The Swedish EV-procurement project, tests of the 20 pre series vehicles and the purchase of the main series

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1. Synopsis

The Swedish technology procurement project for a passenger car has now successfully signed a contract with Volvo for the delivery of another 130 Renault Clio Electrique before end of June 1997 with a possibility to sign new orders until end of September 1997.

The paper discusses the tests made with 20 pre series vehicles and the background for the technology procurement project.

2. Abstract

The Swedish EV procurement program are focusing both a passenger car and a medium duty van. Since 1992 a purchaser group have been working with user specifications of the two vehicle types. During 1996 the consortium formed to procure the passenger car, SEHCC, got a delivery of 20 pre series vehicles all Renault Clio Electrique. Both laboratory tests and measured daily usage are the basis for the purchase of at minimum another 130 cars spread among the consortium in all Sweden. Early in spring 1996 the consortium for the medium duty van ended its negotiations without a purchase but a new procurement will probably be released during 1997.

The paper discuss measurements and evaluation of Renault Clio Electrique which has shown some interesting new aspects both on results and measuring methods. Areas of interest are range, energy efficiency, electromagnetic fields and cold climate performance. It also discuss the results of the evaluation of tenders for the medium van consortium.

3. Introduction

The procurement of electric vehicles (EVs) are one project among several others in the Swedish program for energy efficiency. The basic idea is to stimulate the sales of energy efficient products through market pull activities.

EVs has been on the Swedish market for about five to eight years but has not been to successful. One of the reasons, beside EVs being a new product with range limitations etc, was that service and maintenance of sold products could not match normal back up for any petrol car.

The basic market pull activity undertaken by the Swedish program is a technology procurement. By gathering purchasers and releasing a request for proposal, based on user requirements such as range, cargo space, service and maintenance etc, you focus on demands perceived by the users, i e you send a clear message to the manufacturer both of the willingness to buy but also on things to improve.

The EV procurement has been successful in that the consortium has become a major force in discussing changes on the product and also on measurement methods.

4. Procedure

The EV procurement was made such that the buyer would be as safe as possible. For that reason it was done in three steps. First there was an evaluation of proposals made only on the written proposals. Second 20 vehicles was purchased as so called pre series vehicles, to test and evaluate both the vehicle and service given locally. First after nine month of testing in real life and at a national test laboratory the final decision was taken. In late December 1996 the consortium could finalise a contract with Volvo, for the delivery of Renault Clio Electrique.

5. Pre series evaluation

The evaluation can be divided into three categories, first the tests made at a national laboratory for vehicles, second the real life test including an automatic follow up on mileage, energy consumption also failure reporting etc done by the ten different organisations who bought the pre series vehicles. The third test was made as an interview by the users.

5.1 Results from laboratory tests

The idea behind the laboratory tests was to ensure the buyer that the product fulfilled some important stated figures in the contract, such as range etc. The test was also formed to fulfil some national interest such as total energy consumption and emissions. In all there were fifteen different tests made at the test centre, see table 1.

Table 1 Laboratory tests of two pre series vehicles. The results are average of the two tested vehicles.

Test	Requirements	Test results
Range at +20°C	87 km	85 km
Range at -15°C	no	37.5 km
Acceleration, 0-50 km/h	9 se	9 sec
Acceleration, 0-80 km/h	no	27 sec
Energy consumption during driving (Test A)	0.20 kWh/ton,km including compartment heating and self discharge	0.173 kWh/ton,km or 0.234 kWh/km
Energy consumption for heating the compartment, trough electric preheating and 90 minutes driving. (Test B1 and B2)	Energy consumption at 3°C outdoor temperature and 18°C in the vehicle, see above.	With external electric heater: 1.8 kW or 1.2 kWh. With the heater in the car: 1.9 kW or 2.8 kWh.
Energy consumption due to battery self discharge, (Test B3 and B4	Two tests; one simulating weekend parking 48 hours with connected charger and one simulating vacation or longer stop, 7 days not connected to the grid, see above	The first test; 0.65 kWh The second test; 0.38 kWh
Heat and ventilation system test at -15°C	20°C at drivers feet at -15°C and no ice on the windscreen	OK
Internal sound level (internal)	72 dBA at 70 km/h	68 dBA
External sound level	74 dBA at acceleration	69 dBA
Emissions from heater	CO: 960 mg/min NMHC: 22 mg/min NOx: 114 mg/min Particulate: 22 mg/min	CO: 78 mg/min NMHC: not detectable NOx: 14 mg/min Particulate: 0.6 mg/min
Electromagnetic fields	10 nTesla	max 765 nTesla
Safety against electric chock	due to prEN 1987-3:1995 “Protection of users against electrical hazards”	OK

All the tests are below given comments relating to the specifications given by the manufacturer or from the wiev from the user in the absence of specifications given by the maufacturer.

5.1.1 Range at 20°C

The range at 20°C is satisfactory, relative to the requirements, but the real life test, see below, shows that most of the users are not able to drive 85 km/charge, which indicates that the test method not fully reflects real driving.

5.1.2 Range at -15°C

Range at -15°C was a bit of a surprise. The batteries themselves was not expected to lower the range more than 15% i e about 13 km wich means that the internal resistance is higher than expected. As a result of these findings Renault is now trying a new oil that will lower the resistance. How much the range is improved is to early to say and it is also to early to say anything about real life. The vehicles has up to now not been tested in an outdoor temperature of -15°C, but such tests will be done during the winter season 96/97.

5.1.3 Acceleration

The acceleration is acceptable from the view of the drivers, as well as for contractual reasons.

5.1.4 Energy consumption

The energy consumption is the key to improvements of total emissions, se “Consequences ...”. The requirement in the procurement is stated such that fulfilling it means improving the local emissions a lot, but also that the total emissions are not increased even if the electricity is produced by an oil fired plant. In Sweden the average electricity production is based on hydropower and nuclear power (95% together), which means that emissions are very low, but on the other hand if a marginal analysis was made it is important that the result even then is positive. Some marginal analysis are made one is “Consequences..” another is “Framtidens...”. They both indicate that introduction of EVs in Sweden is positive in view of total emissions. The total electricity increase is another interesting area studied in “El för framtidens..” and it indicates that even if Sweden forced the introduction of EVs in a similar way that California is doing, it takes 10-20 years before a major impact is made on the electric consumption. In the scenario high the total electricity consumption is 3.1 TWh by 2020 which is about 2% of today’s total electricity consumption in Sweden and the number of EVs are then expected to be 700 000 which is 15-20 % of all Swedish vehicles today.

The proposed method, in Europe, to measure energy consumption in EVs do not reflect that chargers are connected to the grid even after having charged the vehicle also heating of the compartment is not included. Therefor the consortium formed a hopefully more realistic method to measure the total energy consumption.

$$TEC=1/GVW\ [EC/S+1/16000(187.5EH1+187.5EH2+EHSDC+48*EWSDC+250*22.5/48*EWSDC)] \quad (kWh/ton,km)$$

Where:

GVW = gross vehicle weight
EC/S = Test A: measurement in accordance with the proposed standard DOC CEN TC 301 N36 “Electrically Propelled Road Vehicle - Measurement of Energy Performance”.
EH1 = Test B1: heating with external electric heater, see “Testing of 2 Rena..”
EH2 = Test B2: heating with on board heater, see “Testing of 2 Rena..”
EHSDC = Test B4: holiday self discharge (multiplied two times), see “Testing of 2 Rena..”
EWSDC = Test B3: weekend self discharge, see “Testing of 2 Rena..”

This formula is based on the following presumptions:

The vehicle is driven for 1.5 hours during each of 250 days per year. The vehicle is being heated during each of 187.5 days per year, each time with a combination of electric preheating and use of the car heater for 1.5 hours. The vehicle is subject to battery self discharge as follows: 1 continuos period of 14 days per year; 48 two-day weekends per year; during 22.5 hours for each 250 days per year, each day with a self discharge amounting to 22.5/48*EWSDC.

Using this formula the total consumption becomes 0.19 kWh/ton,km. This indicates that the total energy consumption for this vehicle is about 10% higher than the measuring method and also that more than 2% of the electricity consumption is due to the charger being kept on after charging.

5.1.5 Sound levels

The sound level measurements are important both for the driver and the city environment. The test is lower than what the initial request from the consortia and better than stated.

5.1.6 Heater emissions

The emissions from the heater is nearly a tenth lower then requested and is fully satisfactory but the consortia tried to get a type of heater using a CO_2 emission free (or next to) fuel.

5.1.7 Electr omagnetic fields

Electromagnetic fields is an area of great concern at least in Sweden. The fields are measured at the level of the drivers head and the first requirements in the RFP was set to 200 nTesla. This level is a voluntary standard set for computers in Sweden. At first Renault thought that this level was set very high so they accepted a level of 10 nTesla in the contract with the consortium. The measurement on the other hand shows that the real emissions are greater than the voluntary standard. There are no medical evidence that these levels of electromagnetic fields should be harmful but the measurements indicates that this is an issue that has to be followed. The measurements indicates that the fields are induced by the chopper and are stronger in the back seat than in the front seat.

5.2 Results from field measurements

In October 1996 the 20 pre series vehicles had accumulated over 50000 km under which they have been equipped with a measurement system. Based on this system the consortium has been able to calculate, daily mileage, distance driven between charging, electric consumption, total, per km and per ton,km.

The daily mileage has been calculated as an average over a period of four month. Among the vehicles the longest daily mileage was 64 km and the shortest 14.3 km. On average they were driven 32 km/day.

Average distance between charging measured as a monthly average per vehicle varies from 5.7 km to 55.9 km. The total average was 22 km and the longest distance between charges are 90 km. There are large differences in how to use the charging facilities. If the batteries or the system has a so called memory effect there is a need for information on how to charge.

The average energy consumption, based on all cars but with the exception of certain unreliable data, was 0.289 kWh/km or 0.233 kWh/ton,km. For individual cars the average energy consumption varied from 0.187 kWh/ton,km up to 0.284 kWh/ton,km.

5.3 Results from interviews with the drivers

An interview scheme has been set up in order to be able to follow changing attitudes to EVs before and after a period of approximately 6 month. An idea was also to get ideas for improvements to the main series vehicles.

Totally 18 drivers where interviewed before and after driving for 6 month. The main conclusion was that the drivers were very positive toward the vehicle, that it is easy to drive. The drivers meant that it is a environmentally friendly vehicle and it has very low noise. The range is felt to be to short but a range of 120 km would be enough. The acceleration up to 50 km/h is good but it can not fully follow the traffic rhythm at higher speed. Beside improving this, automatic light control, automatic parking brake, a system that indicates braking when strong regenerative braking is being made was wanted by the users.

6. Comments to the test methods

The test method for range was not possible to follow because NiCd batteries do not give its maximum range until they have been used for a while. In these tests the vehicles could not fulfil the range before approximately 5000 km driven. This indicates that the test method has to be changed such that the properties for each battery type is reflected.

The method for testing energy consumption should also be changed. It is of great importance that the chargers electricity consumption after a full charge is included in the test and also that battery self discharge is included. If heating should be included is a matter of discussion because the varying need for heating. If heating is included cooling should also be a part of the test. The reason for including the charger use of electricity after a full charge is that this and other tests being made in Sweden indicates 2-10 % increase of total electricity consumption without getting anything but increased costs and higher emissions caused by the electricity produced. I e if the vehicle is sold by its environmental benefits this is a matter that has to be followed and which is probably easy to minimise.

The method for measuring electromagnetic fields is also discussible. It is set up to measure at the drivers head. If the fields are coming from the connection between the batteries and the motor it is likely that the fields are stronger at the floor level.

7. Evaluation of proposals for the van consortia

The van consortia got a total of three proposals and nearly one and a half year of negotiations followed. In the end the consortia could conclude that a great deal of the requirements was possible to get fulfilled but at a price which could not be accepted. A major reason for this is that the battery becomes a greater part of the vehicle price when the vehicle increases, which means that mass production or at least a lower price for batteries is of even greater important for this larger type of vehicle (3.5-4.5 ton gross vehicle weight).

The negotiations was ended without a purchase but the buyers are still as interested to buy as they were. During spring of 1997 this consortia will therefore discuss the possibility to realise a new request for proposal.

8. Conclusions

The tests of the 20 pre series vehicles can be summarised as successful. Therefore the consortia has signed a contract with Volvo to buy at least another 130 Renault Clio Electrique during 1997. The delivery will start in February and end by the end of June 1997.

The main idea behind a technology procurement is to initiate a market for the product. For that reason the contract is open for new consortia members which means new buyers of Renault Clio Electrique until end of September 1997. NUTEK will stimulate new buyers with information and the same small subsidy of 15 000 SEK per vehicle (about 5% of the vehicle price). The only two restrictions for buying is that the buyer is a company and that local service can be made. Volvo guarantees the service can be made if at least five cars are sold in an area near a local dealer. The local dealer has to do investments and training of personnel. NUTEK will also after 1997 work with information and other activities in order to continue to accelerate the sales of EVs.

9. Acknowledgements

I would specially thank all members of the consortia who made this technology procurement come true Normally no company or person buys a vehicle without driving it and testing it carefully. In this project all members had to sign up for a product that could not bee seen until three years later and which they new would have a high price and limited range. The reason behind this is a strong believe that this type of vehicle (EVs or HEVs) can play an important part in making transport more environmentally acceptable. For this reason it is very important that these organisations and companies continues to buy new EVs or environmentally better vehicles coming to the market.

I would also specially thank the chairman of the consortia Mr Uno Engman for his strong support of the project and our expert Mr Lars G Örtegren who has done most of all paperwork and who has led all the negotiations.

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