) €5 million (BD, 2009); State, €65 million, 2009 (Telegraaf, 2009b). What is perhaps most striking, however, is that most initiatives around BEV technology already started *before* resources were made available by the government.

4.3 Regional events

In order to indicate the use of our specific focus on regional events we give a short description of the events that occurred in the Randstad-South region in table 2. In this region 15 events occurred, 10 of those originated from the largest city of the region, Rotterdam.

Table 2
Events in the Randstad-South Region

Date	Function	Sign	Description
24-02-92	F2	P	A electricity corporation in Gouda (20km from Rotterdam) has a BEV on trial for 6 weeks.
11-05-95	F2	P	Researchers at the technical university Delft (12 km from Rotterdam) are developing a new type of battery, that might be suitable for a BEV in the future.
23-05-95	F4	I	A businessman from Rotterdam is allowed to drive BEV as an alternative punishment for repeated speeding violations.
12-03-97	F4	P	The city of Rotterdam suggests to adopt BEV's for its fleet of 400 service vehicles. Perhaps within 2 years time, the city's partner electricity corporation Eneco was more nuanced.
01-12-98	F4	P	Three distribution firms announced that they will be receiving three BEV's to supply inner-city stores. The trial will lasts 2,5 years and is related to a larger European project.
19-04-01	F1	P	The operation with the three BEV's in Rotterdam starts.
07-06-03	F2	P	The ministerial postal service trials three BEV's for use within the city of The Hague (20 km from Rotterdam).
02-03-05	F1	P	A local hospital in Zoetermeer (15 km from Rotterdam) uses a BEV as a taxi vehicle for patients.
22-08-07	F2	P	The postal service in Rotterdam has two BEV's on trial.
07-09-07	F5	P	A charging station in installed in Rotterdam by an electricity corporation (Eneco) and an engineering firm (Eypon). The city municipality will use it to charge two of their electric scooters.
08-01-08	F4	P	Engineering firm (Eypon) is developing BEV batteries in Delft
03-09-08	F1	P	An entrepreneur opens a showroom in Rotterdam with only BEV vehicles.
09-06-09	F4	P	Engineering students in Rotterdam make a BEV as part of their study.
23-09-09	F4	P	The city of Rotterdam would like to be a forerunner regarding BEV's with 1000 vehicles on the city roads in 2014 and 200.000 vehicles in 2025.
23-09-09	F5	P	The city of Rotterdam hands out free parking permits for BEV vehicles.

What is somewhat surprising is our inability to identify events that are the result of previous activities. All events seem to “stand alone”, the inter-relations between events are thus absent or unclear. Furthermore the Randstad-South region houses about 2,5 million people and a substantial part Dutch economic activities. Although it is still very possible that the (recent) activities in the area will have a profound influence on the development of the national TIS in the future, the score of 15 events is not above what could statistically be expected in such a densely populated area.

5. Conclusion and discussion

5.1 Conclusion

While mapping the events that have taken place regarding BEV technology in the (individual regions of the) Netherlands we have created an overview of how the Dutch innovation system regarding BEV technology has developed since 1990. Of all events in the data-set only 26% has been classified on a lower than “national” geographic level. These events mainly take place in the Netherlands most densely populated regions. We have shown that over time two distinct periods can be discerned in which there is considerable attention for the technology which is separated by a period of very little attention. Despite the fact we are currently experiencing a period of high (positive) attention very few BEV's are actually in use and thus we can not yet asses BEV technology as a successful innovation. The occurrence of function 1 (entrepreneurial activities), however, is (unlike in the previous period of high attention) clearly on the rise. This increase in commercial activities shows that BEV technology is becoming market-ready which is an indication for the maturation of the Dutch TIS (albeit it in niche for now).
However, the influence of regional organizations and institutions on the development of the (regional) TIS could not be identified in our study. Connections between individual regional events where either absent or unclear. This is in large part also true for events on a higher geographical level, since in general relatively few connections between events became clearly visible in our study. Our decision to specify events by region allowed for a more complete overview of the development of the Dutch TIS. In this particular case, however, it did not provide us with evidence of a strong influence of regional organizations and institutions. Nonetheless our approach shows that combining a region-specific view with the functions of innovation approach is a viable and useful alternative when researching innovation on which the specific characteristics of regionallity can have a high measure of influence.

5.2 Applicability while lacking technological development

Hekkert et al. (2007) state that when all the functions of their approach are present in the TIS, successful innovation can take place. Regarding BEV technology in the Netherlands this is not the case. Based on the hypothesis of Hekkert et al. (2007) we thus, should conclude that the TIS in the Netherlands is not (yet) fully developed. There are, however, a number of nuances.
BEV's could be assessed as a radically new technology, of which we know it often develops via new, market punctuating firms. In our research, we nevertheless, display that this assessment would be (largely) inaccurate, since BEV technology mainly develops from incumbent firms. Still, this does not need to be problematic, since the functions approach can also be applied when development originates from existing industries. The Netherlands, however, does not hold a large automotive industry. In addition, our focus on the Dutch innovation system led us to classify all foreign events to function four (guidance of the search). This combination of foreign development whilst exclusively focusing on the Dutch TIS, resulted in the relative under-representation of functions related to technological development of BEV's (although some “test-drives” have been classified as function two, most development took place outside of the Netherlands) and thus (at least partially) explains why not all functions are sufficiently met in our study.
The above mentioned account points out a drawback of the functions of innovation systems approach as set-up by Hekkert et al. (2007). The approach, in our opinion, has a

high focus on innovation of “production and development”, whilst somewhat neglecting innovation of “use and adoption”. We believe that here lies a task for future research. Either the method itself could be further developed in order to make it more suitable for research related to innovation of use and adoption. Or an alternative approach is the adaptation of the hypotheses that states that all functions need to be present in order for successful innovation to occur, since innovation can still take place even when when true development of products is located abroad.

5.3 Applicability in the early stages of development

As noted, in general all system functions need to be sufficiently fulfilled in order for the TIS to grow and thus stimulate the development and uptake of the technology. This is not the case for the TIS development regarding BEV technology in the Netherlands. Although this can partly be explained by the characteristics of the Dutch innovation system and the subsequent focus on use and adoption as opposed to production and development, we must take a second notion in consideration. The development trajectory of BEV technology in the Netherlands is far from completed. Despite the large amount of (positive) attention, adoption of BEV technology is virtually non-existent. Our research thus focused on the early stages of TIS development in the Netherlands and although the data shows an increasing occurrence of function one (entrepreneurial activities) which can indicate a successful establishment of BEV technology, it still remains too early to confirm the technology's success, which in turn makes it difficult to asses the exact amount of influence (regional) organizations and institutions have had on the development of the TIS regarding BEV technology.

7. References

Ansheim, B. and Isaksen, A., *“Regional Innovation Systems; The Integration of Local 'Sticky' and Global 'Úbiquitous' Knowledge”* Journal of Technology Transfer, 27 (2002) pp. 77-86

Boschma, R., “*Learning and regional development*” GeoJournal, 49 (May, 2000) pp. 339–343

Braczyk, H.J., Cooke, P., Heidenreich, M., *“Regional Innovation Systems; The Role of Governance in a Globalised World”* UCL (1998) London and Pennsylvania

Carlsson, B., *“Technological Systems and Economic Performance; The Case of Factory Automation”* Kluwer (July, 1995) Dordrecht

Carlsson, B., Jacobsson, S., Holmen, M., Rickne, A., *“Innovation systems; analytical and methodological issues”* Research Policy, 31 (2002) pp. 233-245

Carlsson, B. and Stankiewicz, R., “*On the Nature, Function and Composition of Technological Systems”* Corlson (1995) pp. 21-56

Camagni R., *“From the local milieu to innovation through cooperation networks”* Innovation networks: spatial perspectives (1991)

Cooke, P., Uranga, and M.G., Etxebarria, G., *“Regional Systems of Innovation; Institutional and Organizational Dimensions”* Research Policy, 26 (1997) pp. 475-91

Creutzig, F., Papson, A., Schipper, L., Kammen, D.M., *“Economic and environmental evaluation of compressed-air cars”* Environmental Research Letters, 4 (2009) pp. 9

Edquist, C., *“Systems of innovation; Technologies, Institutions and Organizations”* Routlege, Pinter (June 10, 1997) London

Edquist, C., *“Systems of innovation; Perspectives and challenges”* J. Fagerberg, D.C. Mowery & R.R. Nelson, The Oxford Handbook of Innovation, Oxford University Press (April, 2004) pp. 181-208

Fogelberg, H., *“Beyond regulation: The California electric car controversy”* Electrifying visions. The technopolitics of electric cars in California and Sweden during the 1990’s, (2000) Götenborg, Götenborg University, pp. 53-99

Freeman, C., *“Technology Policy and Economic Performance; Lessons from Japan”* Pinter (November, 1987) London

Hekkert, M.P., Suurs, R.A.A., Negro, S.O., Kuhlmann, S., Smits, R.E.H.M., *“Functions of Innovation systems; A new approach for analyzing technological change”* Technological Forecasting & Social Change, 74 (2007) pp. 413-432

Jacobsson, S., Sanden, B.A., Bangens, L., *“Transforming the energy system—The evolution of the German technological system for solar cells”* Technol. Anal. Strateg. Manag. 16 (1) (2004) pp. 3–30.

Johnson, A., *“Functions in Innovation System Approaches”* in Paper for DRUID’s Nelson-Winter Conference. 2001. Aalborg, Denmark

Knowlen, C., Mattick, A.T., Bruckner, A.P., Hertzberg, A., *“High-Efficiency Energy Conversion Systems for Liquid Nitrogen Automobiles”* SAE International, (August 1998)

Liu, X., White, S., “*Comparing innovation systems: a framework and application to China’s transitional context*” Res. Policy, 30 (2001) pp.1091–1114.

Metkemeijer, P. and Achard, P., “*Ammonia as a feedstock for a hydrogen fuel cell; reformer and fuel cell behaviour”* Journal of Power Sources, 49 (1994) pp. 271-282

Negro, S.O., Hekkert, M.P., Smits, R.E., *“Explaining the failure of the Dutch innovation system for biomass digestion – A functional analysis”* Energy Policy, 35 (2007) pp. 925-938

Porter, M. E., *“The competititve advantage of Nations”* Free Press (1990) New York

Ragauskas, A.J., Williams, C.K., Davison, B.H., Britovsek, G., Cairney, J., Eckert, C.A., Frederick, W.J., Hallett, J.P., Leak, D.J., Liotta, C.L., Mielenz, J.R., Murphy, R., Templer, R., Tschaplinski, T., “The Path Forward for Biofuels and Biomaterials” Science, Vol. 311 (January 2006) pp. 484–489

Rifkin, J., *“The Hydrogen Economy”* Tarcher, (August 25, 2003) New York

Suurs, R.A.A. and Hekkert, M., *“Cumulative Causation in the Formation of a Technological Innovation System; The Case of Biofuels in The Netherlands”* Technological Forecasting & Social Change, 76 (2009) pp. 1003–1020

Wichmann, E.H., *“Schützen Umweltzonen unsere Gesundheit oder sind sie unwirksam?”* Umweltmed Forsch Prax, 13 (2008) pp. 7–10

Websites:

CBS (Statistics Netherlands) (2010)
http://www.cbs.nl

LexisNexis (2010)
http://www.lexisnexis.com/

Ode Magazine (2008)
http://nl.odemagazine.com/doc/0110/Meer-stroom-op-straat/

OECD (1992)
www.oecd.org/dataoecd/13/23/1884214.pdf

Second strategic energy review of the EU (2008)
http://ec.europa.eu/energy/strategies/2008/2008_11_ser2_en.htm

Newspapers:

AD, 2001; Algemeen Dagblad, 19/04/01 *“Milieuvriendelijk stadsbestelwerk; Primeur met elektrische bestelbus”*

AD, 2006; Algemeen Dagblad, 01/12/06 *“Autofabrikant claimt door betere accu's veel grotere actieradius dan grote concurrent Toyota - GM knokt terug via stopcontact”*

AD, 2009; AD/Utrechts Nieuwsblad, 12/08/09 *“Veertig elektrische taxi's - Milieuvriendelijk vervoer in Utrecht in opkomst”*

ANP, 1997; Algemeen Nederlands Persbureau, 30/06/97 *“Elektrische personenauto's 40 procent goedkoper”*

BD, 2009; Brabants Dagblad, 03/09/09 *“Masterplan energie Nieuwe PvdA-gedeputeerde Lily Jacobs start met groot project - 'Energie wordt ondergewaardeerd'”*

BN/DeStem, 2008; BN/, 10/10/08 DeStem *“Oud-Gastels bedrijf bouwt mee aan eerste reeks elektrische wagens - Essent stapt in elektrische auto's”*

Dagblad vh Noorden, 2006; Dagblad van het Noorden, 22/12/06 *“Amsterdam houdt proef met vrachttram; Minder uitstoot Nauwelijks lawaai”*

FD, 2007; Het Financieele Dagblad, 22/08/07 *“Elektrische auto is voor TNT begin van milieuoffensief”*

GC, 2003; Goudsche Courant, 07/06/03 *“Van Binnen – Uit”*

NRC, 1990a; NRC Handelsblad, 19/04/90 *“De nieuwe elektrische auto van General Motors”*

NRC, 1990b; NRC Handelsblad, 24/11/90 *“Met natriumzwavel-acu's de weg op; Elektro-auto's getest”*

NRC, 1992; NRC Handelsblad, 04/08/92 *“Tien miljoen voor vervoer op elektriciteit”*

NRC, 1998; NRC Handelsblad, 31/10/98 *“De benzine voorbij; Elektrisch rijden was vaak betrouwbaarder en winstgevender”*

NRC, 2006; NRC Handelsblad, 01/02/06 *“Een verslaafde natie”*

NRC, 2009a ; NRC Handelsblad, 20/03/09 *“Elektrische auto nog snel uitgeput en duur; Auto-industrie Plannen voor grootschalige introductie van elektrische auto's in Nederland”*

NRC, 2009b; NRC Handelsblad, 09/05/09 *“'Vuile' auto mag toch in centrum A'dam”*

NRC, 2009c; NRC Handelsblad, 09/09/09 *“Consortium wil 3.000 elektrische auto's bestellen”*

R&G, 1999; Rijn en Gouwe, 08/04/99 *“Impuls voor elektrische auto; Project Schoon en Mobiel van EWR, gemeente en bedrijven”*

Telegraaf, 2009a; De Telegraaf, 25/04/09 *“Overal stroom tanken; Oplaadpunten op 10.000 plaatsen”*

Telegraaf, 2009b; De Telegraaf, 16/09/09 *“Stimulans elektro-auto Rechten vluchtelingen Bedrijven blijven zuinig”*

UN, 2002; Utrechts Nieuwsblad, 26/10/02 *“Greencab hoopt met milieuprijs op snelle doorstart”*

Volkskrant, 1996; De Volkskrant, 06/09/96 *“Bus op LPG vrijgesteld van wegenbelasting”*

Volkskrant, 2009; De Volkskrant, 19/02/09 *“Stad en provincie gaan de crisis met eigen plannen te lijf”*

Appendix I Source periodicals			
Newspapers	*Local newspapers*	*Professional magazines*	*Newsmagazine*
AD / Algemeen Dagblad	AD / Amersfoortse Courant	Beleggers Belangen	Elsevier
Agrarisch Dagblad	AD / De Dordtenaar	BIZZ	De Groene Amsterdammer
Dag	AD / Groene Hart	Boerderij	Opzij
Het Financieele Dagblad	AD / Haagsche Courant	Bouwwereld	Quote
Metro	AD / Rivierenland	Distrifood	Vrij Nederland
Nederlands Dagblad	AD / Rotterdams Dagblad	FEM Business	
NRC Handelsblad	AD / Utrechts Nieuwsblad	Het Technisch Weekblad	
NRC.NEXT	Apeldoornse Courant	Logistiek Krant	
Het Parool	BN/Destem	Missets Horeca	
Reformatorisch Dagblad	Brabants Dagblad	Pakblad	
Spits!	Dagblad Flevoland	Psychologie Magazine	
De Telegraaf	Dagblad Tubantia	Transport & Opslag	
Trouw	Dagblad van het Noorden	Zorgvisie	
De Volkskrant	Deventer Dagblad	Distrifood	
	Eindhovens Dagblad		
	Friesch Dagblad		
	Gelders Dagblad		
	De Gelderlander		
	Haarlems Dagblad		
	Leeuwarder Courant		
	Nieuw Kamper Dagblad		
	Leidsch Dagblad		
	Limburgs Dagblad		
	Noordhollands Dagblad		
	Overijssels Dagblad		
	Het Parool		
	Provinciale Zeeuwse Courant		
	Veluws Dagblad		
	Zwolse Courant		

Appendix II Provinces (CBS, 2008)				
Province	*Abbreviation*	*Population*	*surface*	*Pop. Density (pop./km²)*
Groningen	GR	577.081	2960.03	247
Friesland	FR	646.318	5748.74	193
Drenthe	DR	490.870	2680.37	186
Overijssel	OV	1.130.380	3420.86	340
Flevoland	FL	387.698	2412.30	274
Gelderland	GL	1999135	5136.51	402
Utrecht	UT	1.220.324	1449.12	881
Noord-Holland	NH	2.668.197	4091.76	999
Zuid-Holland	ZH	3.502.595	3418.50	1244
Zeeland	ZL	381.477	2933.89	213
Noord-Brabant	NB	2.444.435	5081.76	497
Limburg	LB	1.122.990	2209.22	522

Appendix III
Regions (CBS, 2008)

Region	*Abbreviation*	*Municipalities*	*Remarks*
Netherlands-North	NN	Friesland (province) Groningen (province)	Coincides with the two northernmost provinces
Twente	TW	Almelo Borne Dinkelland Enschede Haaksbergen Hellendoorn Hengelo Hof van Twente Lossen Oldenzaal Rijssen-Holten Twenterand Tubbergen Wierden	
Limburg-South	LS	Beek Brunssum Eijsden Gulpen-Wittem Heerlen Hoensbroek Kerkrade Landgraaf Maastricht Margraten Meerssen Nuth Onderbanken Schinnen Simpelveld Sittard-Geleen Stein Vaals Valkenburg aan de Geul Voerendaal	
Eindhoven	EI	Asten Bergeijk Bladel Cranendonck Deurne Eersel Eindhoven Geldrop-Mierlo Gemert-Brakel Heeze-Leende Helmond Laarbeek Nuenen Oirschot Reusel-De Mierden Someren Son en Breugel Valkenswaard Veldhoven Waalre	Coincides with a local region of high cooperation between the individual municipalities. (Samenwerkingsverband Regio Eindhoven)
Randstad-South	RS	Albrandswaard Barendrecht Capelle aan den IJssel Delft Gouda 's-Gravenhage Krimpen aan den IJssel Lansingerland Leidschendam-Voorburg Maassluis Midden-Delfland	

		Pijnacker-Nootdorp Ridderkerk Rijswijk Rotterdam Schiedam Spijkenisse Vlaardingen Wassenaar Westland Zoetermeer Zuidplas Zwijndrecht	
Randstad-North	RN	Aalsmeer Amsterdam Amstelveen Diemen Haarlemmerliede en Spaarnwoude Haarlemmermeer Muiden Ouder-Amstel Uithoorn Weesp Zaandam Zaanstad	

Appendix IV
Municipalities

Municipality	*Number of events*
Almelo	1
Alphen aan de Rijn	5
Amsterdam	12
Apeldoorn	1
Arnhem	2
Borger-Odoorn	1
Boxtel	4
Delft	4
Eindhoven	4
Enschede	1
's-Gravenhage	1
Groningen	1
Haarlem	1
Heerlen	1
's-Hertogenbosch	3
Leeuwarden	3
Lochem	1
Maastricht	1
Nieuwkoop	1
Nijmegen	2
Oosterhout	1
Roermond	1
Roosendaal	1
Rotterdam	10
Sittard-Geleen	1
Terschelling	1
Tilburg	1
Tytsjerksteradiel	1
Utrecht	3
Vaals	1
Veenendaal	1
Vlieland	1
Zaanstad	1
Zeist	1
Zijpe	1
Zoetermeer	1