GREEN TECHNOLOGIES

Electric Cars with Hydrogen Fuel Cells

Two hundred years ago, Swiss engineer François Isaac de Rivaz invented an internal combustion engine that used a mixture of hydrogen and oxygen as fuel. But the car he designed to go with it was a failure. The first electric cars were invented some 25 years later, long before Messrs. Daimler, inventor of the modern gas engine in 1885, and Benz, recipient of patent DRP 37435 for a gas-fueled car in 1886, came along.

At the turn of 20th Century electric cars were more popular than gasoline-powered models, for much the same reasons that consumers are taking a second look at electric cars today: they did not emit noxious fumes, were quiet, smoother and easier to drive. So why did the more-polluting gasoline-powered cars take over the market? Several factors came into play.

Henry Ford, good roads, cheap gas

"I will build a car for the great multitude," declared Henry Ford in 1903. And so he did: the Model T, with an internal combustion engine that ran on gasoline, was released in 1908, selling for US$950. During its 19 years in production, its price tag would fall as low as US$280. No other car could compete – let alone electric cars, which, when at their peak in 1912, sold on average for US$1,950. The writing was on the wall.

Electric cars also lost out because of their limited range. At the turn for the century, this had not been a problem, as the only suitable roads for driving were in towns. But after the First World War, nations started to build highways and roads to connect their towns. Car owners soon wanted to venture out further than the electric cars could take them.

The discovery of plentiful crude oil resources reduced the price of petrol, making gasoline more affordable. But electric cars did not disappear – nor did the use of hydrogen as fuel. They simply faded out of the mass consciousness until the 1970s gas crisis and environmental concerns brought them back to the fore.

Clean energy

Today's internal combustion engines can be readily converted to run on a variety of fuels, including hydrogen. However, hydrogen fuel cells used to power cars with electric motors are two to three times more efficient than gas-fuelled internal combustion engines. Moreover, they have zero-emissions and, because they have few moving parts, are quiet and vibration-free.

Hydrogen is one of the most plentiful elements in the universe. It can be extracted from natural gas, coal, crude oil, etc., but water is the only pollution-free source of hydrogen. The hydrogen and oxygen atoms in water can be easily and cleanly split apart by electrolysis, ideally using electricity from clean sources, such as solar panels and wind turbines. The resulting hydrogen can be compressed for storage and use in fuel cells.

It was a Welsh physicist, William Grove, who in 1842 invented the first simple hydrogen fuel cell. Grove recombined hydrogen with oxygen – the reverse of the process of electrolysis – to produce electricity with only pure water as a by-product.

Francis Bacon, a chemical engineer at Cambridge University in the U.K, whose interest was piqued when he read the papers published by Grove some 100 years earlier, dramatically advanced the technology in the 1950s. Pratt and Whitney licensed Bacon's fuel cell patents in the 1960s and further developed the technology for use by NASA – the same fuel cell could provide electricity for in-flight power, heat and clean drinking water for the crews aboard space crafts. The Apollo, Gemini and all subsequent NASA missions, including the space shuttle, used fuel cells. Grove's technology had come of age.

A number of companies founded after the oil crisis of the 1970s based their business models on the hydrogen fuel cell as a clean source of renewable energy, using Grove's paper and Bacon's patent information as the starting point for their research. Researchers are now working on many types of fuels cells, as shown by the hundreds of international patent applications filed under the Patent Cooperation Treaty (PCT) for fuel cell-related inventions over the last few years.

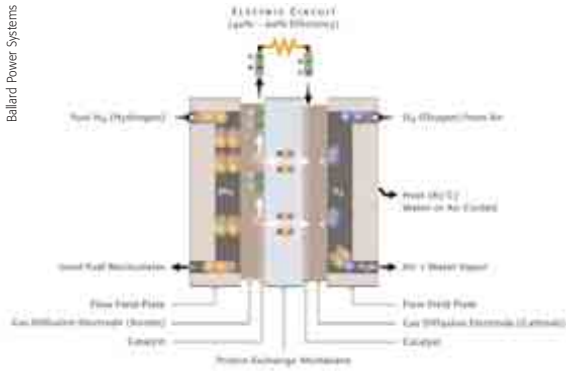
But is it Safe?

Mention hydrogen and many people think of the Hindenburg disaster of 1937, when a hydrogen filled Zeppelin went up in flames, killing all 35 people aboard. But numerous studies, such as those conducted by retired NASA engineer Addison Bain in 1997, have concluded that hydrogen played no part in starting the Hindenburg fire. The extreme flammability of the Hindenburg's aluminum fabric envelope caused the disaster, not the gas inside.

Hydrogen is very flammable, but so is gasoline. Moreover, hydrogen is not inherently explosive, and where there are no ignition sources, it is highly unlikely that hydrogen will ignite in the open atmosphere. While petrol will self ignite at temperatures between 228-501°C, the self ignition temperature for hydrogen is 550°C. In principle, for an explosion to occur, hydrogen would first have to accumulate and reach a four percent concentration in air in a closed space and then an ignition source would have to be triggered. With proper safety systems in place, this is unlikely to ever happen. Hydrogen is lighter than air and dissipates rapidly, so the risk of a hydrogen fire or explosion in an open area is also much lower than that of gasoline.

Source www.fuelcellmarkets.com

Ballard Power Systems



Ballard has filed 46 international patent applications relating to hydrogen fuel cell technology since the company started using the PCT in 2004.

Credit: DaimlerChrysler

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In the 1990s, a research team at Ballard Power Systems in Canada made a major breakthrough when they discovered a way to increase the power density of hydrogen, upping the average figure from 200 Watts/liter to some 1,500. Using Ballard's PEM fuel cell technology, a car with a motor of similar size to that of a gasoline car can match it in performance – going from naught to 100 km/hour in 15 seconds, with top speeds around 150 km/hour. The technology is also viable for residential use – electricity and heating – or as backup power applications.

Fill her up: Compressed hydrogen, please

DaimlerChrysler, Ford, Honda, General Motors, Mazda – all of these big car companies have developed fuel cell concept cars, some of which have been delivered to customers for trial. In 2003, a team from DaimlerChrysler crossed the U.S. in 12 days with the fuel cell NECAR 5, reaching a record speed of 160 Km/hour and proving that fuel cell cars could go the distance. Mazda started leasing fuel cell RX-8s to commercial customers in Japan in early 2006, making it the first manufacturer to put a hydrogen vehicle in customer hands.

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Madrid System trademark 801390 registered in 2002.

Photo: Intelligent Energy Ltd.

Sleek and silent – the ENV Bike

Courtesy Honda

Honda demonstrates the FCX Concept Vehicle, a fully functional next-generation fuel cell electric car. Honda has filed over 40 fuel cell-related PCT patents.

Refueling currently remains a problem for customers, unless they live in California, which plans to build 150 to 200 hydrogen-fueling stations by 2010. A number of car companies aim to tackle the problem by providing consumers with home hydrogen refueling units. Honda recently unveiled the third generation of a home unit designed in conjunction with U.S. fuel cell company Plug Power Inc. And GM, whose Vice Chairman Bob Lutz believes fuel cells could create a new golden age for the company, plans to release a home model, which would make hydrogen either from electricity or sunlight, in 2011. This year, GM aims to place 100 hydrogen fuel cell Chevrolet Equinox SUVs for trial with consumers.

Looking good

François Isaac de Rivaz's car failed due to its poor design. But a glance at the fuel cell vehicles in these pages shows that manufacturers are now keenly aware of the strategic importance of good design. Their eco-friendly credentials may win consumers' minds but it is good design that will win their hearts.

The ENV Bike from Intelligent Energy Ltd. won an IDEA gold award for design in 2006 (see *WIPO Magazine* issue 5/2006 – News Round Up). It was built from the ground up to demonstrate the use of hydrogen fuel cells, is virtually silent and has a top speed of 80 km/hour. Intelligent Energy intends to make the bike available to consumer in mid 2007 for under US$10,000. The Company started using the PCT in 2003 and has ten published international patent applications for their fuel cell technology, including "Core," a portable hydrogen fuel cell that can be used in the ENV Bike, to power a boat or a small house.

On the road again

In a recent press release, the government of Brazil announced that São Paulo, one of the world's most polluted cities, which also has the world's largest metropolitan bus fleet, would start operating up to five hydrogen fuel cell buses in November 2007. The US$16 million project is supported by the United Nations Development Program (UNDP), the Global Environmental Facility (GEF) and the Financing Agency of Studies and Projects (FINEP). The project objectives are:

- To develop a zero emission public transportation solution;
- To build an understanding of fuel cell and hydrogen technology, enabling Brazil to obtain a leading position, due to its potential market;
- To work to develop expertise and knowledge in Brazil with the objective of creating a market for hydrogen and fuel cell technologies; and
- To develop Brazilian specifications for the safe and efficient production, handling, stationary and automotive applications, enabling the development of a safe and efficient use of hydrogen.

Santa Clara, USA, Perth, Australia, Beijing, China and ten European cities already have hydrogen fuel cell buses undergoing trials in their public transportation systems. The results so far are positive. The three buses operating in Perth since September 2004 have been running more than eight hours

Courtesy General Motors

The GM Sequel is expected to reach the market in 2012. With acceleration to 100 km/hour in under 10 seconds, it is much faster than the current average for fuel cell cars.

Photo: Ballard Power Systems

Hydrogen fuel cell buses undergoing trials in Perth, Australia.

Solar-Hydrogen Home

Mike Strizki, an engineer at Renewable Energy International, Inc. and Advanced Solar Products, Inc., built a pollution-free power system for his home, using 56 solar panels and an electrolyzer to pull hydrogen out of water, which he then stores in tanks on his property. The solar panels provide 160 percent of the electricity needs of the home during the summer and 60 percent of such needs during the winter. Seasonal power management builds a supply of hydrogen during the summer for use during the winter. And, sufficient hydrogen is available to power vehicles and household appliances, including hydrogen cooking, throughout the year. He has more than enough energy to power his hot tub, swimming pool, big-screen TV and hydrogen fuel cell cars.

Photo: Renewable Energy International

a day, five days a week. Says bus driver Paul Wroblewski, "Passengers have been very keen on the new fuel cell buses. The quietness inside the bus has allowed me to overhear some lively discussions about the new technology and their new found knowledge."

Are we there yet?

Not quite. There are a few drawbacks to hydrogen:

- It takes quite a bit of energy to extract hydrogen from water.
- Hydrogen, a gas at room temperature, is difficult to store: It has to be strongly compressed – requiring pressure safe storage tanks – or liquefied by cooling (cryogenic hydrogen).
- Fuel cell technology is relatively new and the cells are fragile and expensive.

Work is ongoing to develop less costly fuel cells that meet or beat the performance specifications for the applications in which they are being used. Researchers recently announced an alternative method of creating hydrogen directly from sunlight and water through a metallic catalyst, which may provide an economical, direct conversion of solar energy into hydrogen. Scientists are also investigating metal hydrides and crystalline materials as solutions to the storage problems. Metal hydrides result from combining pure hydrogen with a pure or alloyed metal and permit a higher storage density of hydrogen than compression.

In a relatively short time, research and human ingenuity have developed what was a moribund technology into a possible solution to the renewable energy problem, providing clean and attractive vehicles. Who knows what other nuggets may lie languishing in faded scientific papers and patent information?