Practical Infrastructure Development For Electric Vehicles In Brussels Capital Region.

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1 Abstract

Electric vehicles present a considerable potential for use in urban areas. In urban traffic, due to their beneficial effect on environment, electric vehicles are an important factor for improvement of traffic and more particularly for a healthier living environment. The electric vehicle makes use of energy sources which make it particularly suitable for use in urban and suburban areas.
As of today however, electric vehicles are only found in a limited number of applications, mostly in captive fleets of government administration. In order to allow to extend the number of electric vehicles to a number which reflects the electric vehicle's technical possibilities, the market must be opened, as to lower, through larger-scale production, the selling price of the vehicle to a level which can appeal the average user.
On the other hand, publicly accessible charging infrastructures are to be developed, as to allow the electric vehicle to be supplied with energy at locations away from their home base, making the electric vehicle more flexible and attractive.
The initiative to deploy such infrastructure lies largely in the hands of the local authorities.
This paper describes a proposition to deploy a network of charging stations in the Brussels Capital Region. [1] Taking into account the experiences already accumulated on foreign locations, the technical developments in the field, particularly concerning standardisation, accessories have been selected and thirty locations in the Region have been identified, taking into account mobility needs and the integration of mobility policies towards local authorities.
Furthermore, practical experiences with electrically powered vehicles in the Brussels Capital Region are described.

2 Keywords

battery charge, conductive charger, city traffic, infrastructure, promotion

3 Electric Vehicles and the Environment.

The problems of mobility, traffic and environment represent one of the biggest challenges that confront today's cities. The era of cheap oil is coming to an end; considerable price increases are expected by 2010. The need to use alternative energy sources is arising; the use of electricity is an optimal alternative since it can be obtained from different primary energy sources, being generated and consumed with a very high efficiency and with a low impact on the environment.
An electric motor has a much higher efficiency than its internal-combustion counterparts and thus uses much less energy, even taking into account the energy cost of generating electricity. Electric vehicles can use up to 75% less direct and indirect energy compared to gasoline vehicles, depending on the way electricity is generated.
Furthermore, the largest attractiveness of electric vehicles is that they do not emit any exhaust gases. The introduction of electric vehicles will lead to a considerable reduction of noxious emissions in the atmosphere, even taking into account the emissions of electricity generation.

In the framework of the "Clean Vehicle" project, performed by the Brussels Universities VUB and ULB and commissioned by the Brussels Institute for Management of the Environment (BIM-IBGE), [2], several types of vehicles were compared through the establishment of an "ecoscore", quantising the environmental impact of these vehicles.

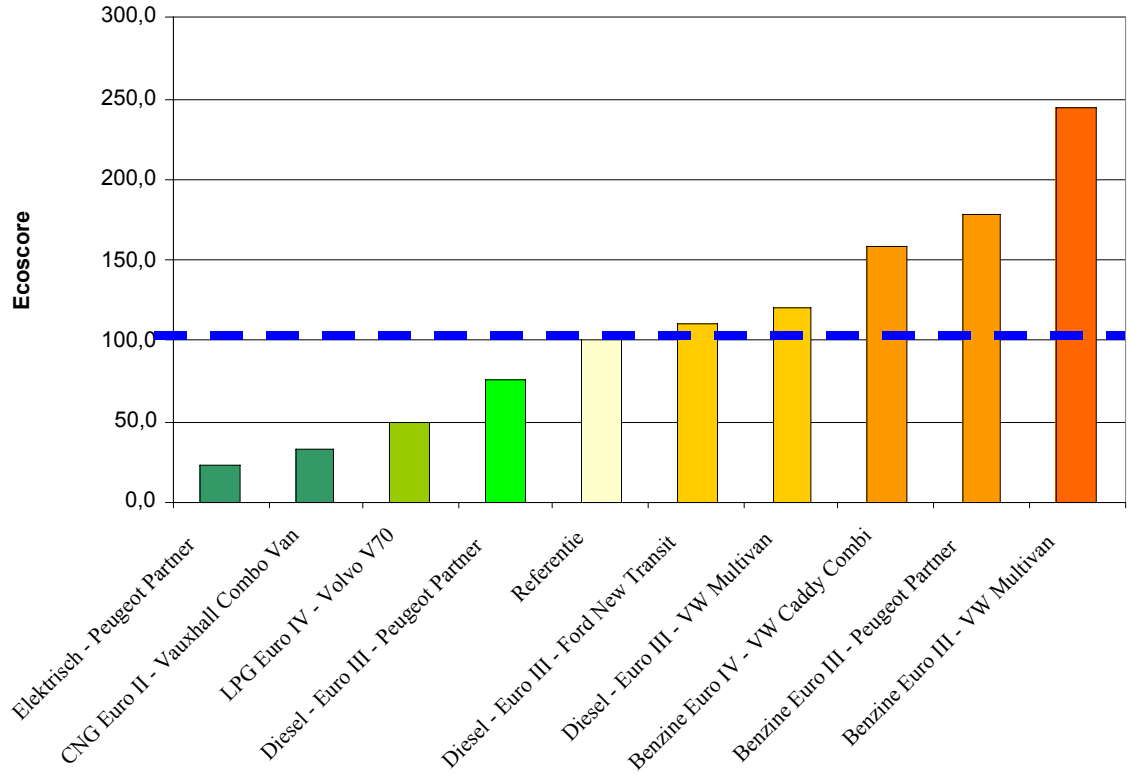

Figure 1: “Ecoscore”

The electric vehicle scores best of all, with an ecoscore of 25 (Figure 1).

Finally, electric vehicles generate much less noise than internal-combustion engined vehicles.

The purchase price of electric vehicles is still high today, which is mainly due to low production volumes.
Taking into account the very low energy consumption cost, electricity can be as cost-effective as diesel however, when a distance of at least 10.000 km is covered yearly.

4 Charging Infrastructure

Electric vehicles need access to charging infrastructure, which can take different forms:

- Using conventional socket-outlets (“mode 1”)
- Using conventional socket-outlets with an in-cable protection device (“mode 2”) – the use of this mode is not relevant for Europe and has thus not been taken into account in this study.
- Using dedicated socket-outlets for electric vehicles, incorporating additional safety measures such as a “pilot contact” (“mode 3”)
- Using an external (fast) charger with DC connection (“mode 4”)

Charging stations to be deployed on the public highway shall be “mode 3” only. This mode in fact presents very high safety features: the outlet will only dispense current to an electric vehicle which is correctly connected, and if no vehicle is present, the socket-outlet is dead.
The network of charging stations may be completed with a limited number of fast charging stations, which can be used in emergency situations, besides offering a psychological support easing the acceptance of the electric vehicle by the user.

The proposal is limited to infrastructures for conductive charging, since these are the most widespread and allow easy compatibility with the whole range of vehicles on the European market. Inductive charging is rather pursued for specialist fleet applications.

5 The Brussels Capital Region

The Brussels Capital Region (B.C.R.) is one of the three regions that constitute the federal state of the Kingdom of Belgium. It is an urbanised area extending over 161 km^2 with a population just under one million. The Region is constituted of 19 communes, the city of Brussels proper being one of them.
Under the Belgian federal government system, the B.C.R. has its own parliament and government which is competent for matters like urban planning, environment, housing, economy, energy supply, public works, transport, public sanitation and external relations. Person-related matters like education and culture however are covered by the governments of the Flemish and French Communities.
The B.C.R. is a key centre for administrative (Belgian Federal Government, Brussels Regional Government, Flemish Regional Government, and also European institutions), educative (several universities and higher education establishments), cultural and industrial functions. This means that it is also a major traffic centre and transport hub with a large influx of goods and passengers. The B.C.R. is served by all traffic modes: road, rail (with connections to the high speed network), air (through the nearby Zaventem airport) and water (with a sea canal allowing access to coastal vessels).
Traffic and transport problems in the B.C.R are stringent, mainly due to the large influx of commuters for Brussels' administrations. Total employment in the B.C.R. is 632000, of which 347500 commute in from outside the area. Car use is still large (73% of displacements to work) and the B.C.R. Government has devised several studies and action plans, to overcome the traffic and congestion problems present. The main strongholds of these actions include, among others:

- Improvement of public transport, including the creation of a regional express rail network extending about 30 km beyond the borders of the B.C.R., in order to control car access by commuters
- Promotion of bicycle use (which is now very low in B.C.R.) through the creation of a network of bicycle routes throughout the area.
- Measures in the field of goods transport, such as the promotion of waterborne transport and the creation of distribution centres.

6 Proposed Locations for Charging Infrastructure in B.C.R.

6.1 Service Vehicles

A number of electric vehicles are used by administrations such as the Fire Brigade. These vehicles are normally charged in their depots, and charging can be performed using "mode 1" here without problems.
It is advisable however to make use of accessories (plugs) which are compatible with the accessories to be used in the public charging infrastructure, as to allow easy access of the vehicles to existing infrastructures all over the Region.
The deployment of fast chargers in vehicle depots has been envisaged; experiences from existing fleets show however that these rather expensive devices are rarely used when the vehicles are properly deployed on the type of missions for which they are intended, and when due care is given to battery charging and management.

6.2 Publicly Accessible Infrastructures

The deployment of publicly accessible infrastructures is a key element in the public promotion of electric vehicles. A first proposal for the Brussels Capital Region involves about thirty locations for implanting charging stations.

- Eleven locations in key activity zones and transit points where high electric vehicle activity can be expected
    - A. The *city centre* or downtown area, near the Central Station where the main activity poles are tourism, shopping, entertainment, government offices. An on-street charging station could be beneficially built on a high-visibility location as a policy dissemination measure.
    - A' The *uptown* area (Porte de Namur), a premier shopping and business district
    - B. The *North station area*: regional administration, business offices and a key transport hub.
    - C. The *South station area*: the main railway station in Brussels, on the high-speed network
    - D. The *European quarter*: seats of the European institutions, and high-visibility area for policy demonstration
    - E. The *South-east* quarter (Elsene-Ixelles), with its universities and business centres
    - F. The *Woluwe* area, with a concentration of new business developments and an academic hospital
    - G. The *North-east* area (Evere), in the direction of the airport
    - H. The *Heizel*, a focal point for leisure activities and the exhibition centre
    - I. The *West* (Jette) , with its medical campus and transit functions close to the main ring road
    - J. The *South-west* area (Anderlecht) with another major hospital centre and business area

- Twenty locations in residential areas, (marked "R") typically located near the town halls of the 19 communes of the B.C.R. (including one in the former commune of Laken which is now merged with the city of Brussels). For the city of Brussels, a residential location in the west of the old city has been chosen, as the city hall area is not residential and is already served by station A. These are also aimed at those private users who do not have access to a private garage.

A schematic overview of the proposed charging stations is given in Figure 2.

The possibility of installing charging points in existing multi-storey car parks has also been taken into account. The interest of the main car park operator in Brussels (Interparking) to participate in such a project was very limited however.

Concerning the fast charging stations, two potential locations have been identified, in the north-western area of the Region (Heizel) and in the south-east (Delta).

6.3 Choice of Infrastructures to be Deployed

6.3.1 Plugs and Sockets

The choice for "mode 3" charging imposes the use of special accessories with an additional contact for the pilot conductor. Two products which are available on the European market: the Italian "Scame" plug and the German "Mennekes" plug. Both accessories comply to the standard for industrial plugs IEC 60309-1; the Mennekes plug presents the additional advantage to be compatible with IEC 60309-2, allowing charging (albeit in "mode 1") at the popular "blue industrial" socket-outlets. The Scame plug presents a particularly compact and lightweight design. These two products are now being investigated by VUB as to their operating characteristics such as user friendliness and durability

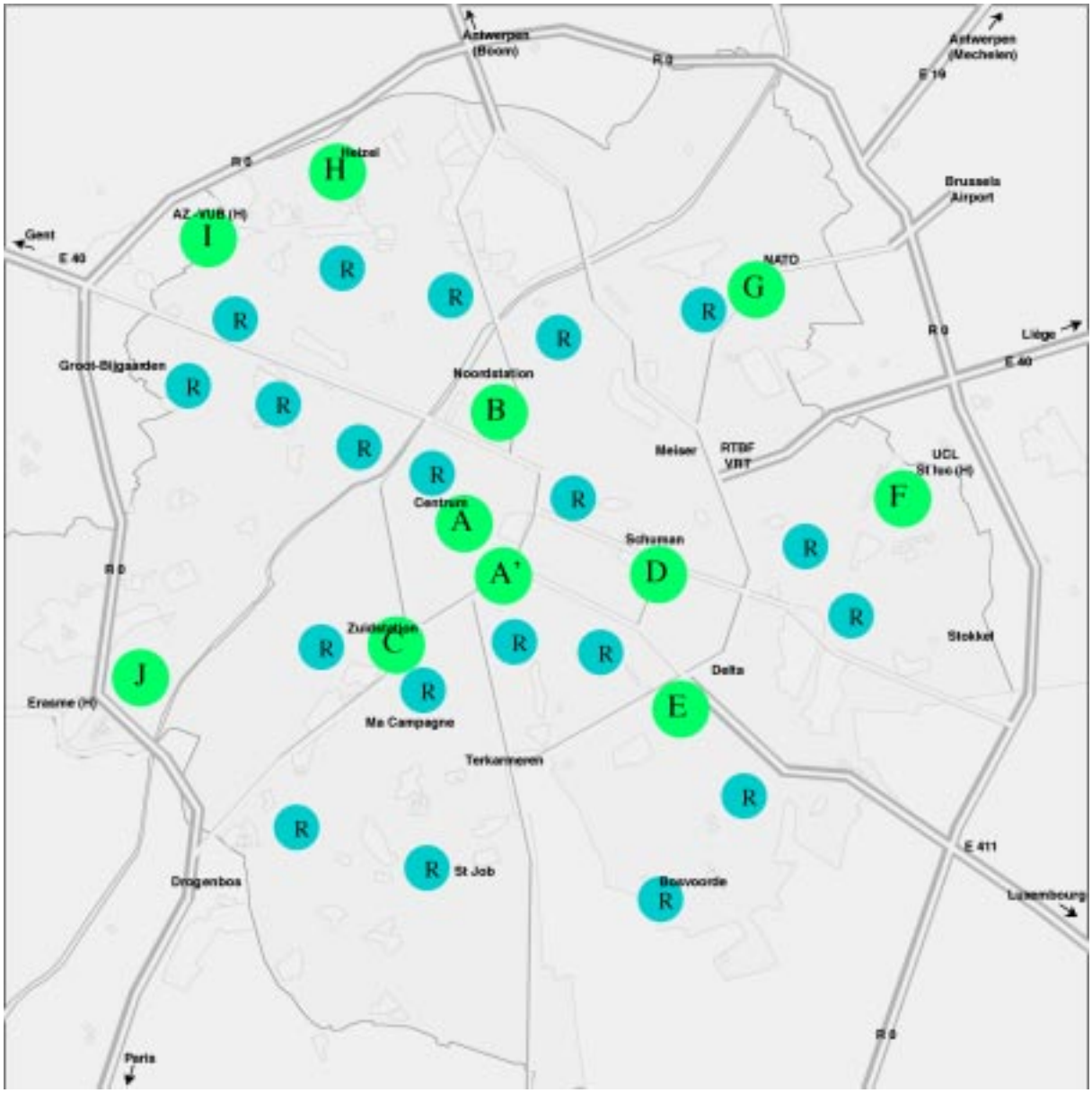

Figure 2: Proposed locations for charging infrastructures in Brussels Capital Region

6.3.2 Charging Posts

The infrastructures to be deployed on the urban thoroughfare must be integrated of course in its urban environment, being a kind of "urban furniture". Furthermore, they must be strong enough to withstand collisions with vehicles and acts of vandalism.

The use of standard plastic cabinets is generally not accepted by local authorities, these being considered as unaesthetic.

Steel posts for electricity distribution are offered on the market; these devices are strongly built, have an acceptable aspect and are specifically provided to allow the passage of a cable even in closed and locked position.

It is foreseen to equip each charging post with two "mode 3" socket-outlets rated up to 32 A, thus allowing semi-fast charging. The switchgear to be implemented for each socket-outlet consists of:

- An automatic circuit breaker to protect against short-circuits and overcurrents
- A residual current device for the protection of personnel

- A control pilot monitor which allows the socket-outlet to become live if an electric vehicle is correctly connected, and which monitors the continuity of the protective earth conductor.

The complete price of such a charging post amounts to € 4.300 to € 5.600, connection to the grid included.

As for the fast charging stations, these are offered on the market at a price of € 41.375 each, connection to the grid included.

6.4 Payment Systems for the User

6.4.1 Forecast Electricity Consumption

The electricity consumption of the charging posts can be forecast based on experiences in other countries like Switzerland or France; it varies from 2 kWh to 11 kWh per day and per socket-outlet.

It seems advisable here to negotiate a fixed cost per charging post for the electricity consumption with the electricity utilities (also taking into account the Belgian situation that local authorities are involved with electricity distribution). This way, it is no longer necessary to provide an electricity counter in each charging post, allowing a more slender design of the post, which is less obtrusive and less expensive.

6.4.2 Payment for the User

The preferable solution for the implementation of a payment system will have to take into account the cost of the system itself in function of the expected revenue. Due to the relatively low value of the electric energy consumed during one charge (one hour of charging, at normal daytime rates, consumes about 3 kWh, worth € 0,50), the implementation of a specific payment system will often not be justifiable.

6.4.3 Payment with Cards

The use of the "Proton" card for payment has been considered. Proton is an electronic purse which has a widespread use in Belgium, the Proton chip being present on virtually every banking card. The implementation of Proton would however cause the charging posts to become very expensive (€ 16.000 for a post with two socket-outlets, i.e. three times the price of an equivalent post without payment system). The extra cost is mainly due to the extra "intelligence" to be provided in the post for the control and the communication with the Proton terminal. This extra cost can never be recuperated by generated revenue. The implementation of such a system can thus not be justified.

6.4.4 Integrated Tariff

An integrated, fixed tarification seems the most advisable solution.
In order to contribute to the realisation of an internationally integrated network, it has been proposed to join the international Park&Charge network, which has its roots in Switzerland and is also established in Germany and Austria.
In this system, all charging posts are accessed using a common key which is distributed to all EV-users who subscribe to the system.
Payment is done through a vignette put on the vehicle's windscreen. For a four-wheel electric vehicle, this vignette costs € 67,55 per annum. This price, which is common to Park&Charge organisations in all countries, is based on the average use of the public charging infrastructures.
The system is managed through an autonomous local entity, in collaboration with Park&Charge in Switzerland. This entity is responsible for the management and maintenance

of the system, and for the local management of the members in Belgium (distribution of keys and sale of vignettes). It is financially fully independent of Park&Charge organisations in other countries.

7 Analysis of E.V. Use in the B.C.R.

At this moment, the number of electric vehicles in use by administrations in the Brussels Capital Region amounts to about seventy units. Some of the most significant users are described here.

7.1 Fire Brigade

The largest fleet of electric vehicles in B.C.R. is used by the Brussels Regional Fire Brigade: 29 vehicles of the types Peugeot 106 and Peugeot Partner.
These vehicles are part of the service vehicle fleet: they are not used for interventions, but find their application in general service such as control visits to buildings and the like.
The average cost of their use, inclusive of depreciation and maintenance, is € 0,4372 per km.
The electric vehicles are generally positively appreciated by the users, their performances being considered equivalent to small gasoline cars. They are considered as "ideal second family cars".
The silence of the vehicles is appreciated in particular.
It can be said that the electric vehicles fit the needs of the Fire Brigade for general service vehicles; the main objection however is their high purchase cost. If this would be lower, the use of such vehicles would be generalised to all missions for which they are fit.
Problems cited with the use of the vehicles are on one hand related to battery conditions and range (these are mainly due to the short distances covered per day, and can be remedied by a sensible management of battery charging), and on the other hand with auxiliary components such as combustion heaters.

7.2 Cabinet Secretary of State Delathouwer

The Cabinet of Secretary of State Robert Delathouwer, who is responsible for Mobility, has a small fleet of electrically driven vehicles available.
The users are generally pleased with the performances and the range of the vehicle. The fleet also consists of electric scooters and power-assisted bicycles, which prove to be very popular for short displacements in the city.

7.3 Sanitation Department

The regional sanitation department "Net Brussel" has 7 electric scooters and 2 small electric bins available.
The scooters were initially intended for the service of the brigadiers; this personnel showed a lack of motivation to drive these vehicles however. Nowadays they are mostly used by the central office, where they don't show any problems.
The experiences with the small electric bins have been generally positive.

7.4 Municipalities Services

Electric vehicles have been purchased by a number of communes in the B.C.R., who use them for business displacements on their territory. The experiences with these vehicles have been generally positive, as for extending the fleet, the administrations are however facing the limitations of the market.

8 Advices for Optimal Use of the Material

It is clear that the electrically powered vehicles which are present on today's market are fit to perform a considerable number of missions; in order to get the best results it is necessary however to follow up a number of simple recommendations, which can be summarised as follows, and which reflect the experience of several demonstration programmes in the field [3]:

- **Know your route!** The electric vehicle is a premier performer for heavy-duty urban service. Such routes however are completely different from more usual types of journey, and the energy consumption will be accordingly higher.
- **Drive your vehicle!** A regular or daily use of the vehicle leads to optimal utilisation and therefore lower energy consumption. Batteries are not meant to be left alone; furthermore, a stationary vehicle has no contribution whatsoever to energy, emission or mobility issues.
- **Charge your batteries sensibly!** Good charging practices optimise energy consumption and preserve the batteries. Opportunity charging has energetic benefits when limited to more or less 80% fullcharge, while frequent full recharging after small trips (f.i. shorter than 50% of the battery range) increases energy consumption levels.
- **Follow up your energy consumption!** In fleet operations, regular logging of vehicle performance and consumption is a critical management tool to allow optimisation of electric vehicle use.
- **Motivate your personnel!** The human factor remains a key element in the success of any project. The personnel in charge of operating the vehicles must be properly instructed and motivated to use them properly, otherwise the chances of success are limited.

An information session for those administrations which are using electric vehicles or which are interested in them has been organised to inform personnel about the electric vehicle technology and the related infrastructures. On this event, an overview of the technology of electrically driven vehicles and of their infrastructure has been presented, and the advices for optimal use have been explained as to their practical implementation.

9 Acknowledgements

The research activities underlying to this paper have been performed within a research project performed by the Vrije Universiteit Brussel, Department Electrical Engineering and Energy Technology, on behalf of the Brussels Capital Region. [1]

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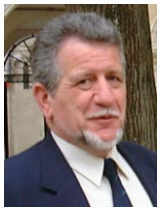

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