



FUEL CELL TODAY

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**2007 China International
Hydrogen and Fuel Cell
Investment and Trade Expo
– Event Report**

Shanghai Everbright
Convention and Exhibition
Center, 21st – 23rd July 2007

**Dr Mike Hugh, Fuel Cell Today
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Introduction

The inaugural China International Hydrogen and Fuel Cell Investment and Trade Expo (HFCE 2007) took place between the 21st July and 23rd July 2007 at the Shanghai Everbright Convention and Exhibition Center.

When Fuel Cell Today was asked to participate in the Expo as the English language media partner, it was an opportunity not to be missed. China has long been identified as an emerging economic and social superpower, and here was a chance to find out if the Chinese domestic fuel cell industry matched the scale and ambitions of the nation as a whole. When you think about major national fuel cell industries, for most people China does not rank alongside the United States, Japan or Canada - but maybe this is about to change.

The first question to ask is why should China hold its first major fuel cell Expo now? There are perhaps three powerful reasons why the domestic industries are buoyant and feel the need to showcase their talents on the international stage.

Firstly, the Beijing Olympics, due to be held in just one year's time, have clearly provided a huge impetus to the funding and development of high tech 'prestige' industries. The Olympics are seen as an opportunity to present Chinese technological sophistication to the world, and will result in a major demonstration opportunity for (predominantly) automotive fuel cell applications. One of several thematic titles of the 2008 Games being used by its organisers is the "Green Olympics", giving fuel cells yet further opportunities.

Secondly, China is fortunate in that it will host a second major world event a short time later, namely the 2010 World Expo in Shanghai. With these two events held within two years of each other, the domestic fuel cell industry has an enviably public and sustained demonstration opportunity.

Finally, the National High-Tech Research and Development '863' Programme, implemented in 1986 and now in its 3rd phase (each of 5 years), emphasises the need for China to 'leapfrog' current energy technology paradigms. The hydrogen and fuel cell industries of China have benefited greatly as a result. The major universities, notably Tsinghua University in Beijing, have received substantial funding from central government to pursue fuel cell related activities, as have a number of organisations such as local company Shanghai Shen-Li High Tech (more on this company later) and Sunrise Power Company, based in the city of Dalian to the North. The broader goals of the 863 programme are to improve the efficiency of Chinese industry, reduce resource consumption, and mitigate adverse impacts on the environment. This latter goal might not sound like a typical Chinese governmental stance to people who follow, for example, international climate change negotiations, but I strongly got the feeling that local air and water quality in the major cities have been damaged to such an extent that the national and regional authorities are very serious indeed about pursuing cleaner technological alternatives.

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So the time clearly seemed right to the national fuel cell industries to host a major exhibition and invite international colleagues to attend. This was achieved successfully, with exhibitor representation from 15 countries, and attendee representation from many more. In addition, the Expo secured the attendance of a number of major companies from around the world, such as General Motors, BMW, Shell Hydrogen, Johnson Matthey and DuPont. In total, there were 66 exhibitors and maybe around 2000 visitors over the course of 3 days. Whilst established major international fuel cell industry events such as the Tokyo FC Expo or the Hannover Fair are much larger in terms of exhibitor and visitor numbers, for an inaugural event such as this the figures must be encouraging to the organisers, Shanghai Tiansheng Exhibition Service.

The Expo – first impressions

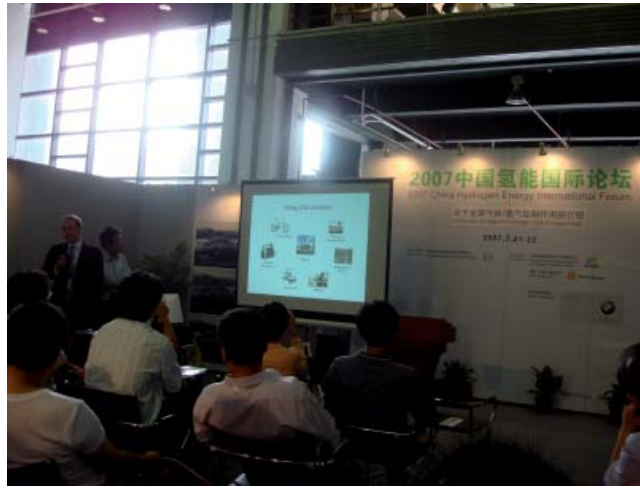
The first day was busy, which was perhaps surprising as it was a Saturday. Speaking from my perspective on the Fuel Cell Today stand, it was pleasing to find that a good number of visitors to our booth (and there were a good number) from China know of and already use our services.

The second and third days were much quieter in terms of visitor numbers, and a number of exhibitors began to pack up in the morning of the third and final day, before the end. The duration of a conference is a difficult thing to judge on the first occasion, and possibly the organisers of HFCE 2008 might consider a more condensed 2-day format. On this occasion there were simply not adequate visitor numbers to justify three days, though this may change in future as the event grows.

It was clear that whilst a number of major companies may not have chosen to actually exhibit at the HFCE 2007, many had sent a representative along to have a look. For an inaugural event, this is not surprising, and I suspect that next year exhibitor numbers will be up following positive reports.

Walking around the hall, which covered some 3,000m², it became clear that there was more to the show than just hydrogen and fuel cells. Also exhibiting were wind power and photovoltaic companies, solar heating companies, general engineering concerns, and primary products suppliers. This is no bad thing – for example, one of the great strengths of the Group Exhibit Hydrogen + Fuel Cells at the Hannover Fair is that the hydrogen and fuel cells section shares a hall with other clean-tech companies, which brings a steady stream of interested but non-specialist attendees to look at the fuel cell exhibits. However, with some organisations at the HFCE 2007, I must confess I struggled to find any tangible fuel cell connection at all.

The structure of the conference assumed what is a now standard exhibition format – a main hall where the company booths were located, an area where small vehicles could be demonstrated, and a walled-off forum which accommodated around 200 people. Due to a good flow of visitors to the Fuel Cell Today stand on Day 1, I was unable to sit in on any talks until Day 2. However the presentations I went to were well attended, although the occasional lack of simultaneous translation was problematic for those of us who did not speak Chinese. It was standing room only at the forum on Day 2, and again the organisers might learn from this for next year and increase the seating area.



The forum – well attended with interesting company presentations. Here, Dragon EnviroPower launches their eMAG 250 metal air unit.

Perhaps the one area which needs improvement is security. The flow of people into the hall seemed to be fairly unrestrained, despite a noticeable police and security presence at the venue, and I was constantly warned not to turn my back on my laptop which was being used to demonstrate the Fuel Cell Today website. Again, this can be put down to 'teething' problems, and I'm sure that this will be corrected by next year.

The exhibitors

It total, there were some 66 exhibitors, of which 12 were foreign companies. In terms of supply chain representation, a good spread of OEMs and systems integrators was present. In terms of applications, transport was dominant – on display were scooters, cars, a forklift and a bus. There were no large scale stationary systems present, nor any residential-scale fuel cells. Only a handful of companies exhibited portable systems. Hydrogen production and storage systems were well represented, as were 2nd and 3rd tier suppliers of materials and basic components.



The China Association for Hydrogen Energy (CAHE) exhibit. Prof. Zong Qiang Mao, Chairman of the CAHE, is seated on the left.

As mentioned previously, HFCE 2007 managed to attract several major international players, which is no mean feat considering they were investing time and money in this conference with no prior knowledge of the likely rewards. But the conference really belonged to Chinese industry, and I was impressed at the effort that local exhibitors had clearly made.

The first exhibitor I visited was Shanghai Pearl Hydrogen Power Source Technology (hereafter referred to as just 'Pearl'). Pearl is a very young company, established in 2006 and now 12 people strong, which is aiming to become a major producer of air cooled PEMFCs. They have applied for 17 patents so far, and their particular design route centres on a cylindrical stack configuration which they claim is more compact than traditional square or rectangular formats. Like many of the fuel cells I saw in China, it operates on ambient pressure in conjunction with a fan instead of a compressor. Miniaturisation appears to be the primary goal instead of high power output. Still, I am told that the power density is in the region of 0.4W/cm² which is respectable.

One of the main advantages of the cylindrical stack format is that fact that it does not require end plates, which normally add to system weight and cost. I am not sure if the requirement for endplates in square-type stacks is genuinely a serious technical problem in need of a solution, but the effort taken by Pearl to develop novel engineering strategies should be applauded. Technical boundaries, real or perceived, should always be pushed.



Mr. Dong Hui, Vice President of Shanghai Pearl Hydrogen Power Source Technology Company Ltd., demonstrating his company's metal-hydride powered PEM bicycle.

In terms of markets, Pearl is looking at small transport applications, and I was shown a converted 'e-bike' (electric bicycle). I saw thousands of lead-acid battery powered e-bikes whizzing around Shanghai, and was subsequently told that this was because the local authorities have banned gasoline-powered motorbikes because of the adverse impact on local air quality. Thus, an instant and massive potential fuel cell market has been created. There were 85m e-bikes on China's roads in 2005, and an annual growth rate of 13% has been conservatively estimated. The model I saw was essentially a conventional, locally mass-produced e-bike frame, retrofitted with the Pearl PEMFC. Pearl is looking to move into mass production within a couple of years, and is targeting overseas markets as well as domestic. They have been negotiating with an unnamed UK importer, but apparently some design changes have been requested before completion of any deal. The PEMFC of the bike is rated at 240W, and can get around 80 km from a charge of 2 metal hydride canisters.

Pearl has big plans, and is looking to develop systems for forklifts, golf carts and small boats (another significant market in China, as several provinces have banned gasoline motorboats from lakes for environmental protection reasons). For a company that has been in existence for a little over a year, and given that (unusually for Chinese fuel cell companies) it is entirely funded by private sector business angels and receives no money from government, its achievements are impressive.



An aisle in the latter stages of the HFCE 2007 Expo. The first day was by far the busiest.

From very small industry to very large, next I visited General Motors. GM had brought their HydroGen 3 along to the HFCE 2007 Expo. This car is one of a fleet of demonstration vehicles GM takes around the world, but the model on display is now permanently located in China. As such, it had been fully decked out in Chinese livery, including a new grill badge with the Chinese character for 'hydrogen'. I have seen the HydroGen 3 several times before, and must confess to being slightly disappointed that they had not brought along their new Chevrolet Volt, which was unveiled in Shanghai just a couple of months previously. An opportunity missed.

Opposite the GM stand were BMW, with their (now almost ubiquitous) 7-series hydrogen combustion car. No fuel cell, and a completely different strategy for breaching a hydrogen-powered market than that of GM and most of the other major automotive companies, but a very impressive car nonetheless.



Big name automotive companies were out in force at the Expo.

(Left) General Motors' HydroGEN 3, complete with Chinese character on the front grill saying "Hydrogen". (Right) BMW's hydrogen combustion-based 7-Series exhibit – fuel cell vehicles were not the only hydrogen technologies on display at the Expo.

Next up was Shanghai Shen-Li High Tech Company, whose facilities I had been fortunate enough to visit a couple of days before the Expo. Shen-Li is one of the three largest fuel cell developers in China, together with Dalian Sunrise Power and Wuhan WUT New Energy Company. The company was established in 1998 and now has around 120 employees working within its 30,000m² production facility. It had taken the opportunity presented by the Expo to unveil its latest product – a PEMFC forklift truck.

Shen-Li develop a wide range of system sizes, from 10 W to 150 kW. It focuses exclusively on PEMFCs, working at ambient pressure and relatively low temperatures. Shen-Li has developed and successfully demonstrated a number of fuel cell vehicles, including buses, cars and now the forklift. The 2008 Olympics will provide yet further opportunities for demonstration – of the 20 or so fuel cell vehicles planned to be in circulation in total, Shen-Li is aiming to supply fuel cell systems for at least 10 of these (Dalian Sunrise Power will be the other main contender). Looking beyond the Olympics, the “Tens, Hundreds and Thousands” programme [1] of the Shanghai local government will present another major opportunity for Shen-Li.

The company is also keen to branch out into international partnerships and markets. The forklift has been developed in collaboration with Infintium Energy of the US, and Shen-Li will apply for a supply contract in Transport for London’s flagship demonstration programme in 2010. The company reportedly already has a major supply contract to export up to 41 buses to the city of Rome between 2007-2008.

Looking the future, Shen-Li will be looking to concentrate its activities on buses and forklifts, with mass production firmly in its sights. Looking at historical performance figures for its stacks, between its 1st and 5th generation passenger car products it has achieved major improvements in net power output (from 33kW up to 55kW), power density (from 77 W/Kg up to 245 W / Kg), and weight production (426 Kg down to 230.9 Kg). The government, far and away the single most important source of funding for fuel cell development in China, clearly has confidence in Shen-Li’s potential - the company has attracted around US\$30m from the National 10th 5-year plan and other governmental sources.

Another company launching a product at the HFCE2007 Expo was Dragon EnviroPower, who unveiled the eMAG250 on behalf of MagPower Systems of Canada. Dragon EnviroPower holds the exclusive manufacturing and distribution rights for both the eMAG 250 product as well as its refuelling cartridges. The system uses a magnesium fuel source and a proprietary electrolyte management system. It is worth pointing out that there is some debate as to whether metal air products such as the eMAG 250 are indeed fuel cells at all - it is a question of which technical definition of ‘fuel cell’ you chose. The fundamental operation of such products is different from that of fuel cells in the conventional definition, but there are a number of similarities and the output is impressive. The eMAG 250 produces 250 W DC output with a 20 amp capacity. It is noiseless, pollution free at the point of use and non-toxic. It is certainly easy to use, with the magnesium cartridges being pulled out by hand and replaced once spent. The unit itself looks good – simple and rugged, with a commercial build quality about it.



Mr. Kevin Leung, General Manager of Dragon EnviroPower International, demonstrating one use of the eMAG 250 metal air 'fuel cell', which was unveiled at the Expo.

The applications envisaged are all those where lead acid batteries are currently used – such as e-bikes, trolling motors for fishing boats, and soldier power in the lucrative military market.

The company has a highly aggressive business plan which aims to produce 30,000 units by the end of 2008. The initial market, interestingly, will be New Zealand, apparently because of the nation's high new technology adoption rate and the environmental sensibilities of its population. Dragon aims to have a positive cashflow within 6 months, and to be profitable within just 1 year. If it manages it, this will be remarkable achievement.

Finally, it is worth mentioning Wuhan WUT New Energy Co., one of the big 3 Chinese fuel cell companies. Established in 2006 as a spin-out from the Wuhan University of Technology (WUT), it is primarily a PEMFC MEA supplier (indeed it is the first dedicated MEA producer in China) although it also offers catalyst coated membranes (CCMs). Wuhan, like Shen-li and Sunrise, has attracted significant government funding, partly through WUT itself (universities in China are almost exclusively publicly funded).

In terms of route to market, WUT has already established production lines for 'mass' fabrication of PEMFC CCMs and MEAs, which it sells mainly to US and Chinese fuel cell companies and universities.

This concludes coverage of the HFCE 2007 Expo. By way of a conclusion, here are some final observations about the Expo as well as the wider state of the fuel cell industry in China, formed from visits to various fuel cell companies away from the exhibition:

Final observations

- **First time difficulties**

The HFCE 2007 Expo did not go off without a hitch, for exhibitors and possibly for visitors too. Starting with minor gripes, some of the amenities that regular conference goers have come to expect such as on-site availability of food appeared to be lacking. Security for exhibition equipment was also a problem. As has been mentioned previously, the Expo was a day too long, given the number of exhibitors present. Annoyingly, for foreign delegates, there was a lack of consistent simultaneous translation in the forum. However, it must be emphasised that for some of these difficulties there were genuine mitigating circumstances, and in any case all of these problems are easy to correct before next year.

- **Exhibitor list**

Attracting 66 exhibitors, including 12 foreign companies (amongst them some of the largest brand names in the world) for a first conference is a great achievement. It should be remembered that although they are disproportionately bigger and well attended today, established annual events such as the Hanover Fair had significantly fewer exhibitors than the HFCE 2007 did at the first time of asking. The international fuel cell conference calendar has become very congested in recent years, and organisers are now in open competition for the limited travel budgets of their clients, the exhibitors and visitors. It is into this difficult and now mature market that the organisers of HFCE 2007 have jumped, and it has been a successful entrance. The Expo was dominated by Chinese industry, and this may be a strong selling point for an international audience that is now familiar with fuel cell developments outside of China but less versed in developments inside it.

- **Heavy emphasis on transport applications in China**

In terms of fuel cell applications, transportation was easily the best represented. Everything from forklifts to e-bikes to buses was on display. I saw less than 5 stationary systems, and even fewer portables. The reason for this is probably linked to the prevailing funding structure of the Chinese fuel cell industry – namely government funding which comes with strict conditions as to how the money can be spent. The overriding priority in the field of fuel cells for the Chinese government is to try to alleviate the all-pervasive problem of poor local air quality in cities, hence funding is directed accordingly.

This heavy emphasis on transport applications (invariably PEMFC-based) in China may have been chosen by government for pragmatic reasons, as suggested above, but there are potential downsides for the national industry as a whole in pursuing this somewhat one-sided technology development path. Historically, the majority of worldwide research and development funding has gone into PEMFCs for transport applications. Chinese industry (and, by default, government) is therefore attempting to enter a market that is perhaps not saturated, but certainly well-subscribed. Their competitors in the US, Japan, Germany and Canada have the advantage of decades of development experience, and, in many cases, significant financial backing not just from government but from big industry as well. Another observation is that profits in many transport markets are thought by many commentators to be a more distant prospect than for other fuel cell applications. Chinese fuel cell developers will therefore need to secure governmental funding for many years to come in order to bridge the gap between now and profitability, if the lack of funding from the private sector in China continues.

- **Strong government support for fuel cells**

Government support for fuel cells is generally directed by the priorities set out in the 863 Program. However the Programme is rather general in nature, as it encompasses such diffuse topics as high-tech agriculture, IT, and bio-technology. The goals of the 863 Programme are a complex mixture of giving China a technological edge over developed countries by 'leap-frogging' technological paradigms, increasing the efficiency of China's notoriously inefficient methods of production, environmental protection, and national prestige. Fuel cells can satisfy many of these general goals, and at one level local industries appear to have benefited greatly from the patronage of government. Of course, the downside of a proscriptive approach to funding is that the freedom to innovate can be stifled. Incidentally, environmental protection is taken very seriously by government of China, contrary to popular understanding outside of the country. However, the emphasis is firmly on solving the occasionally dire condition of local air and water quality, rather than on minimising CO2 emissions.

- **Excellent and sustained fuel cell demonstration opportunities**

The Chinese fuel cell industry has a double opportunity ahead of it to showcase its talents and make an impact on the international scene. First the Beijing Olympics in 2010, followed by the World Expo in Shanghai in 2012, has leveraged large sums of money from government and has also created an almost perfect marketing opportunity. The fact that the Shanghai World Expo follows 2 years after the Olympics means that investment will be sustained beyond the brief duration of the Games. Beijing already has 2 hydrogen refuelling stations, and Shanghai will get its first very soon.

- **Large and distributed sources of industrial by-product hydrogen**

China's vast requirements for steel have resulted in massive amounts of by-product hydrogen. Hydrogen is produced in the process of making coke from coal (in turn coke is used to manufacture steel). This by-product hydrogen is currently fuelling almost all of the country's fuel cell vehicle demonstration fleet, and this is likely to continue long into the future. Today, virtually all of China's by-product hydrogen is simply vented into the atmosphere, but companies such as Boqing Gas (unsurprisingly part of the Bao Steel Group) have begun to market and distribute by-product gas. Furthermore, the diffuse geographical distribution of coke plants across China means that when it comes to building a national hydrogen infrastructure, expenditure can be limited to relatively local distribution infrastructure costs rather than long-distance, cross-country distribution.

- **High-tech innovation, not just low cost manufacturing**

Many Chinese companies I spoke to were keen to point out that they are now capable of developing their own genuinely high-technology products, not just cheaply mass-producing products designed elsewhere. Still, there are few (or no) Chinese companies which feature alongside technology leaders of the level of Ballard, UTC or Toshiba, and it will be a few years yet until the preconceptions of the international industry are broken down. Also I was told by a number of Chinese companies, and in no uncertain terms, that the frequent accusations levelled at them of a lack of due regard for international patent protection are unfair and inaccurate.

- **Lack of involvement in fuel cells by large domestic companies**

Most fuel cell development work being done in China is carried out by relatively small concerns, usually companies which were set up specifically to make fuel cell parts or systems.

This is at odds with the prevailing model in other countries, notably China's Asian neighbour Japan, where the majority of development is carried out by large companies whose principal interests are elsewhere (e.g. Tokyo Gas, Honda, Toshiba etc.).

- **Demonstration and route to market rather than technical perfection**

Chinese fuel cell companies seem intent on being first to market, rather than on developing the most refined technology. The rate at which the companies develop a product is phenomenal (for example, Pearl), but then the sole thought seems to be getting their products to the market rather than tweaking the product for optimum performance. It is a very practical approach, and this carries over to the way in which demonstration programmes are aggressively pursued. From a very modest start just a few years ago, the Chinese industry has advanced rapidly, and the desire to see vehicles on the road rather than in the lab or at exhibitions seems to be paying dividends. The technology may not be as advanced as in those produced elsewhere, but I would not bet against being able to see more of it about over the course of the next few years.

- **Legislated niche markets**

The banning of conventional motorbikes in Shanghai and of fossil-fuel powered boats in other provinces has created instant and sizeable market opportunities for fuel cells. This is perhaps an example of government influence on markets at its most direct, and is peculiar to nations such as China which retain a high degree of central planning.

- **Strong university research base**

China now has some of the world's largest and well-funded universities, notably Tsinghua and Beijing Universities. The leading institutions have large amounts of government funding, and will be more than able to support the expansion of the technical workforce for the growing domestic fuel cell industry. Tsinghua University in particular is heavily involved in fuel cell research and, interestingly, demonstration (it has its own fleet of 5 domestically produced fuel cell buses, and many more cars).

- **A bright future for fuel cells in China?**

Quite possibly - but it is hard to predict in which sectors the Chinese fuel cell industry will ultimately find success. The government (both national and, in some cases, regional) is clearly highly supportive of fuel cell technology development as it sees it as a way of alleviating massive problems associated with local air and water pollution, improving general manufacturing efficiency in other areas, and tangibly demonstrating the nation's technological sophistication to the rest of the world. However, public funding is usually provided with the proviso that it is directed towards the development of transport applications. Whilst at one level government funding is beneficial to developers, in the long run problems may arise. For example, due to the costs of building up a refuelling infrastructure, transportation applications have perhaps the longest "valley-of-death" – i.e. the period between development of a product and its commercialisation - of any fuel cell applications. Over-reliance on one source of funding over this protracted period carries inherent risks.

However, the forthcoming 2008 Olympics and the World Fair in 2010 in Shanghai offer domestic companies a golden opportunity to gain supply contracts for the showpiece demonstration programmes, as well as a platform for selling their technologies and capabilities to the wider fuel cell world.

China has a solid and well-funded university base which will continue to provide highly skilled engineers and innovators to the fuel cell industry. The industry appears to produce new products at a frenetic pace, though within the confines of its mandated technology applications. There is also great importance placed on demonstration.

Chinese fuel cell companies are determined to become as well known for their high tech capabilities and innovation as they are for low cost production. They have successfully replaced a reputation for low-cost, low-quality production with one of low-cost, high-quality production, but this is the start and not the end of the industry's aspirations. It may be a few years yet before Shen-Li High Tech or Sunrise Power are spoken of in the same terms as Ballard or Plug Power, but the current rate of progress is such that it is not an unrealistic proposition over the next 5-10 years.

And finally...

- **Most freakish exhibit award**

No fuel cell conference is complete without some general weirdness. The award this time goes to the manufacturer, whose name I did not catch, of the fuel cell-powered personal stun gun. Sadly I also have no photo: the man waving the gun around looked bored, and in order to liven things up, I think he was suggesting that he give me a demonstration. However as I have an aversion to being shot with high voltage electricity, I beat a tactical retreat.

- **Best named company award**

Amongst a host of exotically named Chinese fuel cell companies (Dragon, Sunrise, Pearl, Golden Energy, Beijing Hold Fortune Industry Company...), first prize goes to – the Tianjin Number One Technology Company. No contest!



Well done.

Notes

[1] The “Tens, Hundreds and Thousands” Programme has already been launched by the Shanghai local government. The original plan was to have literally thousands of fuel cell vehicles on the roads of Shanghai by the 2010 World Expo. This ambitious target will certainly not be met, but the Programme will nonetheless catapult Shanghai into a leading position of worldwide fuel cell demonstration sites, with hundreds of vehicles likely. Exact target figures are not available.

About the author

Dr. Mike Hugh works as a Senior Analyst, Asia for Fuel Cell Today. His main areas of interest are fuel cell markets in the Far East, and fuel cell companies as investment propositions for the financial sector. Mike can be contacted via mikehugh@fuelcelltoday.com.

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