Fuel cells: future shock

Few investors or funds are sure of the structure and direction of one of the most significant 'below the radar' markets. In the wake of the UN Bali Global Warming Conference R&R invited **Phil Doran** and **Simon Robeson** of Core Technologies (CoreTec), to help us get a grip on

Fuel cells can potentially power any device that can be powered by electricity, in other words, virtually anything. They are also an underperforming sector within the wider renewable energy industry. In this article, we set out to uncover why this is and yet, despite this, possess all the hallmarks of a technology with significant potential for venture returns.

The technologies

There are essentially five related, but distinct, fuel cell types. Each generates electricity and useful heat electrochemically, using a different type of electrolyte material to facilitate the conversion of hydrogen gas (H_2) and oxygen (O_2), taken from the air. This essential difference between fuel cells determines their respective operating characteristics which in turn largely determines the types of application (automotive, stationary, consumer electronics, etc) each fuel cell system is ideally suited to power.

Given the vast array of prospective markets it would be misleading to view the huge potential of fuel cells from a winner-takes-all perspective. In short, there is room for many players. There are also substantially different price entry points for those various markets (from premium to commodity – again, in common with other industries). This is clearly why the premium markets are likely to provide companies with the earliest sales opportunities.

It is also important to note that, while fuel cells can potentially meet the growing demands of

Comparative fuel cell types by electrolyte, applications, power and heat capabilities

Electrolyte classification	Polymer (PEMfuel cell)	Alkaline (Afuel cell)	Phosphonic Acid (PAfuel cell)	Molten Carbonate (MCfuel cell)	Solid Oxide (SOfuel cell)
Operating temperature	50 – 100°C	50 – 100°C	~200°C	~600°C	500 – 1000°C
Electrical Efficiency	40-50% ~20%*	70%	40 –50%	50 – 60%	50 – 60%
Potential power range	50 watts – 200 kW	20kW	200 kW	200 kW – single-digit MW	500watts – single digit MW
Potential application areas	Automotive, electricity, and heat generation portable electronics	Aerospace	Electricity and heat generation	Electricity and heat generation	Automotive, electricity and heat generation, portable electronics

Adapted from: Doran et al, 'Introduction to Fuel Cells', UBS Warburg, November 2000
**Refers to Direct Methanol Fuel Cells, a variant of PEM technology*

"significant potential for venture returns"

environmental legislation and energy security, the success of the technology is not dependent upon these issues. The main attractions of fuel cells are that they represent an inherently efficient, disruptive technology that will affect how goods and services are manufactured, delivered and consumed. In addition to changing existing markets they will create, as yet, unanticipated new products and services, opportunities and benefits. Fuel cell companies have moved from talking about technology to talk of competition based upon price, not environmental performance.

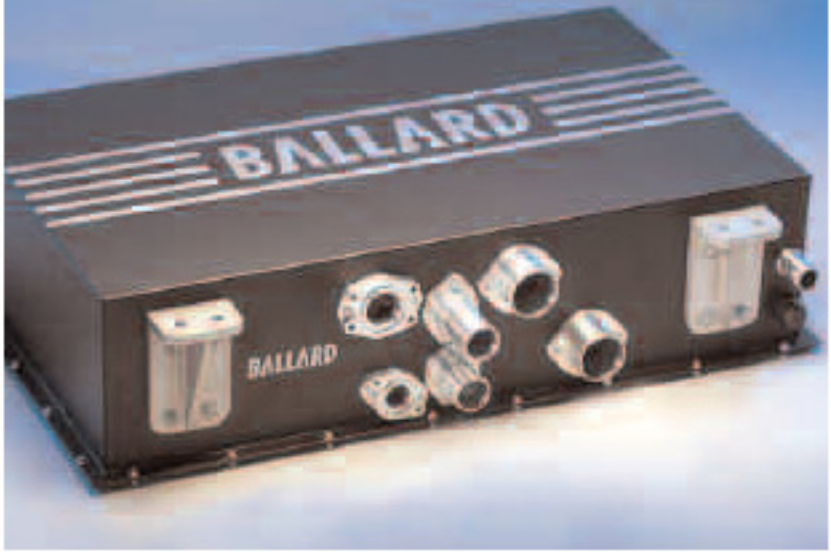
Flexibility

From a technical viewpoint, the attraction of the technology lies in two key characteristics; on the one hand their applications flexibility, and on the other their fuel flexibility.

The chart presents a family of fuel cell technologies which are, in principle capable of powering any device that can be powered by electricity. These range from low-power consumer and defence electronics such as lap-top computers and night vision equipment to all manner of transport vehicles, from speciality vehicles in airports and factories to passenger cars and municipal and commercial vehicles, to residential and commercial buildings and multiple-megawatt industrial plant. There is no technology on the horizon that comes anywhere near matching this range of applications.

In terms of fuel flexibility, fuel cells can be powered by any fuel that contains hydrogen including oil and gas, alcohols and bio-fuels as well as the carbon-free hydrogen generated from wind, solar or even nuclear power. As such fuel cells offer the prospect of a bridge between today's fossil fuel economy and any future hydrogen economy.

At the heart of any fuel cell system is the membrane. The picture is of the Ballard Proton Exchange Membrane (PEM) fuel cell power module, designed for integration into light- or heavy-duty vehicle applications

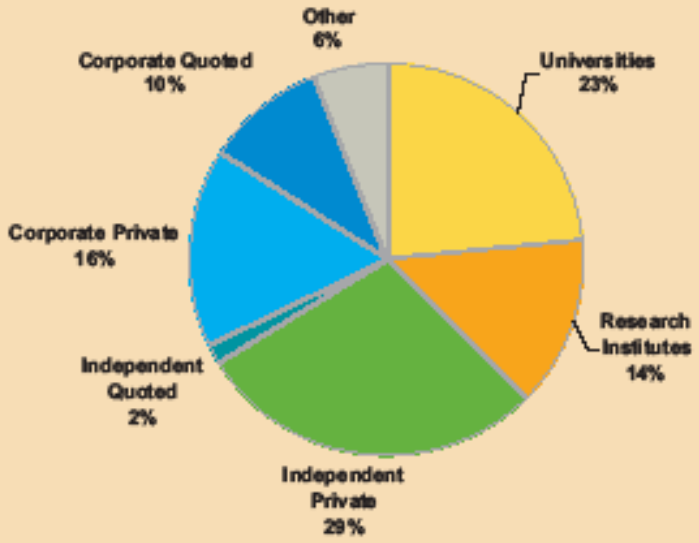


'Below the Radar'

The fuel cell industry, for the most part, is one of those 'below the radar' sectors and to some degree is beyond the scope of the traditional VC community. In part this can be explained by the fact that it displays all the characteristics of a disruptive technology being advanced by a huge number of independent developers. Roads2HyCom, an EU-backed consortium is charged with mapping the European Hydrogen and fuel cell industry, estimates that today there are some 1,500 'entities' engaged in H2 and fuel cell technology development in Europe. The Roads2HyCom graph (Graph 1), based on a web-based survey of several hundred H2 and fuel cell developers supplied by the project, gives some insight into the structure of the European fuel cell industry. The chart clearly shows that the European industry is numerically dominated by independent private developers (29 per cent) and academic and research institutes, which account for a combined 66 per cent of the sample, while the combined corporate sector accounts for a more modest 26 per cent.

Fuel cells are a unique technology both in terms of the range of market applications and their fuel flexibility. As such, they have the potential to compete in any market where electricity can be used to power equipment. Such markets range

Graph 1: structure of European fuel cell sector



Corporate: refers to economically successful companies whose main business activity is not the development of hydrogen and fuel cell technologies, e.g. Johnson Matthey; (quoted) Schunk (private)

Independent: refers to companies whose business activity is exclusively the development of hydrogen and fuel cell technologies, eg. ideTech, (quoted), h-tec (private)

Source: Roads2Hy.com

"…one of those 'below the radar' sectors"

from consumer and defence electronic devices to the provision of residential, commercial, industrial and remote power supplies to all manner of transport applications. The profitability to be earned from securing even a modest share of any one of these markets is vast. As previously noted, the combination of both fuel and applications flexibility makes fuel cells the most likely bridge from today's carbon economy to any future renewable, carbon-free economy.

There is a growing confluence of global policy concerns, epitomised in December's UN organised Bali Global Warming Conference, which fuel cells are uniquely suited to mitigate. On the one hand, fuel cells meet the need to reduce carbon emissions, even when powered by fossil fuel owing to their superior efficiency, and at the same time virtually eliminate local air and water pollution problems owing to their electrochemical method of energy conversion. On the other, the wide-spread introduction of fuel cells will go some way to lessening the West's dependence on fossil fuels, thereby meeting the goals of energy security.

Against this regulatory and policy backdrop the wider renewables sector has continued to evolve and expand. For example, since its launch at the end of 2003 the Jefferies Global Clean Technology Composite IndexTM, which includes solar, wind, fuel cell, microturbine, battery technology and biofuel companies has risen some 245%, and 78% over the first 11 months of 2007.

Bubble

Following the listing of Ballard and Fuel Cell Energy in the mid-1990s, a number of fuel cell companies in the US took advantage of the technology bubble and the euphoria surrounding fuel cells and undertook both primary and secondary stock market issues, between 1999 and 2000. During this time, regulators, policy makers and investors saw fuel cells as a revolutionary

"…capable of powering any device that can be powered by electricity"

Automotive power solutions

Daimler AG has taken a majority 51.1% stake in Automotive Fuel Cell Cooperation, a company founded in November 2007 for fuel cell applications in the automotive sector. With the newly founded company, the globally leading position in automotive fuel cell applications is to be further expanded together with Ford Motor Company and Ballard Power Systems. Ballard Power Systems transfers its automotive division to the new company to be able to concentrate on the marketing of stationary fuel cell applications.

With numerous patents and 150 highly specialized employees, Automotive Fuel Cell Cooperation is the technology leader in automotive fuel cell stacks. The new company is to be a guarantor for the successful further development of automotive fuel cell technology and will closely cooperate with the research and development departments of the automakers involved.

Sixty Mercedes-Benz A-Class F-Cell passenger cars, like the one seen here, are being operated by customers in Singapore, Japan, Germany and the U.S. In addition, 33 Mercedes-Benz Citaro buses are in revenue service on roads in varjous parts of the world. Daimler AG acquired Ballard in April 2007 after powering more than 100 vehicles on its fuel cell technology around the world.

"…risen some 245%, and 78% over the first 11 months of 2007"

technology with the near-term potential to solve many of society's energy and environmental problems.

The bursting of the bubble coupled with the realisation that fuel cells were further from commercialisation than the market had been led to believe resulted in many within the financial community swinging sharply against the sector. Europe witnessed its first fuel cell IPO in June 2004 with the flotation of ITM Power and since that time more than 10 fuel cell companies have listed on AIM, including North American, German, Italian and Australian as well as British developers. Despite the various macro drivers that have thus far supported the wider renewable energy sector, only three of these companies have performed well since flotation. The rest are trading below their listing prices.

There is little venture capital funding available to European H2 and fuel cell developers. According to the Roads2HyCom survey venture capital has so far played a minor role in the financing of the European H2 & fuel cell sector. As a group, independent developers reported that less than 15% of their financing was sourced from venture capitalists.

The funding gap for H2 and fuel cell players is exacerbated by the absence of significant venture capital expertise and variously inappropriate local, national and EU funding programmes. This is extraordinary considering the importance given to the sector by both the EU and various national governments. To date, AIM has filled the gap and this has enabled a number of very early stage developers to breathe life into their programmes.

"…AIM is…closed to the H2 and fuel cell sector"

Commercialisation

However, at the time of writing, AIM is to all intents and purposes closed to the H2 and fuel cell sector as participants are generally unable to demonstrate profitability within 18-24 months of an IPO. This inevitably cuts of the majority of developers from staging an IPO, but opens the way to some attractive investment opportunities for venture capitalists.

There are signs of a slight narrowing of the funding gap both in terms of the increasing relevance of national and EU funding to developers and the interest being shown by the venture capital community as the technology nears commercialisation, in certain of its application areas. Investment valuations are also coming down thanks to falling quoted company valuations and more realistic timetables to commercialisation as investors learn from previous mistakes. 25 investments were made in private developers in 2006 with 20 in the US and five in Europe. This represented a year on year 30% increase in funding by number of investments and a 120% increase in the amount invested to $231.3m.

At the macro level, privately and venture funded development is backed up by that being carried out by established industrial players. All of the world's major auto companies have long-standing fuel cell development programmes. Indeed, Honda and GM recently announced they would each be making over 100 fuel cell cars available to the public in selected US cities in 2008. Honda and GM are not alone with the fuel cell fleets of most of the major manufacturers continuing to expand as reflected by the increasing number of field trials.

The highly successful European CUTE project (2001-2006) operating 27 Daimler/Ballard fuel cell buses in nine EU countries has been succeeded by the HyFleet:CUTE project, (2006-2009), which operates 47 buses in seven major European cities plus Beijing and Perth in Australia. The Japanese H2 and Fuel Cell Demonstration Project, field testing 60 fuel cell vehicles supported by 11 hydrogen refuelling stations, was established in 2002 and is due to end in 2010. In the US, the California Fuel Cell Partnership has been in operation since 2000 and is now the largest fuel cell vehicle demonstration project in the world with 102 cars and seven buses currently in operation. They are supported by 25 hydrogen refuelling stations, with a further 10 planned.

Over the course of the past few years Europe has seen the installation of more almost 13MW of fuel cell capacity, while the US has installed more than

Membrane advances

ITM Power (AIM: ITM) has developed a new generation of membrane and cell design which has reduced the cost of its electrochemical cells significantly below those based upon Nafion (a membrane developed by DuPont in the 1960's and used in over 90% of low temperature PEM fuel cells). For example, its last publicly disclosed cost achievement for its electrolyser and fuel cell were $164/kW and $500/kW respectively and ITM puts forward costs of $50/kW and $100/kW respectively which compares to other low temperature (PEM) cells in the thousands of dollars per kW. ITM has, however, suffered from a lack of belief in its technology, partly due to the industry's numerous false starts and broken promises. This skepticism has been further fuelled by ITM's strong and insular IP strategy (it does not intend to supply components or membrane, is very selective when choosing commercial partners and is entering commercial production itself) which it believes will maximise shareholder value for its technology.

CHP developments

Ceres Power (AIM: CWR) and British Gas have jointly won the Rushlight Hydrogen and Fuel Cells Award for their collaboration on combined heat and power (micro-CHP) systems for small-scale residential micro-generation. The Rushlight Awards are designed to celebrate the significant achievements of UK and Irish technology, innovation and commerce in helping to address the key issues of climate change and waste management.

40MW. The overwhelming majority of these systems are connected to the natural gas network from where the hydrogen needed to power these units is sourced. These systems have been deployed in single and multi-family homes, banks, hotels, hospitals company headquarters and factories. Meanwhile many fuel cell companies are now focusing on the high value UPS and back-up power markets. UPS sales for 2006 exceeded 300 units, an increase on the previous year of 25.2 per cent.

The portable fuel cell sector is widely regarded as being closest to commercialisation. Toshiba, for example, unveiled its DM fuel cell multi-media 'Gigabeat' unit, which is scheduled for market introduction in 2008. The company is now focusing on developing standardised refuelling, allowing all of its forthcoming fuel cell laptop, mobile phones and other devices to be refuelled from a single methanol-based system. Crucially, there have been important legislative breakthroughs in the portable sector, notably the International Civil Aviation Authority's (ICAO) ruling on 1 January 2007 allowing fuel cells and up to two refuelling cartridges onto planes. A subsequent ruling from the US House of Representatives has brought US national law in this area into line with that of the ICAO.

Progress

Despite this history of underperformance in the quoted markets, it is our opinion that the investment community should continue to watch the fuel cell sector carefully. Whilst long-term transport markets continue to absorb investment from the large automotive companies, the prospect of much nearer-term markets in the UPS, the highly diverse and large speciality vehicle sectors, and consumer electronics markets will ultimately serve to reinforce investor confidence across the application spectrum.

This view is supported by the robust technical progress the fuel cell industry as a whole has made as shown by the increasing number of systems under demonstration across the world today. In part this has not been reflected in stock performance owing to the industry's structure, which reflects the disruptive nature of the technology.

Depleting oil reserves, exacerbated by the growing Chinese and Indian economies, is the main driver of accelerating developments in fuel cell technology. For investors, staying ahead of the component parts of this technology and understanding the developing supply chains within the industry are the keys to success.

It should also be clear that the industry's emerging supply chain is populated by companies across the globe. As such investors must cultivate, or pay to gain access to, a network that can help to place their potential investment in the context of the global development activity. R&R

Further information:
www.infotools.hfpeurope.org/hfp_pro/
www.coretecventures.com

Phil Doran founded Core Technology Ventures Services (CoreTec) with his partner Simon Robeson, both ex-investment bankers, in 2001 and now has offices in the UK and Germany. The company has become an established provider of alternative energy consultancy services to SMEs, large corporates, investment banks, investors, research institutes and governments. Contact: phil@coretecventures.com

Going commercial with micro-CHP

Energetix (AIM: EGX) begs to differ with the UK Conservative Party when it says its proposed a plan for 'decentralised' energy, where at least 1 million households and businesses would receive financial incentives for generating their own energy, could take a decade to introduce. CEO Adrian Hutchings says its microchip (micro combined heat and power) is available now ready to deploy commercially, and has already been delivered to major boiler manufacturers on the European mainland. The Dutch government alone has pledged to launch 10,000 microCHP units into households by 2009. The units have efficiencies of up to 95 per cent and were shipped to Daalderop BV in the Netherlands and to another major boiler manufacturer on the European mainland.