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CITELEC – electric vehicles on the move in Europe's cities

P. Van den Bossche, G. Maggetto and M. Liccardo
CITELEC, Pleinlaan 2, 1050 Brussels (Belgium)

Abstract

Today, urban areas are faced with major environment- and traffic-related problems. Electric vehicles are able to bring a contribution to the solution of these problems; currently available electric vehicles are well suited for the typical speed and range characteristics shown by cars and vans operating in towns and cities. Cities are thus likely to be the first large-scale operation theatre for electric vehicles, whether for municipal use, for public transport or as private vehicles. A growing number of European cities are united into CITELEC (European association of cities interested in electric vehicles) to study the opportunities for the introduction of electric vehicles, to share common experiences and to follow up developments. CITELEC informs and assists its members in the introduction and exploitation of electric vehicles; furthermore, it is organizing realistic test demonstrations of electric vehicles in urban traffic ('Twelve Electric Hours') and performs studies on different aspects of the introduction of electric vehicles in cities: user's requirements, battery charging, energy distribution, infrastructure, safety aspects, and others. The paper will present the Association and its activities, focusing on current and future developments in European cities.

Introduction

In today's cities and urban communities, quality of life is going down rapidly, due to several kinds of pollution caused for an important part by automobile traffic. Motor vehicles have become the biggest obstacle to clean air in cities. Road traffic has shown many disadvantages for the environment: directly measurable influences like air and noise pollution, but also many side effects like traffic hazards, traffic congestion which can ultimately destroy the intended mobility, losses of time, parking problems and visual pollution. On the other hand, the motor vehicle has become an important part of our lifestyle: a city that wants to live should keep rolling on and its traffic flows are its vital arteries.

Different solutions to this problem have been presented. The use of electricity as an alternative fuel is the most promising step in the right way. Electric vehicles could be an essential and inevitable part or our life in the future. Electric vehicles cause no pollution during their operation. They are quiet, fun to drive and easy to maintain. They are also more efficient in their use of energy and allow a greater independence in the choice of primary energy sources.

Electric vehicles in city traffic

Even with the advanced battery and drive technology available today, electric vehicles are still considered as slow performers with limited range. This deters many

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potential users. It is necessary to take a clear look at the real requirements for urban vehicles.

Actual vehicle use

A study performed in the framework of the Brussels Universities' Electric Vehicle Experiment [1] included a survey of displacements for business reasons inside the capital region of Brussels. It showed that most trips were no longer than 10 to 15 km. This was confirmed by the displacement pattern of electric vehicles rented out for urban trips during this experiment. Similar results for other cities were gathered by a CITELEC study among European city administrations [2]. In many cases, for vehicles used in urban areas, the daily mileages do not exceed 50 km. The average speed obtained in cities are also very low; in many towns, the commercial speed does not exceed 20 km/h, and things are getting worse each year.

For private cars, similar results are obtained. A German study [3] shows that only 2% of all displacements with cars is actually exceeding 50 km, and that three-quarters of the displacements are shorter than 10 km.

Electric vehicle performances

These actual data should be compared with the performances of today's electric vehicles. To this effect, CITELEC is organizing, on a regular basis, test demonstrations called the 'Twelve Electric Hours'. In these tests, electric vehicles are operated in conditions close to real life: on city streets, in daily urban traffic. The vehicles drive around during two 6-hours periods, with charging stops when needed, and the covered distance and energy consumption are measured.

On the last 'Twelve Electric Hours', which was held in Namur, Belgium, in September 1991 [4], several electric vehicles were able to cover distances largely sufficient to cover most transportation needs in urban areas. The results of these 'Twelve Electric Hours' are given in Table 1.

Battery technology

The best absolute performances in these demonstrations were delivered by advanced battery systems: nickel–cadmium, sodium–sulfur, zinc–bromine. Such batteries, however, not always represent a practical solution: they are very expensive, and the newer types such as sodium–sulfur or zinc–bromine are only available as precommercial prototypes.

The most widespread battery is thus still the lead/acid battery. This venerable power source is still offering excellent value for urban use, some vehicles being able to cover over 120 km on one charge. Lead/acid traction cells are affordable, and being a proven industrial product, they offer good reliability. The evolution of the lead/acid technology, however, is not at its end, and better performances are expected in a near future.

In many cases, the sealed, maintenance-free battery is used. This type is in fact much easier for the user, though still more expensive in purchase and shorter in cycle life.

The most popular cell for small and medium road vehicles is the 6 V monobloc, with capacities from 160 to 200 A h. Due to its low height, this battery is easy to install, especially in converting existing vehicles. Choosing one specific cell size for a vehicle, however, restricts the flexibility in adapting the battery capacity to the required range and payload.

TABLE 1

Results of the '12 Electric Hours' of Namur, Belgium

No	Vehicle	Battery	Charge	Weight[a] (kg)	Running time (h)	Stop time (h)	Distance (km)	Energy (kW h)	Consumption (kW h/km)	Specific consumption (kW h/t km)	Average speed (km/h)
1	VOLTA	Pb	normal	1270	9:07	2:53	185	36.10	0.20	0.15	20.29
2	ELCAT	Pb	normal	1250	12:00	0:00	245	54.60	0.22	0.18	20.42
3	Fridez Pinguin 4	Pb	normal	770	8:45	3:15	172	31.75	0.18	0.24	19.62
4	MTC SURYA	Pb	change	1330	11:35	0:25	256	84.55	0.32	0.24	22.13
5	VUB PGE TM	Pb	normal	1470	7:27	4:33	150	65.05	0.43	0.29	20.09
6	SEA Fiat Panda	Zn–Br	normal	1060	11:42	0:18	254	77.40	0.31	0.29	21.70
7	VOLTA	Ni–Cd	normal	1120	10:53	1:07	244	56.60	0.23	0.21	22.38
8	NEC MELEX	Pb	normal	370	7:24	4:36	105	13.90	0.13	0.35	14.21
9	NEC MELEX	Pb	normal	370	10:38	1:22	154	22.60	0.15	0.39	14.48
10	MTC SURYA	Pb	normal	1170	8:43	3:17	176	34.30	0.19	0.17	20.16
11	VUB PGE 3P	Pb	normal	1170	6:52	5:08	141	51.45	0.36	0.31	20.49
12	Fridez Tavria	Pb	normal	1185	8:08	3:52	159	60.90	0.38	0.32	19.53
14	Hercules bicycle	Ni–Cd	change	105	6:21	5:39	103	0.95	0.01	0.08	16.20
15	NEC MELEX	Pb	normal	370	10:27	1:33	157	22.65	0.14	0.38	14.98
16	VW transporter	Na–S	normal	2200	11:59	0:01	258	106.10	0.40	0.18	21.54
17	MTC moped	Pb	change	160	11:52	0:08	242	15.37	0.06	0.39	20.40
18	PASQUINI BOXEL	Pb	normal	1070	0:54	11:06	17	9.00	0.52	0.49	19.09
19	SCHOLL Optima	Ni–Cd–Pb	change	670	11:46	0:14	267	53.85	0.20	0.30	22.66
20	Renault Master	Ni–Cd	normal	3070	10:19	1:41	230	137.10	0.59	0.19	22.30
No	Vehicle	Fuel	Charge	Weight[a] (kg)	Running time (h)	Stop time (h)	Distance (km)	Energy (l)	Consumption (l/km)	Specific consumption (l/t km)	Average speed (km/h)
21	ICE VEHICLE	Petrol		845	11:44	0:16	254	30.5	0.12	0.14	21.61
22	ICE VEHICLE	Diesel		1800	11:57	0:03	256	45.0	0.17	0.10	21.41
23	ALTROBUS	Pb	(Hybrid)	13000	[b]	[b]	186	73.0	0.39	0.03	[b]

[a]70 kg added for weight of driver.
[b]Vehicle participating outside competition.

Electric vehicle potential

How can the electric vehicle deployment potential be quantified? The major European COST 302 (technical and economical conditions for the use of electric road vehicles) study [5], which was performed in the mid-eighties, put forward a penetration potential of 7% for cars and 12% for vans. Today, such figures can be considered as rather conservative. In our case, we would rather put forward a penetration potential of not less than 30% for both cars and vans. This takes into account the typical use of business vehicles on one hand, and the fact that second family cars are likely to be electrified on the others hand. These 30% represent an important share of the market. This market, however, is to be built up gradually. In some references, the penetration potential for electric vehicles in city centres is estimated to be over 80% [6].

Influence on energy consumption

Internal combustion engine vehicles filling their tanks and electric vehicles charging their batteries are using different kinds of energy. To compare them, we should consider the primary energy consumption.

Let us consider a typical petrol–engined car, with an average fuel consumption of 8,5 l/100 km, which is quite an acceptable value in urban traffic. This amount of fuel has an energy content of 306 MJ. Taking into account the efficiency of petrol refining and transport, which can be estimated at 90%, we obtain a primary energy consumption of 340 MJ.

An equivalent electric car on the other hand takes 28 kW h/100 km out of the grid. This value is typical for a medium-sized car in city traffic. This 28 kW h corresponds to 100 MJ. The average efficiency of electricity generation can be estimated at 36%; we obtain a primary consumption of 277 MJ.

This value is significantly lower than the petrol car; this is mainly due to the poor efficiency of the internal combustion engine, in particular the petrol engine. Diesel engines, due to their higher efficiency, would show better values and come on a par with the electric. Furthermore, the primary energy for electricity generation can be obtained from many different energy sources, making the electric vehicle less dependent from one energy supply. One can see, however, that a large amount of energy is still lost during electricity generation. The use of small, combined heat/power generation groups where the waste heat can be used for different heating purposes, for example heating buildings or swimming pools, can raise the total thermal efficiency of the generation process to about 80%. Installations of this kind are already being used extensively, for example in the Netherlands and Denmark.

The previously mentioned 30% of cars and vans to be electrified represent a considerable number of vehicles: what will be their influence on national energy consumption? The following data take into account the Belgian situation. Suppose that all cars concerned are running on lead-free petrol. The total consumption of petrol would be lowered by 34%. Supposing that all vans use diesel engines, the total consumption of diesel oil would bw lowered by 4%. Electricity consumption would rise by an average 7%; this figure reflects today's electric vehicle technology; using new, more efficient technology it could go down to about 4%. Taking into account that battery charging will mainly be done overnight, when cheap excess power is available, this demand can be coped with by the existing base power stations.

The wholesale introduction of electric vehicles requires an adequate distribution infrastructure. Charging stations should be designed for maximal energy efficiency and user comfort. Smart chargers with integrated communication systems can monitor the battery and adapt their characteristics to the type and particular state of each connected battery. Connecting a vehicle to its charger still requires a physical intervention from the driver; the use of inductive charging systems allows to get rid of this manipulation. The billing and accounting of electric energy used for electric vehicle charging has to be considered in particular. The main charging of the battery is usually done overnight, at cheap off-peak rates. Opportunity charging during the day takes place at the full rate, of course. In certain areas, the use of electric accumulation heating has been advocated by electricity suppliers as part of their peak-shaving strategy. Power for heating is offered at a very low rate, but its access is remotely controlled to suit the supplier's load dividing policy. This principle could also be applied to electric vehicle charging. The introduction of remote billing systems is particularly useful when considering automatic rent-a-car systems with electric vehicles; such systems can bring a solution for different traffic problems in cities.

Environmental aspects

Electric vehicles are 'zero emission vehicles': the electric vehicle emits no exhaust gases whatsoever. On the place they are used, they contribute in no way to air pollution. The production of electric energy, however, has of course its impact on the environment. The calculation of this impact should be done taking into account the particular production mix in the country concerned.

Different studies [5–7] have been performed about this subject. It comes out that in Europe the emissions of the major pollutants (carbon dioxide, sulfur dioxide, nitrous oxides, hydrocarbons, dust particles and carbon monoxide) are decreased compared with internal combustion engined vehicles, except for sulfur dioxide. This is due to the sulfurous coal still used for electricity generation in Europe. In modern coal-fired power stations, however, sulfur emissions are actually being reduced by flue treatment and by switching to coal containing less sulfur.

It can thus be said more than ever that electric vehicles are bringing a considerable contribution to the improvement of the urban environment.

CITELEC

Today more than ever, saving the quality of our living environment is considered as an essential concern for our life. The management of the environment is a major task for local authorities such as city or town administrations. They need objective appraisal of the actual possibilities of electric vehicles as a means of transport, and of the improvements the technological evolution could give them. To offer cities and towns the necessary support for electric vehicle development, CITELEC, European Association of cities interested in electric vehicles, was founded in 1990 under the patronage of the European Community. CITELEC's aim is to study the environmental, administrative and economic aspects of the introduction of electric vehicles, to develop demonstration programmes for electric vehicles, and to promote new development projects. Active membership of the Association is open to all towns and cities in Europe; other institutions and firms may become associate members. Today, 40 cities of over 10 different countries have joined CITELEC.

CITELEC is a European Association; its action will complement other European actions in the field of electric vehicles. The action plan of CITELEC could be summarized as follows:

Information actions. Many potential users of electric vehicles are unaware of the opportunities modern electric vehicles can offer them. CITELEC provides documentation on the electric vehicle as a product, highlighting nonpolluting aspects and giving potential users a better knowledge. The experience of cities already using electric vehicles is also a valuable information source to be exchanged. CITELEC can also provide manufacturers with a clear definition of user requirements, as to develop the market. The electric vehicle being something quite different from a conventional vehicle, the attitude and behaviour of the user needs to be adapted: to this effect, CITELEC assists cities with user training. A good preparation of fleet management, energy management and servicing will allow the economic operation of electric vehicle fleets in cities.

Demonstrations actions. CITELEC is organizing, on a regular base, demonstration actions following the 'Twelve Electric Hours' formula mentioned before.

Studies. Furthermore, the Association also performs studies concerning different aspects of electric vehicle introduction: traffic organization, use patterns of city vehicles, safety and security aspects of electric vehicles and their infrastructures, etc.

Conclusion

Electric vehicles could become the mainstay of urban transport in the twenty-first century. Their introduction in cities will allow the improvement of quality of life and the development of new markets. The association CITELEC aims to promote this introduction by uniting local authorities as prime actors in urban transport policy.

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