In the contest for sustainable mobility, the electric car seems to be ahead of the hydrogen car. But the race is still long. Changing the automobile is a matter of perseverance.

The race between the electric car and the hydrogen car

by Hans Verwijs

Fuel for sustainable transport can be divided into three categories: biofuel, hydrogen and electricity. According to Pieter Kroon, a specialist in energy and environmental studies at the Energy Research Centre of the Netherlands (ECN), by the year 2030, biofuel will not be able to meet more than 25% of demand in Europe. He bases his belief on a study ECN published in March. 'Agricultural acreages and the development of the proper plants are the restrictive factors here. Biofuel will always be just a partial solution,' he says.

Consequently, the current debate around the car of the future focuses mainly on hydrogen versus electric vehicles. Hydrogen is more versatile and can feed both a combustion engine and a fuel cell. The fuel cell in turn drives an electric motor. BMW is the only car manufacturer to have opted for a direct-driven combustion engine. Other car manufacturers are going for the electric motor. The great advantage of hydrogen is its high energy density as compared to a battery. Kroon says, 'For an electric lorry, for example, the required battery packs would be too heavy. So hydrogen will probably be the preferred fuel for this kind of transport. For passenger transport, electric power with batteries stands a fair chance. Batteries have recently improved in leaps and bounds and have therefore contributed greatly to this option.'

Kroon does point out, however, that it will still be quite some time before vehicles make widespread use of hydrogen and electricity. 'Both hydrogen and batteries are still very expensive. And it will take 15 years to replace all cars on the road. According to Hi Ways, an extensive survey carried out in 2007 among oil companies, car manufacturers and research institutes, approximately 5% of the passenger car market could, under the most favourable conditions, be fitted with fuel cells by 2020. More recent studies that are still being analysed indicate that batteries could take the place of fuel cells but that their combined market share will not exceed 5% by 2020.'

Kroon warns that the trade in CO_2 emission rights will have no direct influence on how quickly sustainable transport is implemented. The implementation of sustainable transport is much more

Tesla Roadster Photos: Tesla

expensive than the cost of buying emission rights. A much more realistic measure to bring hybrid cars on to the roads, he says, is to accelerate the reduction of CO_2 emission norms for cars.

Plug-in

Kroon does not expect the hydrogen and the electric cars to develop at an equal pace. 'Even car manufacturers can spend their money only once. The predecessor of the electric car is today's hybrid car. These cars will continue to develop and probably by 2020, all makes of cars will have a hybrid version propelled partially by brake energy regenerated via their battery. Hybrid cars will be succeeded by plug-in hybrid cars whose batteries can also be recharged via the mains. And the next step is to get rid of the combustion engine, giving us the electric car.'

Steps are already being taken in the progression from hybrid to plug-in hybrid to fully electric cars. One million Toyota Prius hybrids have been sold. Toyota is currently carrying out a test involving one thousand plug-in hybrids and expects this car to be introduced onto the market in 2010.

Also in 2010, General Motors will introduce the Chevy Volt, an electric car with a 1-litre diesel generator that can recharge the battery over longer distances. Renault is aiming to produce an electric version of its present models in Israel in 2011.

There are also new players with their own entirely electric cars but bearing a price tag that will appeal only to a limited few. Tesla Roadster of Tesla Motors in California intends to roll 100 cars out of its factory at the end of this year. The Tesla Roadster can accelerate from 0 to 100 km per hour in 3.9 seconds and runs for 365 km on a single charge. It will cost €99,000 in Europe. Venturi Automobiles in Monaco produces 25 Venturi Fétish cars with a price tag of €297,000 each. There are also cars for commercial use but with a lower speed and a more limited range, such as the Edison electric minibus made by British manufacturer Smith Electric Vehicles.

The introduction of electric transport is strongly influenced by the development of the battery. The acid batteries of today's cars are too heavy for long distance trips. Dirk Uwe Sauer, professor at Aachen University's Electrochemical Energy Conversion and Storage Institute for Power Electronics and Electrical Drives, regards the lithium-ion battery as the technology of choice for the coming years. His institute studies the performance, life span and diagnosis algorithms for on-board applications of this battery. The electrical and thermal behaviour is of special interest, since batteries must not overheat during charging. Lithium-ion batteries are able to collect most of their energy during brief moments of braking, which is important for the car's efficiency. Today, the production of a single battery costs between €10,000 and 25,000. Sauer compares the costs to those of laptop batteries: within twelve years these became six times cheaper due to mass production and higher energy density, thus saving materials. He expects that manufacturing costs will drop significantly once fully automated production lines are implemented.

When electric cars become mass produced, motorists will no longer refuel at a petrol station but probably charge their batteries at home overnight. The Netherlands' largest utility, Essent, has decided to take advantage of this development by introducing a programme called the Smart Mobile Grid, in which the link-up of car batteries to the grid is studied. According to Essent's innovations manager, Erik van Engelen, the electric car can contribute significantly to the efficient use of energy.

Electric Car Recharging at Public Outlet. Photo: Martyn Goddard/Corbis

Batteries requiring charging can be a good storage area for wind energy produced at night when demand is low. Even when the power used to charge the car battery is not sustainable, an electric car is still three times more efficient and its emission is proportionally lower, says Van Engelen. Essent wants approximately 200 cars of its own fleet converted before the end of 2009. The company wants to learn as much as possible about the charging and converting processes and to use that knowledge when the new electric cars come on the market in 2010.

Essent has good relations with Volkswagen, Volvo and new players such as Duracar and Detroit Electric, which are entirely focused on electric cars. According to Van Engelen, the other Dutch energy companies have reacted positively. 'They are eager to cooperate in standardising hook-ups and payment systems. We would like everyone from car suppliers to pressure groups to pull their weight. We want to generate momentum, starting with the business-to-business market.'

The most formidable technical challenge for Essent is to optimise supply and demand. Car owners should be able to charge their cars at night when electricity is cheaper without

someone having to attend to it. Companies are currently looking for quicker ways to charge batteries. Epyon, a Dutch company, has developed a system that reduces the charging time from approximately four hours to fifteen minutes. Epyon's will be conducting experiments with fast-charge points in the cities of Rotterdam and Leeuwarden.

Competition

Hydrogen needs filling stations, so its situation is similar to the current distribution of fossil fuels. Electric cars can do without filling stations. This creates rivalry between electricity companies and oil companies. Kroon thinks it only natural that both groups stand up for their own markets. 'But in the end it is the car owners who will determine which one comes out on top. They go for ease and the least costly.'

Electric car recharges at a plug at the international media center of the G8 Leaders Summit. Photo: Corbis

According to Shell spokesman Andre Romeyn, the oil company is taking all possible developments into account but also chooses to communicate a clear message to governments.
'We are calling for a level playing field through predictable policies that encourage the reduction of CO_2. That provides the best hope for a sustainable future.' In the most favourable scenario, in which governments apply themselves to limiting CO_2 emissions, Shell expects that in 2050 half the cars are battery or hydrogen driven.

> *'Everyone seems convinced that the plug-in hybrid will be the winner'*

Gert Jan Kramer, principal scientist at the Research & Innovation Department of Shell Global Solutions and part-time professor at Eindhoven University, acknowledges in Shell's in-house publication 'Venster' (July-August 2008) that for Shell, the development of the electric car 'seems to present more threats than opportunities...hydrogen as a fuel dovetails better with our existing activities.' So far, the introduction of the electric car has progressed faster than that of the hydrogen/fuel cell car, Kramer observes. 'Over the past five years we have seen a shift from the near-certainty that the hydrogen era was drawing near, to the situation today in which everyone seems convinced that the plug-in hybrid will be the winner.'

'But,' he says, 'if you look at how much attention the car industry is investing in hydrogen you can see steady, ongoing development.' Shell will continue to develop its hydrogen activities. In the US (and especially in California), Shell Hydrogen is setting up "mini networks" for hydrogen cars, in addition to which they are working hard to develop "sustainable hydrogen", produced by means of electrolysis and green energy. The best methods for this is gasification and synthesis of biomass. According to Shell Venster, 95% of all hydrogen in the world today is still produced in refineries and at gas production locations by converting natural gas or by gasifying coal or petroleum coke. The big question is whether the plug-in technology will throw a spanner in the wheels of the hydrogen car. Kramer says, 'If the plug-in hybrid soon becomes a big success it will certainly ease the time pressure on the development of hydrogen in combination with fuel cells. But for greater distances you will still be unable to get by on any other energy source than batteries. Perhaps one day someone will come up with a combination of hydrogen and fuel cells as a "range extender" for plug-in hybrid electric cars.' ■

It's a question of scale

Bill Moggridge, cofounder of worldwide design group IDEO, says, 'If we look at the different options we have for powering movement, the only one with the huge infrastructure that already exists is electricity. It would take decades to build a new infrastructure for hydrogen. It is very urgent that we do something different other than running on oil and if we look at the performance of new electric vehicles, it is much better and it is going to happen sooner rather than later.'
Moggridge, who worked as a design advisor for sports car manufacturer Tesla, says that the cost of the battery technology has to come down. 'If you look at the little Tesla compared to the Lotus Elite, which has the same chassis, the big difference in cost is $40,000 to $50,000 for the battery. Economy and scale are the things other than a breakthrough in battery technology that will change the situation. So it's a question of scale. The hybrids are just a small step in that direction but what we want is battery technology that is light and powerful enough to give us the charge for the kind of distances we need to travel. Lithium seems to be the best possibility right now.' (contributed by Satish Kumar Beella)