The Consumer's Perspective on Hydrogen in Transportation – The Experiences of the World's Third Largest Automobile Club with a Hydrogen Vehicle in Road Patrol Service

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The Consumer's Perspective on Hydrogen in Transportation – The Experiences of the World's Third Largest Automobile Club with a Hydrogen Vehicle in Road Patrol Service

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ADAC is the worlds third largest Automobile Club. ADAC annually assists its 16.8 million members in approx. 3.9 million breakdowns. 1,700 road patrol vehicles are specifically equipped with parts and tools for breakdown assistance. At the "ADAC Technik Zentrum" – ADAC's technical centre – in Landsberg near Munich, road patrols receive training on current and future vehicle technologies. Also, the ADAC Technik Zentrum is the European automobile clubs' "European test centre", developing a joint test programme of environmental, safety and consumer protection tests. The tests include various crash tests, durability and long-term driving tests for alternative fuels, environmental assessment based on well-to-wheel analysis, ADAC's EcoTest and web-based market research analysis. In Berlin, ADAC has been running a GM/Opel road patrol vehicle driven by a hydrogen fuel cell since 2009. ADAC is interested in future consumer expectations on hydrogen cars and refuelling infrastructure, experiences with the GM/Opel hydrogen road patrol car and fuel-cell capabilities under real-life driving conditions, as well as well-to-wheel studies.

1 Consumer Expectations

Like electric vehicles, fuel-cell vehicles are powered by electric engines. But rather than carry the required electric power in a battery, they produce it right there in the fuel cell. Therefore we can transpose some of the results of a recent ADAC survey on battery electric vehicles to fuel-cell electric vehicles.

The results of the survey show that future car buyers are prepared to switch from fossil fuels to electric power or other alternative power-trains/fuels. But they are not prepared to accept makeshift solutions or any loss in comfort. Nor are they prepared to pay more.

First and foremost, the price must be right: Almost 40 % of the respondents are not prepared to spend more in terms of the total cost of ownership for a vehicle with an alternative power-train than they would for a comparable conventional car.

Furthermore, the vast majority are not prepared to compromise on range, top speed, refuelling and space. Consumer expectations like top speed, space and range are not a problem in fuel-cell electric vehicles, unlike in battery electric vehicles. Therefore battery electric vehicles may remain for niche use only, like city cars with limited range, but adequate fuelling infrastructure at power points. Therefore the niche of battery electric vehicles is defined by range limitations.

In contrast fuel-cell electric vehicles offer a large utilisation. But in order to facilitate their launch and ensure acceptance, we need to establish a wide-area network of hydrogen refuelling stations. However such a network would have to be built from scratch. Therefore the niche for fuel-cell electric vehicles is defined by infrastructure limitations.

In addition, some aspects come into plays which have thus far made the consumer reluctant. They include the question of the hydrogen production chain (coal, nuclear, renewable) and also the fact that the safe storage and transport of hydrogen in vehicles are quite energy-intensive. Therefore sustainable scenarios calculate a minimum share of 50 % renewable energy. These energy and cost scenario calculations show that hydrogen cost may result in 10 years in a fuel price of 1.10 - 1.60 € per litre petrol equivalent at the fuel pump, which may be reduced by further 15 % in long term (www.germanhy.de). If the German fuel taxes and added value taxes (VAT) for petrol are added to these hydrogen cost, it would result in 2.10 - 2.70 € per litre of petrol equivalent.

2 The Road Patrol Project

GM is currently having 100 HydroGen4 vehicles world-wide tested by customers. Ten are being used in Berlin under the Clean Energy Partnership (CEP). Opel made one of them available to the ADAC's Berlin road patrol. The vehicle is fully equipped with road patrol tools and spares. The test period runs from February 2009 to the end of 2010. The test is aimed at gathering experience with the fuel-cell drive under everyday conditions of operation and the logistics of hydrogen refuelling.

3 The Vehicle

The basis of the hydrogen car is a Chevrolet Equinox. The vehicles are fuelled with 4.2 kg of hydrogen (app. 16 litre petrol equivalent) stored in three 700-bar high-pressure hydrogen tanks made of a carbon fibre compound. In a fuel-cell stack made of 440 in-line polymer electrolyte membrane cells, hydrogen and oxygen are electro-chemically synthesised to water and, in the process, electrical and thermal energy are released. The system has a power output of 93 kW.

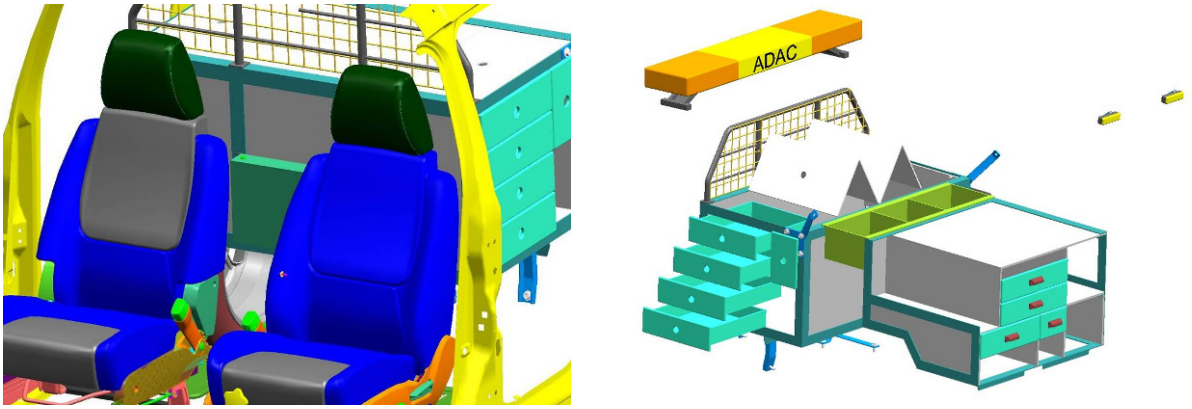

Figure 1: Components for HydroGen4 for Berlin road patrol.

A 73 kW three-phase synchronous motor with integrated power management and a planetary gearbox produces 320 Nm of torque and accelerates from 0 to 100 kph in 12 seconds. The vehicle's top speed is 160 kph. Only the original test vehicles have the effective range of 320 km. With the added weight of its equipment and the additional systems served by the power source (**Figure 1**), ADAC's road patrol vehicle only has a range of approx. 150 km.

4 ADAC Experiences

The hydrogen road patrol vehicle has clocked over 1,000 operating hours and run up approx. 15,000 km under standard road patrol conditions. For almost 60 % of the operating hours, the vehicle stood with the engine idling, since Opel/GM instructions require the system not to be powered off during breakdown assistance in order to ensure the power supply. Based on the available data, Opel/GM is now determining whether the system can be powered off at least during longer assistance stops (**Figure 2**).

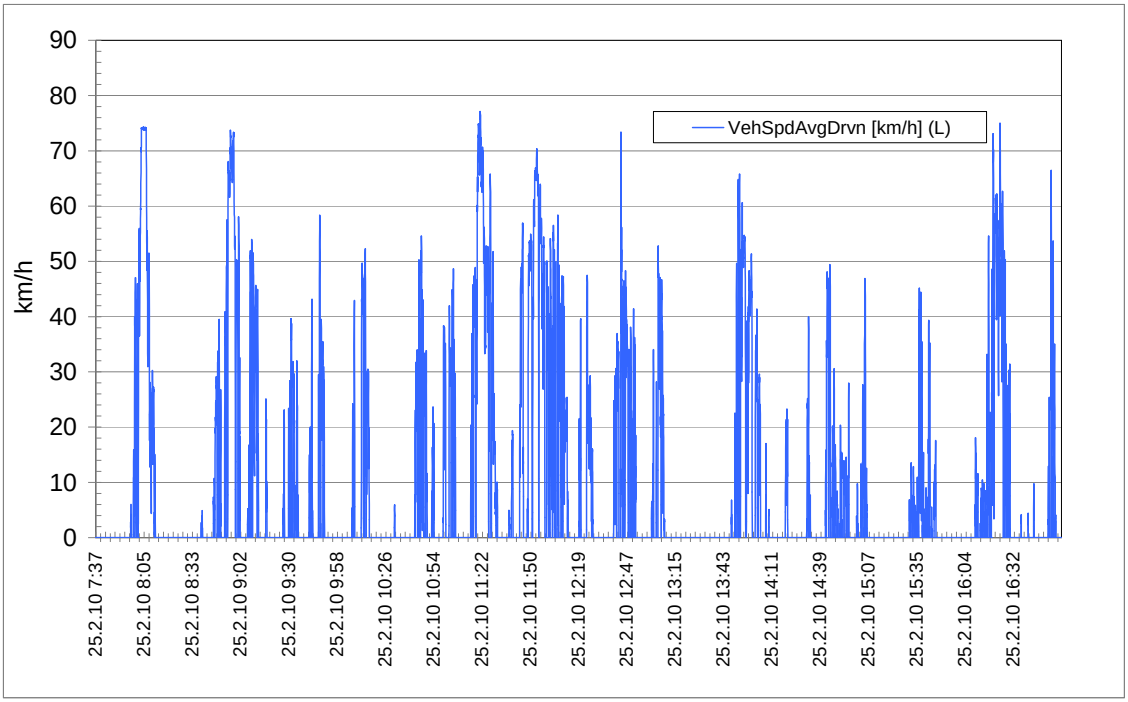

Figure 2: Driving conditions of Berlin road patrol.

The vehicle can be put to the same uses as any other road patrol vehicle, except for towing, since it is not equipped with either a tow hook or a tow lug allowing the attachment of a tow bar or rope.

The road patrols did not report any system failure. It seems to be working quite reliably under any conditions and temperatures – despite the higher demand on the system due to the additional weight and power equipment served. The vehicle carries three ADAC portable power stations. Two of them are used for jump-starting, one as an additional power source for the vehicle (flashlights, radio etc.). The power stations are powerful enough to jump-start

larger vehicles. The special recharging devices developed for the power stations have so far proved efficient and adequate (**Figure 3**).

For refuelling, there is a fuel station with 700-bar technology at Berlin-Spandau. This is the first commercial fuel station world-wide equipped with an infrared vehicle-to-station data communication interface. The interface communicates the data relevant to the recharging process (such as temperature and pressure) as well as the recorded driving and operating cycle and fuel consumption data directly to Opel. With the technology developed for this station, refuelling does not take longer than conventional filling up. Two other fuel stations are not equipped with the 700-bar technology, which renders refuelling considerably longer.

Figure 3: Berlin road patrol HydroGen4.

Actually, the only problems are with the logistics of refuelling, which were also included in the scope of the test. The refuelling pumps are often out of service due to soft- or hardware problems. When this happens, the hydrogen road patrol vehicle takes an involuntary break since refuelling at other stations is too time-consuming to be practical for us.

During its over 1,000 hours of operation and approx. 15,000 km on the road, the fuel-cell vehicle was refuelled 172 times. On average, it runs 100 km on 2.4 kg of hydrogen (app. 8.8 litre petrol equivalent). Again, we need to consider that for almost 60 % of the time, the system was idling (during breakdown assistance stops). Looking at the driving cycles as such, the average hydrogen consumption per 100 km is only 1.3 kg (app. 4.8 litre petrol equivalent).

5 Conclusions

Together with GM, ADAC has proved, that fuel-cell electric vehicles can offer the same technology standard, as required from today's diesel and petrol cars. Fuel cell cars have significant benefits in areas, where the fuelling infrastructure is available. Even if in principle the feasibility for an introduction of fuel-cell technology in cars is proofed, open questions on cost of clean fuels, storage cost and vehicle cost must be answered, before steps for a market introduction are taken. If these questions on cost are answered satisfactory for consumers, there are no barriers for public acceptance of fuel- cell vehicles.