THE "TWELVE ELECTRIC HOURS" COMPETITION: A GOOD WAY TO EVALUATE ELECTRIC VEHICLES IN CITY TRAFFIC

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ABSTRACT

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.
To this effect, CITELEC is organizing test demonstrations called "12 Electric Hours". The purpose of the "12 Electric Hours" is to demonstrate that electric vehicles are able to be integrated in urban traffic and that they offer an adequate solution for urban traffic problems.

THE TWELVE ELECTRIC HOURS OF NAMUR

The fifth "12 Electric Hours" took place in Namur, Belgium, on 27-28 September 1991, hosted by the City of Namur, Electrabel and ASBE (Belgian section of AVERE) and, of course, CITELEC.

PARTICIPANTS

Twenty vehicles, from bicycles to vans, participated to the "12 Electric Hours". Two internal-combustion engined vehicles (N° 21 and N° 22) participated for comparison.

The City of La Rochelle presented two "Volta"'s, a typical all-electric small van. N° 01 came with a lead-acid battery, while N° 07 was nickel-cadmium fitted.
The Finnish "Elcat" N° 02, presented by "Imatran Voima Oy" is a converted IC-engined "Subaru" van, powered by a lead-acid battery.
The Dutch company MTC presented its "Surya" electric car, a converted "Yugo", in two versions: N° 04 was fitted with a special battery trailer to allow quick battery exchange, while N° 10 came without this equipment.
SEA, from Austria, presented its Zinc-Bromine battery in N° 06, a converted Fiat Panda.
Two vehicles were presented by Fridez of Switzerland: N° 03, a "Pinguin 4" small city vehicle, and N° 12, a "Tavria" passenger car. These vehicles are actually assembled in Hungary.
N° 19, a small city vehicle presented by Scholl of Switzerland, was the only vehicle fitted with an asynchronous motor. It also featured a Nickel-Cadmium battery and exchange facilities.
The "Boxel" van N° 18, presented by Pasquini of Italy, came with an unusual but interesting tubular steel body. Unfortunately this vehicle was struck by a mechanical failure after four laps.
The Vrije Universiteit Brussel presented two vehicles from its fleet: N° 05 and N° 11.

These vehicles, built in 1979, can be considered as early examples of electric vehicles featuring power electronic control systems.

Two larger utility vehicles participated in the "12 Electric Hours".
N° 16, a Volkswagen transporter presented by ASNE, the Dutch section of AVERE, was, most interestingly fitted with a Sodium-Sulphur battery.
The Renault Master van is a regular guest on the "12 Electric Hours". N° 20, fitted with Nickel-Cadmium batteries, was presented by the City of Châtellerault.

Small electric vehicles may have less visual impact than buses or large vans, but they may be very useful for various missions.
N° 08, N° 09 and N° 15, presented by "Namur Electric Car", Belgium, are "Melex" golf vehicles of a classic and well-proven design.
In N° 14, a "Hercules" bicycle presented by the Technical University of Berlin, the electric propulsion is to be considered as "auxiliary": it completes the "human" power delivered at the pedals!
N° 17, the Dutch "Vidyut" presented by MTC on the other hand, came as a full electric-powered moped.

The "Altrobus" (N° 23), a hybrid city bus presented by Genova Ricerche, Italy, participated outside the competition, but was able to show some of its interesting features.

The presented vehicles offered a good overview of the current electric vehicle technology. More particularly, all important battery types currently available (Pb, Ni-Cd, Na-S, Zn-Br) were present.
It is interesting to note however, that the "traditional" traction systems (lead-acid battery and direct-current motor) are still the most prolific. They represent indeed a simple, proven and reliable technology, whereas the newer, more performant solutions (new batteries, AC motors, …) are mostly more expensive and may show the teething problems inherent to new technologies. It can be foreseen however that these new solutions will gain a bigger market share in the future (let's look forward to the next "12 Electric Hours" for that).

RESULTS

Table I shows the complete results, divided per vehicle category. In each category, vehicles are listed in starting number order.
The "12 Electric Hours" are not strictly to be considered as a "race". Anyway, the covered distance and energy consumption of the vehicles are measured to know their performances in urban traffic. This table yields some interesting results.

The longest distance covered

See table II
Covered distances of over 250 km are now quite common for the two six hour periods which make the "12 Electric Hours". Electric vehicles using advanced battery systems or operating battery exchange are competing very well with the thermal vehicles. The new batteries (Na-S, Zn-Br) show the best results for vehicles without battery

exchange, but even an lead-acid fitted vehicle without exchange, like N° 02 obtains an honourable result.
Such performances cope very well with city traffic requirements; most city vehicles are in fact not covering more than 50 to 100 km a day.

TABLE I: THE 12 ELECTRIC HOURS OF NAMUR

N°	Vehicle	Battery	Charge	Weight*	Running time	Stop time	Distance in 12 h	Electric energy	Energy ccons.	Spec. . ccons.	Average speed
				kg	h	h	km	kWh	kWh/km	kWh/Tkm	km/h
01	VOLTA	Pb	Normal	1270	9:07	2:53	185	36,10	0,20	0,15	20,29
02	ELCAT	Pb	Normal	1250	12:00	0:00	245	54,60	0,22	0,18	20,42
03	Fridez Pinguin 4	Pb	Normal	770	8:45	3:15	172	31,75	0,18	0,24	19,62
04	MTC SURYA	Pb	Change	1330	11:35	0:25	256	84,55	0,32	0,24	22,13
05	VUB PGE TM	Pb	Normal	1470	7:27	4:33	150	65,05	0,43	0,29	20,09
06	SEA Fiat panda	ZnBr	Normal	1060	11:42	0:18	254	77,40	0,31	0,29	21,70
07	VOLTA	NiCd	Normal	1120	10:53	1:07	244	56,60	0,23	0,21	22,38
08	NEC MELEX	Pb	Normal	370	7:24	4:36	105	13,90	0,13	0,35	14,21
09	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 - TU Berlin	NiCd	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	ASNE VW	NaS	Normal	2200	11:59	0:01	258	106,10	0,40	0,18	21,54
17	MTC VIDYUT	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	NiCd	Change	670	11:46	0:14	267	53,85	0,20	0,30	22,66
20	Renault Master	NiCd	Normal	3070	10:19	1:41	230	137,10	0,59	0,19	22,30
21	Ref, PETROL	-	-	845	11:44	0:16	254	30,5 L	0,12 L	0,14 L	21,61
22	Ref, DIESEL	-	-	1800	11:57	0:03	256	45,0 L	0,17 L	0,10 L	21,41
23	ALTROBUS	Pb	(Hybrid)	13000	**	**	186	73,0 L	0,39 L	0,03 L	**

*: 70 kg added for weight of driver
**: - vehicle participating outside competition

The highest average speed

See table III
The average speed on an urban traject is an image of the local traffic situation. As one can see, in Namur it is about 22 km/h. Electric vehicles can easily cope with such traffic conditions; in city traffic, thermal vehicles do not take much benefit from their high maximum speed.

TABLE II: COVERED DISTANCES

N°	Vehicle	Battery	Charge	Distance km
19	SCHOLL Optima	NiCd-Pb	Change	267
16	ASNE VW transporter	NaS	Normal	258
04	MTC SURYA	Pb	Change	256
22	DIESEL	DIESEL	-	256
06	SEA Fiat panda	ZnBr	Normal	254
21	PETROL	PETROL	-	254
02	ELCAT	Pb	Normal	245
07	VOLTA	NiCd	Normal	244
17	MTC VIDYUT	Pb	Change	242
20	Renault Master	NiCd	Normal	230

TABLE III: AVERAGE SPEEDS

N°	Vehicle	Average speed km/h
19	SCHOLL Optima	22,66
07	VOLTA	22,38
20	Renault Master	22,30
04	MTC SURYA	22,13
06	SEA Fiat panda	21,70
21	PETROL	21,61

TABLE IV: ENERGY CONSUMPTION

N°	Vehicle	kWh/km
14	Hercules - TU Berlin	0,01
17	MTC VIDYUT	0,06
08	NEC MELEX	0,13
15	NEC MELEX	0,14
09	NEC MELEX	0,15
03	Fridez Pinguin 4	0,18
10	MTC SURYA	0,19
01	VOLTA	0,20
19	SCHOLL Optima	0,20
02	ELCAT	0,22

The energy consumption (kWh/km)

See table IV
The results are reproduced in ascending order. The first five values correspond to the lightest vehicles. The bicycle N° 14 shows a very low figure because this vehicle is partly human powered.
The five following results show that the typical energy consumption (measured at the mains) for an electric passenger car or small van can be estimated at 0,20 kWh/km.
Let's also have a look at the consumptions of the thermal and hybrid vehicles (table p. 9).
Consumptions of 12 l/100 km for a small petrol van and of 17 l/100 km for a 4x4 diesel are typical for an urban operation of such vehicles.
The consumption for the hybrid Altrobus is to be compared with the consumption of an equivalent diesel city bus. The low consumption of N° 23 is about 30 % lower, due to the hybrid propulsion system .

TABLE V: SPECIFIC ENERGY CONSUMPTION

N°	Vehicle	kWh/Tkm
01	VOLTA	0,15
10	MTC SURYA	0,17
02	ELCAT	0,18
16	ASNE VW transporter	0,18
20	Renault Master	0,19

The specific energy consumption (kWh/Tkm)

See table V. The partly human-powered bicycle N° 14 was omitted from this table, because it makes also use of an unmeasurable energy source.
The specific energy consumption allows to compare differently sized vehicles. One can see that the specific energy consumption decreases when vehicles grow larger. This is a well-known scale effect which indicates a correct design of traction systems.
Very simple, low efficiency battery chargers can be penalizing, however.
Driving style is also very important and partially explains variations between similar vehicles. This phenomenon of "light feet" or "heavy feet" of course also arises in ordinary traffic, but in the case of the "12 Electric Hours" there is another consideration to be made: the use of electric vehicles enforces a different driving philosophy; suitable training of drivers and operators. Electric vehicles in the city are connected to the creation of a new world where the tensions of our current urban automobile traffic will be only a unpleasant memory of the past.

EVOLUTION OF ELECTRIC VEHICLE ENERGY CONSUMPTION

It is interesting to compare electric vehicle energy consumption on this event with the former editions. In Figure 1, the specific consumption data are given for all the former editions of the "12 Electric Hours", together with the advanced "GM Impact" electric vehicle and some Australian vehicles.

The three curves give a relationship between the weight of the vehicle (in tons) and the consumption in Wh/Tkm:

average: V = 150 + **Error!**

lower limit: V = 80 + **Error!**

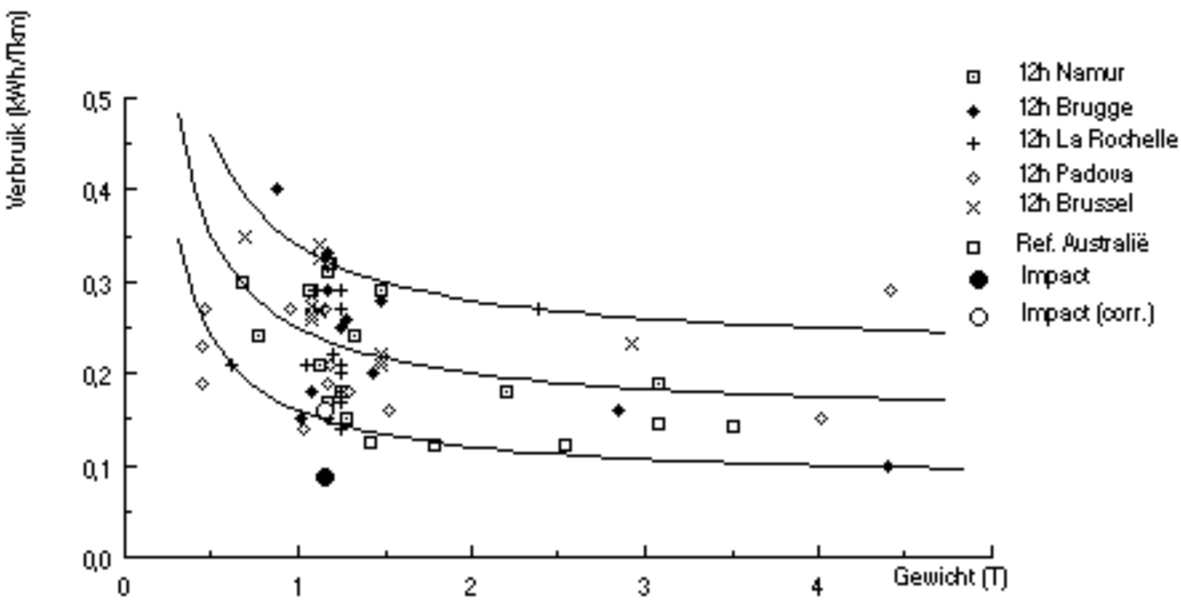
upper limit: V = 220 + **Error!**

The lower limit is to be considered as the cumulation of a very economical driving style ("light foot") with an advanced energy efficient technology (motor, converter, charger). The low limit can be considered as a combination of a "heavy foot" with a less efficient technology.

These curves are valid for weights from 500 to 1500 kg. Above 1500 kg, the specific consumptions go down and can be situated between the average and the lower curve.

Of course the consumption figures are varied among eachother, like with traditional engine-powered vehicle.

One can see however that the lower curve can be considered as an acceptable hypothesis for the near future. The evolution in the electric vehicle technology will allow to reduce even this; the case of the "GM Impact" representing an extremely low value.



CONCLUSION

The "12 Electric Hours of Namur" were a successful event and showed once again the perfect integration of electrically driven vehicles in city traffic: the driving characteristics and performances of state-of-the-art electric vehicles are more than sufficient for their use in the city.
Vehicles designed or goods or passenger transport showed their reliability.
A comparison between different energy storage systems is offered to future users and specialists. The Lead-Acid battery, despite its weight, is still offering excellent value for urban use, and its evolution is not finished. Nickel-Cadmium batteries have proven their value, and the new Sodium-Sulphur and Zinc-Bromine systems are emerging full of promises.

Without any doubt the electric vehicle is at the dawn of a breakthrough which will make it the mainstay of urban road transport in the next century. The electric vehicles present here in Namur have confirmed the progress of technology and the necessity to repeat this demonstration test annually in several cities of Europe.