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# ENEVATE Project - Electric Vehicle Market Drivers and E-Mobility Concepts

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## Abstract

The introduction of electric vehicles provides opportunities as well as limitations for new mobility solutions. This could include new combinations of public and private transport as well as multimodal mobility. Due to the limited driving range of electric vehicles, people may have to adapt their travel behaviour or choose between different mobility modalities based on their needs. Human behaviour is an important driver for the success of these introductions. It is important to know how people react to driving electric vehicles and how people will integrate the electric vehicle and the e-mobility concepts into their daily lives. The overall objective is to support the implementation of the most desirable and realistic scenarios from the users perspective, so that e-mobility becomes an attractive way of travelling. This will be done by working with public authorities, working with the ENEVATE pilots and via the ENEVATE acceleration programs. The study can be divided into four different actions: definition of integrated sustainable e-mobility concepts; market analysis for user acceptance; scenario building for future sustainable integrated e-mobility concepts; and development of support instruments and tools that will be custom built to assist anyone involved in designing, implementing or using an e-mobility scheme. The ENEVATE project is due to report in June 2013. This paper reports on the results of the first two actions and outlines the approach that is being taken for the final two actions.

*Keywords: e-mobility concepts, market drivers, regulation, education, survey, typology, strategic niche management*

## 1 Introduction

Europe's 2020 vision is for a minimum 20% reduction from 1990 in total greenhouse gas emissions [1]. This is to be achieved through a package of measures including measures aimed at the transport sector. Member States however face challenges of growth in user and energy demand and high dependency on fossil fuel sources for transport, contributing to an upward emissions trend. The consensus on fossil fuels as finite means many low carbon energy alternatives now exist, but short-term, electricity or e-mobility provides the only viable solution.

The rate at which electric mobility develops and is taken up as a transport mode depends in part on our ability to engage and learn from initiatives and on the extent of co-operation between various stakeholders. Inefficiencies related to weak co-ordination and dispersed, ad hoc activity mean potential has not been fulfilled. This applies within

North-West Europe (NWE), individual States and also at a global level [2].
It is in recognition of this situation, the need to avoid further duplication and resource waste that the ENEVATE consortium formed [3]. Consisting of 14 partners from NWE, the European Network of Electric Vehicles and Transferring Expertise (ENEVATE) will work together to provide tested, evidence-based solutions.
This paper reports on the actions undertaken as part of the Electric Vehicle Market Drivers and E-Mobility Concepts study. The objectives of this study were to identify: impacts of the introduction of EVs on user and market behaviour; potential for new e-mobility concepts; and market drivers that will influence the acceptance of the different EV mobility concepts and the conditions needed for realising this acceptance.

# 2 E-mobility Concepts

Electric vehicles (EVs) currently operate in two realms. On the one hand, there are niches where they are fully competitive with any alternative driveline technology. Examples are various types of public transport applications such as trams and trolleybuses. Other examples are in certain industrial settings, where products such as electric materials handling equipment are often the norm. For example the use of fork lift trucks in warehousing. In addition, EVs have long been used for certain commercial applications such as milk distribution in the UK [4] and are increasingly used for inner city distribution for their lack of emissions and low noise [5] – this makes them competitive in these settings with conventional internal combustion (IC) drivetrain.
The other EV realm largely relies on subsidies of various kinds. This includes the private EV-as-car-replacement market. An example is the UK plug-in-car grant, which provides a grant towards the initial purchase cost [6]. In order for EVs to enjoy enhanced penetration in the market, it is these latter areas that need to be stimulated in various ways. However, the question then arises as to what way of stimulating such markets is most effective. One approach is strategic niche management.

## 2.1 Socio-Technical Transitions

The socio-technical regime transitions literature [7, 8, 9] and particularly the related notion of 'strategic niche management' has gradually gained a foothold in academic thinking about how technological change might happen. Within this theoretical framework it is argued that a 'regime shift' to a new set of technologies and a new set of accompanying social and economic norms can be initiated through the successful establishment of one or more technological niches. In most cases such niches will arise naturally as a result of changes in the operating environment, such as the invention of new technologies. Geels [8] gives the example of the transition from sail to steam in ships, among others. The learning experience from different niches can be combined and new actors can become supportive and thus gradually, clusters of social and technological factors become more and more powerful, such that they can come to replace an established and hitherto dominant regime. This combination of technological and social factors is essential to bring about such change – technology alone is never sufficient. Changes in the landscape – e.g. the increasing pressure on the use of fossil fuels – weaken the existing regime, thereby opening up windows through which niche technologies and changed social factors can establish themselves. In figure 1, derived from Wells, Nieuwenhuis and Orsato [10], an attempt has been made to show these different elements of STT theory within the context of EV niches.

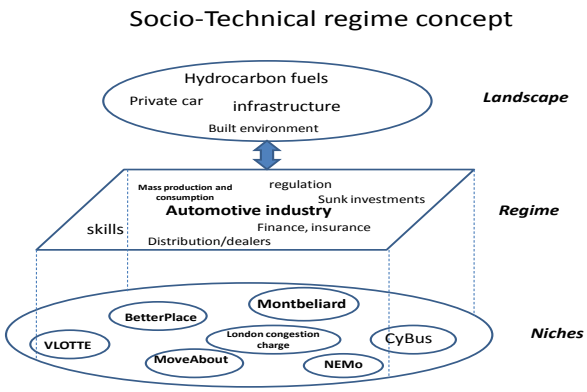


Figure 1: Socio-Technical regime with EV niches

Although niches often arise spontaneously and become competitive to the extent of pressurising the existing regime, and eventually forcing its transition, it is also possible to provide active support for specific niche technologies that are considered particularly desirable. This concept is known as 'strategic niche management' (SNM). Where there is a broader socio-political driver for such a shift – as is the case currently through the desire to reduce carbon emissions from transport,

for example – a number of key actors can come together to initiate experiments to try and promote such a niche. Such experiments attempt to create a protected market space in order to test the viability of an alternative technology and/or set of accompanying norms. If successful, such a concept can then gradually be exposed to ordinary market forces, thereby helping the niche move towards replacing the established, but now less desirable regime via a route that offers gradually less protection from prevailing market forces, which in any case do not normally act with foresight. Niches will then benefit from windows that appear in the dominant regime as a result, very often, of changes in the landscape – e.g. rapidly rising oil prices. In addition, lessons learned from several such experiments can combine into new niches, thereby gradually adapting and strengthening over time.

## 2.2 EV Niche Typology

Experiments that are currently taking place, or that have been conducted in the past, are many and varied and in order to extract useful information from these, a typology is needed. If experiments can be classified under various types, a more useful set of guiding principles can be devised, thus enhancing the output from such projects.

Current and recent experiments and pilot schemes range from electric concept cars, EVs in very limited production, experiments with fleet EVs, shared EVs, electric bicycles, localities with a range of EV incentives, etc. Clearly these are all quite different in nature and need to be analysed in different ways. Some of these could be classed as technical experiments or pilots, while others are clearly linked with broader niches of novel technologies combined with new socio-economic, or business models. It is this mixture that may prove challenging to capture. In addition, there are established EV applications, such as trams and trolleybuses that need to be excluded as these have proved viable and have long moved beyond the experimental stage. Yet, where such types are used in novel ways, they still need to be captured in some way.

The work at Cardiff University as part of the ENEVATE project has identified nine broad categories [11]. These are explained below:

- Type 1 is for EV public transport. Sub-types are dedicated infrastructure and general infrastructure. Examples include the heavily subsidised maglev train; notably the Shanghai airport link [12]. The electric guided bus is a relatively new application, allowing some of the advantages of rail-based systems without the heavy investment in fixed infrastructure and rail vehicles. Also included is the Automated Guided Vehicle (AGV) option, which is still relatively new and still largely experimental in urban environments.
- Type 2 is the type assumed by many commentators, manufacturers and legislators; the private, consumer- owned EV. These may range from conventional car-like EVs such as the Nissan Leaf [13], or Th!nk [14], via electric quadricycles such as the Mega and Reva [15, 16], to electric bicycles, pedelecs (= electric-assisted bicycles, or tricycles such as the Twike [17]) and new types such as Segways [18].
- Type 3 tries to capture a range of situations whereby a local authority in conjunction with other local partners specifically attempts to facilitate the use of EVs in some form. This includes specific EV experiments such as those in La Rochelle, France and Mendrisio, Switzerland [19], but can also be used to include the situation in Oslo and London whereby public subsidies, incentives and infrastructure are used to promote private EV markets. In terms of sub-categorisation they have been provisionally classified according to the role played by public authorities and private actors, respectively. Other categories are attempts to capture the promotion of more specific vehicle types, while one captures infrastructure promotion initiatives. This is probably the most fertile category for research into transitions towards greater acceptance of EVs.
- Type 4 is for various types of EV sharing schemes, which have been categorised according to their organisational and ownership characteristics. These too seem likely subjects for research.
- Type 5 is for depot-based commercial vehicles, currently probably the most viable application of EV technology, with many examples in daily use throughout NW Europe and beyond. It is clear that this category is already competitive with more traditional technologies, offering specific advantages for a number of operators. However, a number of potential users are still considering whether to opt for EVs for their specific needs and some of these may also be worthy of investigation. Clearly, some of these, once established will move to one of the other categories. A special

sub-category is dedicated to fleet EVs that are used specifically for experimental purposes by technology developers.

- Type 6 covers existing and established EV use within industrial environments of various types. These are established applications whereby EV is considered the optimal solution. They are thus fully competitive and do not require support, although it must be recognised that in some cases such applications are driven by existing regulations, particularly those covering in-plant emission and toxin levels under health and safety regimes.
- Type 7 has been introduced to cover broader experiments with alternative business models for EVs. On the whole, EV experiments are largely technology-driven, perhaps ignoring the wider business or societal impacts of any move to EVs, which are different enough from IC vehicles to have the potential to force new business models onto the industry. This is an important area requiring further investigation.
- Type 8 is specifically about fuel cell experiments. This may be a longer term technology compared with battery EVs and is therefore still more dominated by experimentation. These are important in order to assess their potential viability, as well as to develop further this key technology in more market-like operating environments. However, recent adoption of FC materials handling equipment by firms such as Walmart [20] provide a new impetus to hydrogen fuel cell technology and it is important to track any further experiments in this area.
- Type 9 has been introduced to capture EV-specific grid experiments, notably 'smart grids', whereby a means of communication and energy exchange is created between EVs and the energy generating and distribution grid. Additionally, post EV-use applications of EV batteries for energy storage will also be captured by this category.

This typology should be seen very much as a work in progress that is expected to be refined as more EV niche experiments come to light and as new experiments are introduced.

# 3 Market Analysis

According to 'strategic niche management', a niche such as an EV pilot needs to be temporarily protected so it can develop and transition into the mainstream.

By assessing consumer attitudes, ENEVATE looks to assess what incentives would encourage the use of EVs. These incentives can then be used in order to create the 'protection' required for the EV experiment to succeed

The research methodology used in the ENEVATE project was fundamentally influenced by the social scientific principle of triangulation, as conceptualised by Denzin [21] and developed by Bryman [22]. Triangulation refers to the process of using more than one approach in the course of conducting an investigation. Within the social scientific community, there is widespread support for using triangulation in research; triangulation is fundamental in overcoming the limitations of single-track approaches. In order to achieve these aims, the fieldwork will involve three components: initial interviews; follow-up surveys, and, where appropriate; focus groups. The work is described in detail in [23].

## 3.1 Interview Methodology

The interview was designed to be quick and easy to complete. The participant was asked to respond to a series of incentivisation statements starting with the prefix:

*"I would be more likely to consider buying an electric vehicle in the future if…"*

Respondents are then provided with a series of options and asked to place these on Likert scales:

The five-point rating system passes from 'strongly agree 'and 'agree' to 'disagree' and 'strongly disagree' with an option for 'no opinion'. The first three questions looked at financial incentives, followed by infrastructure incentives and finally organisational factors.

After asking participants about EVs in particular, the survey moved on to consider car ownership in general. Participants were posed the question:

*"When buying your next car, how would you rank the following factors in terms of importance, with 1 being the most important and 5 being the least important?"*

They were asked to rank: environmental factors; Performance; purchase costs; running costs; and size.

## 3.2 Interview Results

The first trial of the interview methodology was in Montbéliard, France toward the end of 2011. A total of 214 surveys have been completed to date (September 2012), with responses from all

ENEVATE regions - UK, France, Ireland, Germany, The Netherlands and Belgium. The results offer a mixture of different types of EV experiment involving various models of EV usage including fleets, car clubs, 'station cars', private users, etc.

The results for the financial incentives are shown in figure 2. Unsurprisingly all financial incentives are well received by consumers. However, closer analysis shows consumers exhibit preference for a reduction in 'up front' costs or single point reduction over 'on-going' costs.

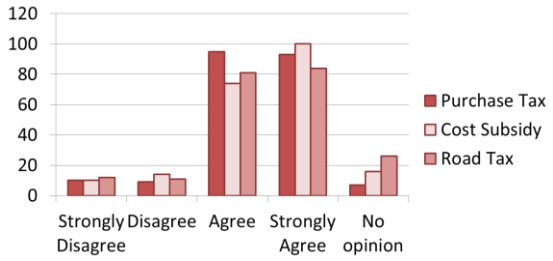


Figure 2: Financial Incentives

For the infrastructure incentives the bias towards charging facilities and charging information is reflective of the consumer concern in relation to EV range or 'range anxiety'.

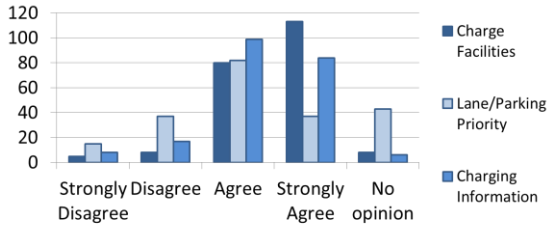


Figure 3: Infrastructure Incentives

The organisational involvement looked at the role of the government (local or national) and private organisations, the implication being that purchase and continued use of EV is dependent on the level of support offered to the consumer. The findings show that the consumer is perhaps ambivalent to the role of government and/or private organisations when compared to the concerns of finance and infrastructure.

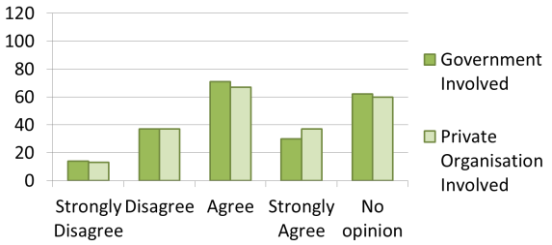


Figure 4: Organisational Involvement

The second part of the interview was concerned with car ownership. This resultant ranking of the five key factors is shown in figure 5. What is clearly apparent is that the prospective car purchaser is concerned with purchase cost and running cost. Size, performance and environmental factor exhibit a flat distribution. For the environmental parameters this is perhaps an acknowledgement that asides from early adopters, who may offset the higher costs with the knowledge of improved environmental credentials, consumers are primarily concerned with cost.

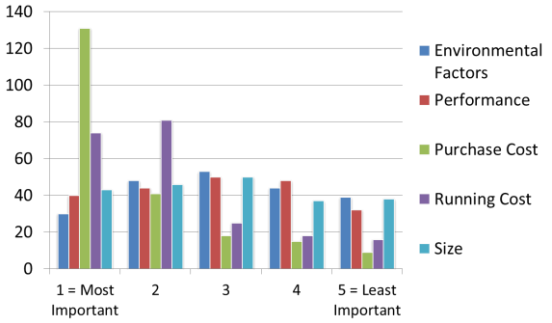


Figure 5: Consumer Motivations

Further analysis breaking the results down by region will be published on the ENEVATE website at the conclusion of the project in 2013 (www.enevate.eu).

## 3.3 Follow-up Survey Methodology

A follow-up survey was undertaken by those participants interested in exploring the issue of mobility concepts. The follow-up survey looked at mobility concepts such as: fixed-term contracts, similar to mobile phones; shared use schemes similar to the 'Vélib' [24] and 'Boris Bike' [25] schemes; co-operative ownership, as community members purchase shares; and car hire, car clubs – i.e. pay for use. In comparison to the previous survey this activity was a semi-structured qualitative interview. The purpose was to explore the domain from the perspective of the consumer. The responses have been transcribed and coded according to the incentives and/or motivations.

These results are then used to support the focus group activity.

### 3.4 Focus Group Methodology

The focus group looks to engage all stakeholders with an interest in e-mobility. The focus group takes the form of a workshop combining brainstorm sessions and expert meetings, design sessions/ateliers and expert lectures. The first of these was held at Cardiff (UK) University in June 2012. This was followed by a similar session in Helmond (NL) at the Automotive Campus NL in September 2012. Two further sessions are planned for before the end of 2012. The different locations enable to engagement of stakeholders from each of the NWE regions. The output of this action is a set of scenarios for future sustainable integrated e-Mobility, including their characteristics, sustainability, user desirability and required steps to be taken by identified stakeholders towards these scenarios.

The focus groups provide the basis for the scenario building. The focus groups are the mechanism for bringing together stakeholder from the regions. These stakeholders cover the consumer, regulator, supplier and manufacturer. The approach is to develop within the stakeholder a wider knowledge of the role of marker drivers and mobility concepts than they may otherwise be exposed to in their present role. The workshop format provides a series of expert lectures based on the 'social technical-transitions theory' outline previously, the 'niche typology' developed as part of the ENEVATE project, and the analysis of the survey results (both the initial quantitative survey and the qualitative follow-up survey). The workshop is structured so that the information and results are provided in sections, with each section tailored to support a 'brainstorming session'. The outcome of the brainstorming session and the provision of expert lectures then facilitate a design session. These design sessions then inform the ENEVATE partnership how sustainable e-mobility concepts need to be defined if they are to be supported by each of the stakeholder groups. The process is unique in that not only do stakeholders from each region experience exchange of information, but they are also exposed to information from other NWE regions. There are four workshops in total, with two completed and a further two yet to be completed. The results will be reported on the ENEVATE website at the conclusion of the workshops (www.enevate.eu)

## 4 Toolkit Development

When we look at the market for clean mobility concepts there are different important stakeholders. These stakeholders are governments, launching customers (companies) and travellers. We can only influence the system if we use a multi stakeholder approach at transnational level. In this multi stakeholders approach we will set up support packages for the different major stakeholder groups (regulators, launching customers and public). By supplying guidance it will enable the stakeholder to use the right elements in their stimulation and decision making processes in order to reach the future integrated sustainable e-mobility concept scenario's and the usage of Electric Vehicles in these scenario's. The support instruments will be the following:

- A tool box for public policy instruments. A policy making model to determine which scenario would best fit the situation the policy maker is in and the steps on how to reach these scenarios. Based on this there are reports with the elements to be influenced by government, guidelines on how to reach the clean mobility concepts and a training program for public policymakers to educate them on influencing possibilities
- A tool box for launching customers. A decision making model to determine which scenario's fits best for their own situations. Guidelines for their decision making and a training program for launching customers will support them in their decision making process.
- An online toolbox (electronic roadmap) with a decision making tree based on travelling schedule and the different clean mobility possibilities to fit this schedule. Also a training program on the different elements of these mobility possibilities is in this online toolbox.

The ENEVATE project has engaged with three stakeholders involved with the development of e-mobility in order to develop the above. These stakeholders are located in Monmouth (UK), Limburg (NL) and Nord-Hessen (GER). This demonstrates the transnational aspect of this work and ensures that the resulting toolbox also has transnational application.

## 5 Conclusions

The introduction of electric vehicles provides opportunities as well as limitations for new mobility solutions. The work presented here provides a transnational approach to investigation of market drivers and e-mobility concepts. The

approach used 'social technical transitions theory' to provide a foundation for explaining the way in which e-mobility concepts may transition from niche to mainstream. The initial activity was to classify known e-mobility concepts using a niche typology. This typology proposed nine broad categories that can be further extended as new e-mobility concepts are introduced. The second activity was then to explore the incentives that may encourage the transition. This activity used the social scientific principle of triangulation. The initial stage was a survey that extended across all regions of North West Europe. The results of these surveys show that in general, consumers place concerns about finance and range above others factors such as environment. The next stages are the focus groups involving key stakeholders from across the North West Europe region and the development of a toolbox that can be used to support those stakeholders interested in implementing e-mobility. The initial workshops have been completed and the results are presently being analysed and will be reported at a workshop in Cardiff in April 2013 and as part of the ENEVATE project final report in June 2013.

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