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Advent of electric vehicles: a research agenda

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Abstract

If one believes the buzz of all electric vehicle introductions and promises coming out of industry and different auto shows, one would think we are a year or two away from electric paradise, and a significant step towards energy independence. The reality is we are not even close. But its time to develop electric vehicles which consumers can afford and want to use. This is a challenge not only to auto industry but also to all different stakeholders who want to promote or develop electric vehicles.

This paper tries to give an attempt in order to stimulate and facilitate electric vehicle introductions. The research agenda focus on different aspects, such as; creating a network and information exchange point for policy makers, entrepreneurs, scientists and a broader public. Bring different activities together and synergy in order to make a strong case for electric vehicles and interest the auto industry towards electric vehicles. The other focus is also to demonstrate the latest developments and make a business case that appeals consumer. Another question is what aspects need to be demonstrated during these demonstrations. The D-INCERT program and project Better-place are given as examples to illustrate initiatives in the Netherlands and international level.

Introduction

The electric car seems on the eve of a breakthrough, is stated by more and more stakeholders in the field of mobility. The environmental advantages of electric mobility compared to our present-day internal combustion based are obvious; no fossil fuels, no local emissions and when batteries charged with electricity generated by renewable sources, hardly any greenhouse gas effects. But these advantages are known already for a long time. Several times in the past electric mobility was high on the agenda of society to be implemented. During the first decades of automotive-development (1850-1930) electric power was the most promising development.

Figure 1 Electric Delivery Van (Harrods UK, Science Museum, London)

More recent in history the front-running public discussions and regulations in the State of California (USA) to stimulate or even to force the development and introduction of electric mobility are famous. One of the most interesting experiments within the framework of these California's ambitions is without doubt the EV1 concept car & electric charging infrastructure of General Motors[1].


Figure 2 EV1 by General Motors

But despite all the technological promising developments in the historical cases and the willingness of important stakeholders at those times the electric car did not reached the 'tipping point' (Gladwell, 2002)

About five years ago the expectations of another technology were tremendous. The automotive industry and knowledge institutes foresaw the hydrogen/fuel cell/electric drive train to be the most realistic concept for future sustainable mobility. Although still mentioned as one of the options the hype around fuel cells is tempered.
No breakthrough for electric mobility happened until now. Which forces are likely to be powerful enough in these times to make this radical change in near future

[1] *Who Killed the Electric Car. Documentary by Chris Paine. Sony Pictures Classics. 2006*

plausible? How strong are the developments and how certain are we about this electric trajectory being an important path towards sustainable mobility?
The success of this kind of transitions is depending of a lot of interdependent variables. Besides the technological developments, the use and behavioural aspects of the potential users, the contextual (natural, build environment and infrastructure) aspects and the governance and business aspects are of all of great importance.
An enormous amount of initiatives in the field of electric mobility are taken recently all over the world. From the perspective of the urgency of making our present mobility more sustainable and the limited resources available (capital, energy, scarce materials) agenda setting is urged.

Recent European developments

In Europe high ambitions are formulated in relation to electric mobility. Different countries are trying to take the lead in the developments (C,MM,N 2009).

- The Government of Ireland announced cooperation with the organisation Better Place aiming at 10% of the national cars to be electric powered by 2020. This means that around 250.000 electric cars will hit the road the coming 12 years. Better Place (USA, Palo Alto) is the world's leading electric vehicle (EV) services provider, catalyzing the transition to sustainable transportation. It delivers services to enable confident adoption and use of EVs. It builds and operates the infrastructure and systems to optimize energy access and use.

Figure 3 Better Place charging point in California (USA)

- Germany is willing to have 1 million electric cars driving around by 2020. Car industry, knowledge institutes and government is working closely together.
- Great Brittan formulated the ambition to become the front-runner in Europe for electric mobility. The British Government promised to allocate 100 million pounds for this recently.
  London will get about 700 charging points. The Olympics to be organized in 2012 will be a demonstration of electric mobility.
- Spain already wants to implement 1 million electric cars by 2014. The Spanish Government agreed with a number of cities to establish a new infrastructure to charge the electric cars. Charging is taking to be place especially in parking estates to avoid a complex adaption of the public road.

- In 2010 the first full electric car will be commercially available in Denmark. By 2020 500.000 electric cars are planned to drive around. This national plan is developed in close cooperation with the organisations Better Place and Renault-Nissan. The introduction of relative large batteries into the electricity grid is attractive for Denmark because of the need for buffer capacity in times of a surplus of wind energy.
- The Portuguese Government is establishing an infrastructure of 1300 charging points. From 2011 on, the whole country should be reachable by electric cars.
- The France car producer Renault is going to concentrate its developments fully on electric mobility. The first full-electric car is to be planned commercially available 2011. Together with the France energy producers and – distributers Renault is setting-up a master plan for a charging infrastructure and also battery swapping stations.
- Norway is producing one a the first commercially available electric cars, the Th!nk. The car got its legal approval recently for the European Community. Th!nk is not just a car, it is a whole mobility concept. As an user you are paying a monthly amount and the batteries are owned by the Th!nk organisation.

Figure 4 Th!nk electric car

These European initiatives are illustrative for the other projects going on in the rest of the world (USA/California, Israel, China, Japan, Australia). For example a big experiment is going on in California with 500 electric Mini's of BMW.

Figure 5 Electric MINI by BMW

The different projects and programs are all initiated and organized by networks of organizations. It is obvious that the transition towards electric mobility cannot be established a single organization. All networks can be characterized as public-private partnerships.

Agenda setting in the Netherlands

Although the Dutch Government was not one of the first in Europe to embrace the transition towards electric mobility, it recently announced an integrated policy plan to foster the development and implementation of electric mobility in the Netherlands (to be launched June 2009).
Before and in preparation to this policy plan a lot of initiative were taken by different coalitions to come to an agenda for research, development and implementation of the electric car in the Netherlands. Why front-running in the Netherlands? The following arguments are of interest;

- The Netherlands is highly dense populated area
    - Having troubles with the air quality (especially in the urban areas)
    - Relatively short travel distances (91% of the car trips are shorter than 150 km/day & 65% even less than 50 km/day)
- High ambitions for the reduction of CO2 (20% reduction by 2020)
- High dependency of oil for transportation
- Organisational power
- Front-runner in decentralized electricity production
- Available financial capital
- Lot of start-up companies related to E-mobility
- 40.000 jobs in research and development in automotive

The challenges for Dutch society is becoming clear to a rapidly increasing number of stakeholders. Several formal and informal conferences, workshops and meetings did try to give an overview of the state-of-the art, to align stakeholders, to start network formation, to influence the national government and formulate action plans for the large-scale implementation of electric mobility[2]. The structure of those meetings was very much alike; keynote speakers, workshops on aspects of electric mobility, prioritizing the actions necessary for the large-scale implementation. The stakeholders attending those events were rather consistent;

- National government (Ministry of Transportation, Ministry of Economic Affairs & Energy)
- Local governments (Amsterdam, Rotterdam, Den Haag, Leeuwarden)
- Energy-producers and –distributers
- Network providers
- Automotive Industry
- Consumer organisations
- NGO's / environmental organisations
- Car Lease companies
- Public Transport providers
- Knowledge Institutes
- Start-up E-mobility companies (charging infrastructure, e-cars, e-scooters, e-bikes)
- Venture capitalists

[2] *D-INCERT meeting March 2009, C'MM'N discussions March 2009, National Platform Electrical Car (NL) meeting April 2009*

- Media (TV, Radio)
- Consultants

Topics addressed in the stakeholder meetings can be categorized according to the following aspects (C,MM,N, 2009): Human, Technology, Context & Infrastructure, Governance & Business models.

Human

The stakeholders see the acceptance of the electric car system by the customers as one of the most important factor in the large-scale implementation. The ease of charging, the maximum range, purchase costs, imago, comfort, safety and electricity prices in the future are all aspects of which the customer is still very uncertain.
Simple substitution of the internal combustion drive train by an electric drive train will need a lot of adaptation of the user for example a different way of 'filling-up the tank' and more well thought planning of the trip.
The switch to electric mobility is also seen as an opportunity for the introduction of new mobility concepts like car-sharing and new lease concepts, other mobility services like chain-mobility but also innovative two- and three wheel concepts. The automotive industry is focused on transportation by car and less by new, other means of transportation. New players in this field are emerging. Knowledge and expertise from other fields is needed.
Involvement of the (future!) user is crucial in order to enhance the public acceptance. A more human-centred approach is needed. An open-source approach looks promising. It not only involves people more, but it also can reduce development costs and it can increase the lifecycle of product parts (Egmond e.a 2009).
Well-guided experiments are needed to research, monitor and evaluate the new and innovative concepts in a realistic situation (living labs).

Figure 6 c,mm,n / open source community on sustainable mobility (Netherlands)

Technology

One of the crucial aspects to accelerate electric mobility is the technology of the batteries (Deutsche Bank, 2008). Important issues are the high costs, long loading cycle and the safety.
Lithium-ion technology is seen as the most promising technology. This technology gives a high range per kilometre, is not toxic. It is still uncertain what large-scale application of Lithium-Ion batteries will mean for the world-resources and the situation in it is extracted. A need is felt to gather data about the long-term 'behaviour' of batteries (load cycles) and power management systems.
Research is needed into other material combinations like for example Zn-Air and ionic conducting liquids.
Batteries are using a lot of space research is suggested to integrate them much more

in the construction of the vehicle. It also can improve the weight distribution of the vehicle.

Four type of charging are distinguished;

- Slow or normal charging (loading time 6-8 hours) is also possible in combination with so-called smart grids. Also the use of the battery as a buffer in the electricity grid (grid to vehicle and vehicle to grid) is possible with this option. People indicated in a recent survey (E-ON, 2009) that home charging is preferred, but less than 50% of the Dutch cars are being parked near the home (CPB, 2009). Solutions have to be developed for slow charging (at night) in public spaces. Vandalism and safety are important factors to manage in those solutions.
- Fast charging (less than 1 hour) is still very expensive and poses high demands on the capacity of the local electricity grid. Research into fast charging technology is of eminent importance.
- Battery swapping requires a high level of standardisation and organisation. The company Better Place introduced the first experimental swapping stations in Japan recently. Still al lot of questions remain about this technique. Standardisation is crucial of course and also the organisational (logistics & financing) aspects around the swapping solution have to be elaborated.
- Range-extenders are small efficient internal combustion electricity generators added to the electric car to make it possible to charge the battery will driving. The R&D activities on range-extenders are still very modest.

Context & Infrastructure,

The electric infrastructure and the way it is integrated in the build environment are important perquisites for the introduction of electric mobility. Urban areas are the most likely to pioneer with electric vehicles. The range of the vehicles also will be limited because of the lack of nation wide coverage of charging facilities. For a widespread introduction this coverage of different kind of charging possibilities like home, work, public spaces and fuel stations is needed to guarantee the usability of the system. On European level standardisation is needed for the charging facilities (BERR, 2008). Recently the car industry and some energy companies agreed upon a standard for the slow charging facilities.
There are still a lot of thing to be defined as for example the ownership of the public energy network and the access of this network for the different suppliers of energy. Cities are developing stimuli for people switching to electric vehicles. It is important to develop policies that are consistent, not discriminating and are long-lasting. Research was suggested in the development of those policy measures.
A lot of uncertainty exists about the capacity of the electricity network. How many electric vehicles can be charged with or without a smart technology? Research is going on this moment on this topic initiated by the energy companies in the Netherlands. The time needed to make the grids smarter is unclear and also who has to pay for it.

Business models

The cooperation of different stakeholders, both private and public, is necessary for the transition to electric mobility. Developing the right business cases is crucial. A lot of uncertainty still exists like the high cost of electric cars and the second-hand value, the long-term developments concerning legislation, taxes and subsidies. The transition to electric mobility will incorporate a reshuffling of the cost- and benefits in

the whole chain. The benefits are sometimes difficult to express financially like reduction of emissions, noise and independency of oil. Innovative public-private partnerships have to be developed as a base for new business models.
The government can play different roles. A clear long-term policy on taxes, subsidies is essential. The public entities can act as lead-users. The announced subsidy program on field experiments has to deliver not only the knowledge on the technological functioning of the electric mobility, the acceptance of the users but also on the different options of business models.

Discussion

This paper gives an overview of the recent discussion on the implementation of electric mobility in the Netherlands. The different workshops & conferences showed a consensus on the research & development topics to address for speeding-up the transition towards electric mobility. The Netherlands has the potential to become an important test area for electric mobility. Focus and coordination is essential to cash in these potentials. The Dutch Technical Universities (3TU) took the initiative to launch a knowledge network on electric mobility, called D-INCERT to stimulate the knowledge development, -application and transfer needed for the transition towards electric mobility (www.d-incert.nl).

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