

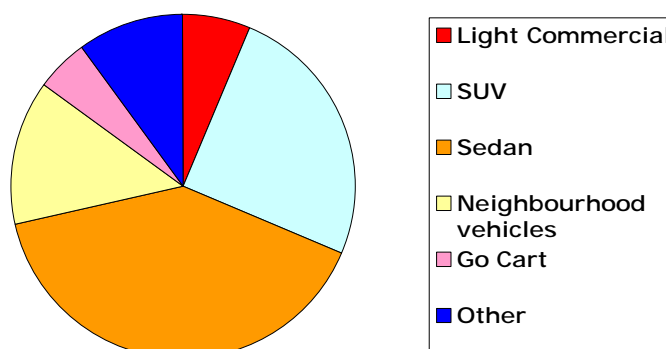
Fuel Cell Vehicle Survey

19 December 2001

The development of fuel cell vehicles (FCVs) has generated considerable excitement over the last few years, and much has been written about their potential and when they might become a commercial reality. Only recently, however, has a sufficient number of prototype vehicles been developed to begin to pass judgement on the emerging sector, and how it might grow.

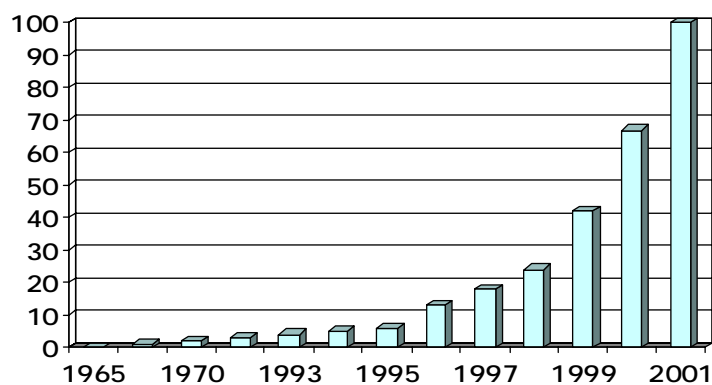
To date around 100 light duty fuel cell vehicles have been built and operated publicly worldwide. This number includes light commercial vehicles (such as vans and pick-up trucks), sedan cars, sports utility vehicles, and smaller vehicles such as golf-buggies and go-carts.

Vehicle Type



Activity in the sector has accelerated in the last few years, as the graph below indicates. Only a handful of one-off prototypes were built between 1966 (when General Motors' unveiled its AFC powered Electrovan) and the mid 1990s. Since then the pace of development has accelerated rapidly, with more and more companies producing prototypes. This year, new prototype FCVs have been unveiled nearly every month, and automotive companies are also, notably, beginning to build prototypes in greater numbers for demonstration and testing.

Cumulative Number of FCVs

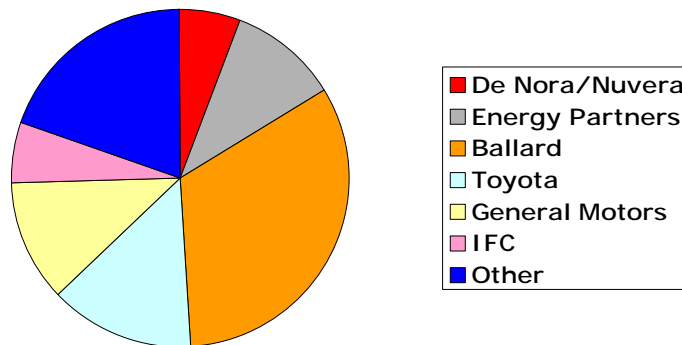


Technologically, FCVs have come a long way in a comparatively short time. In DaimlerChrysler's first prototype – the Nekar 1, unveiled in 1994 – the fuel cell system took up the rear space of a van. Now automotive companies are building and operating FCVs which incorporate the fuel cell system, electric drive and other components within the engine bay and floor pan of small vehicles such as Mercedes-Benz's A-class.

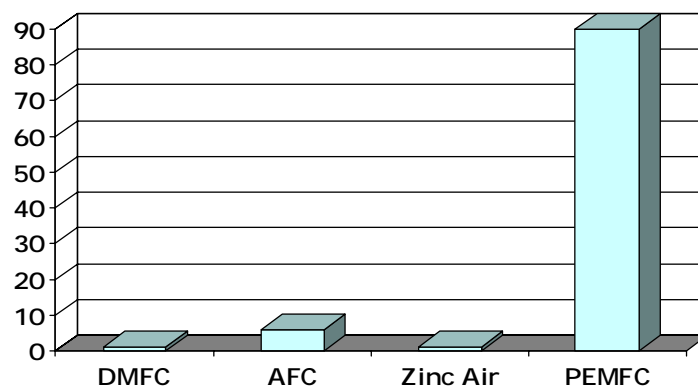
So far as technology type is concerned, nearly all the vehicles in this survey use PEM fuel cells, with the exception of one zinc-air hybrid Honda Insight (built by Evionyx) and a handful powered by alkaline fuel cells. These include a golf-cart built by Astris Energi and two taxis and a park

maintenance van built by Zevco (a subsidiary of Zetek Power), which use 5kW AFC systems as a trickle charger for a battery. The dominant stack developer is, as might be expected, Ballard, although several other companies are also prominent.

Stack Developer



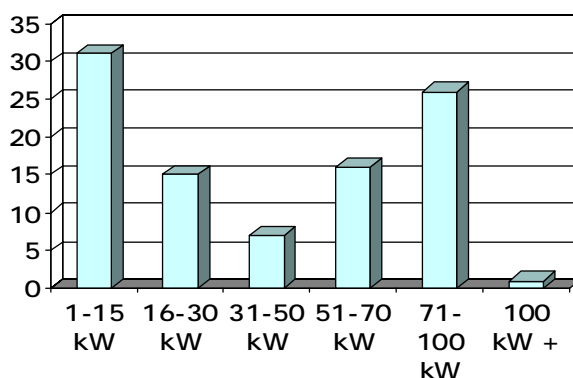
Technology Type



The outputs of the fuel cell systems included in this survey range from a few kilowatts upwards. Some of the less powerful stacks are used to power small vehicles such as golf-carts or personal utility vehicles, a

number of which have been built by, amongst others, Energy Partners and Schatz Energy Research Centre. Several hybrid FCV prototypes also have been built which use a low output fuel cell in conjunction with a battery. These include the Hycar FCV built by ESORO in Switzerland, and the taxi built by Peugeot in 2000, which uses a 5.5kW H Power stack.

Stack Size

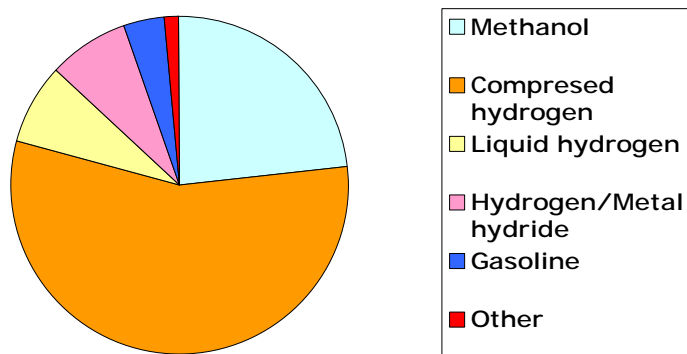


The Peugeot fuel cell van (photo courtesy of www.km77.com)

The issue of fuel choice is still a matter of some uncertainty. Liquid Hydrogen is being used by General Motors and others, but compressed hydrogen is the most popular, and as higher-pressure storage cylinders are developed is looking more promising. Honda is making advances in this

area and recently announced that it would only develop pure hydrogen fuelled FCVs at the present.

Fuel Choice



Most automotive companies have also looked at methanol, which can be handled in much the same way as gasoline, and would be less expensive to introduce than hydrogen. Its popularity could grow if advances continue in the development of direct methanol fuel cells (DMFC). In 2000 DaimlerChrysler and Ballard demonstrated a jointly developed go-cart powered by a 3kW direct methanol fuel cell, and a European Union project is currently developing a DMFC system for cars.

Finally, gasoline is also being explored by a number of automotive companies. In 2001 General Motors unveiled the S10 FCV prototype powered by a 25kW PEMFC running off reformed gasoline, and in October 2001 Toyota unveiled an FCV that will run off a form of refined gasoline, the FCHV-5.

The number of fuel cell vehicles in existence should enjoy steady growth in the coming months and years. The California Fuel Cell Partnership plans to

test at least 50 cars by the end of 2003 (15 of which number will come from DaimlerChrysler), while China's Ministry of Science and Technology is funding a fuel cell vehicle programme to the tune of US\$36 million for the years 2001 to 2005.

Honda and Toyota, meanwhile, both plan to start selling FCVs in small numbers from 2003, and General Motors will shortly scale up its testing programme. Several units of its HydroGen3 are scheduled to hit the roads soon. The numbers of FCVs on our roads might also be pushed up, in the longer term, by companies such as Hypercar, whose Revolution SUV prototype has been designed specifically to ensure affordable production of a fuel cell car.



The Revolution SUV (photo courtesy of Hypercar Inc. (www.hypercar.com))

This review will be updated regularly and should begin to indicate how fuel cell vehicle markets are developing. If you know of, or are involved in, any projects that should be included in this survey, please let us know. Information can be emailed to marketsurvey@fuelcelltoday.com.