



# 2006 Portable Survey

Gemma Crawley,  
Fuel Cell Today,  
- December 2006



## Market overview

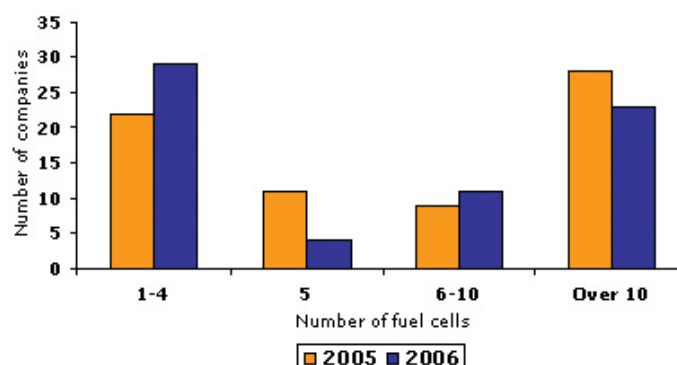
In a year when the fuel cell industry as a whole has seen some exciting developments and taken positive steps towards becoming more commercially successful, the portable sector has been no exception. Whilst news articles were dominated by transport stories at the start of the year, there has been a recent flurry of activity from portable developers, manufacturers and integrators resulting in some exciting commercial prospects.

Perhaps most encouraging of all has been the opinion of many portable fuel cell manufacturers that they have a commercial product ready for launch and the only delay in doing so is coming from external forces such as shipping channels, regulatory governance and insurance processes. This mood reflects just how close to commercialisation many believe the sector to be and the numbers support this view. With over 3,000 new units in 2006 and many key players increasing production figures, the past twelve months have been very promising.

Two main trends have been apparent whilst writing the portable survey this year. Firstly, companies operating in the portable sector are becoming increasingly more cautious in terms of sharing information relating to numbers of units produced. This reflects the move by many organisations to become public companies (and the subsequent impact this has on sharing potentially sensitive information) and the growing awareness within the sector that as it move towards commercial success, data sharing becomes more difficult.

The second notable trend is that whilst several big players have been scaling up production and successfully meeting delivery targets, the sector as a whole has seen a contraction in the number of test, demonstration and evaluation units produced by the smaller companies. For example, several organisations which had previously produced around 5 test or prototype units in 2005 have scaled back to just 1 unit in 2006. This trend can be clearly seen on the graph below. As the number of companies producing 5 units per annum has decreased in 2006, the number of organisations producing 1-4 systems has increased.

Although individually these numbers are only small, together they point towards a trend within the industry for streamlining and the emergence of the first key commercial players in the marketplace.



**Number of fuel cell companies producing units in 2005 and 2006**

Whilst on the surface it may appear to be disappointing that production numbers for the smaller organisations have decreased from those reported in 2005, in reality, the streamlining of the industry is a necessary step to achieve commercialisation. As with any new industry, two or three key players will emerge and the development of one or two units by smaller organisations will begin to decline.

As has traditionally been the case, the driving force behind the commercial development of fuel cells for portable applications remains to be consumer pull for more effective products and cutting edge technology. Government policy has played an insignificant role in the emergence of portable fuel cells for consumer electronics (although military investment for the development of portable soldier power and field communications equipment has aided technology development significantly) and this remains to be largely true. Recent roadmaps and technology strategies may inadvertently help achieve commercial success in the portable sector and this issue will be discussed at a later stage in the report.

One slight disappointment in the past twelve months has been the lack of announcements made by the big electronics companies regarding firm dates for mass commercialisation. Casio heralded the development of a fuel cell for use in laptops but also stated that there were no plans for commercialisation until 2010 at the earliest. DoCoMo has developed a micro fuel cell for its third generation mobile phone handsets but, according to the company, the product will only make its commercial debut "in a couple of years". Hitachi, Toshiba, Samsung and KDDI all announced new prototype units for use with portable consumer electronics products but there have been no press releases stating firm dates for mass commercialisation of these products. A lack of such announcements has led some to question the efforts of these players and if they are falling short. Indeed, the former Executive Vice President and Chief Technology Officer for Nokia Mobile Phones (who is currently a technology adviser to the company) was quoted as saying that fuel cells are not an option for powering new mobile phone platforms. However, others believe that the electronics companies are all waiting on one another and are expecting a flurry of announcements in 2007 from all of the major players unveiling their latest products and stating plans to bring them to market in the period 2007-2008.

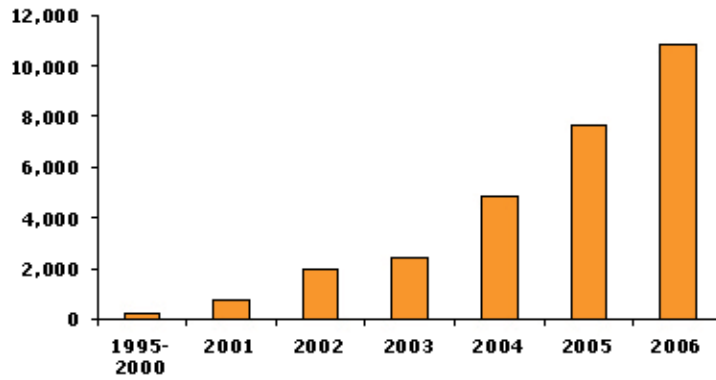
In terms of portable fuel cell development for military applications there has been a lot of activity. Companies such as Idatech, Jadoo Power, Mesoscopic Devices, Millennium Cell, NanoDynamic and Neah Power continue to develop new and innovative solutions to the military's need for portable power. Fuel cell research remains an area of focus for both funding opportunities and development schemes and in 2006 there have been several real-world demonstration programmes jointly undertaken by fuel cell companies and the armed forces.

Overall, the mood within the portable sector remains buoyant as many of the key players continue to look towards 2007-2008 for commercialisation of their technology. The total number of new systems introduced in the past year is certainly significant although one might have hoped to see more evidence of the timeframe for commercialisation.

For the purposes of this survey, it should be noted that the Fuel Cell Today definition of the portable market segment includes units up to 1.5kW which are clearly intended to be moveable and are not used for powering a vehicle or moving contraption. Metal air fuel cells, biological fuel cells and educational fuel cells are also not covered.

### **Market developments**

In the light of new information, we have made some revisions to our 2005 numbers for portable units and the number of systems counted in this year has been reduced slightly. This change has been reflected in the graph shown below which shows number of systems manufactured per calendar year. For 2006, numbers have been included up to 31st December.



**Cumulative number of systems manufactured**

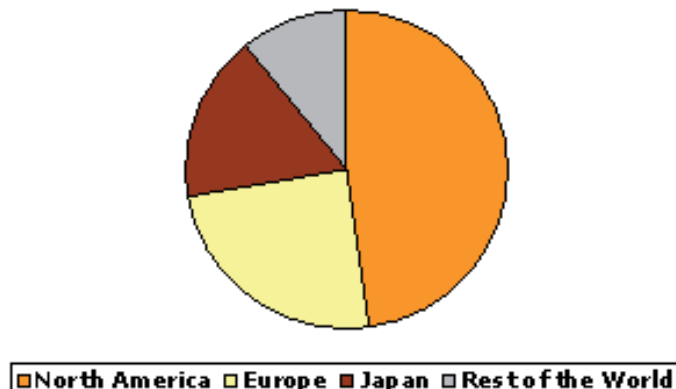
In 2006, the number of new units has been recorded at over 3,000, an increase of 8% compared with the 2005 total. Interestingly, this is not the biggest increase to have been recorded in the history of the Fuel Cell Today portable survey and the change in number of new portable fuel cells manufactured was much more significant between 2003 and 2004. In our 2005 portable survey, the increase in new units between 2004 and 2005 was not particularly noticeable, supporting the earlier observation that the industry is currently streamlining and fewer units are being produced for research and development purposes.

In 2006, the majority of new units have been attributed to companies scaling-up production and increasing the number of systems produced in preparation for larger purchase orders and commercial production in the coming years. Companies such as Idatech, Protonex, Smart Fuel Cell and Voller have begun to ramp up production levels whilst the smaller research institutions have reduced the number of systems produced.

#### Region of development

The graph below shows worldwide portable activity by region of development. It is worth remembering that this is different from region of end use and often, as with the majority of sectors within the fuel cell industry, region of development and region of use for portable fuel cells varies widely.

It is clear to see from the chart that North America accounts for just under half of the global activity in the portable sector and has by far the largest number of companies involved with the development of fuel cells for portable applications. This is in part due to hefty investment in the sector by U.S. military organisations and a strong focus on military applications which is driving companies forward in this region.



**Development efforts by global region**

Within Europe, France, Italy and Germany continue to lead the way in terms of number of companies involved.

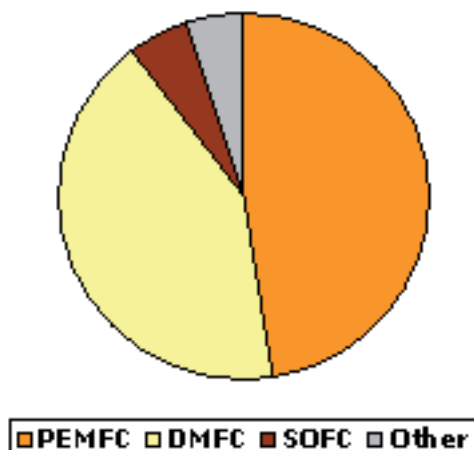
There is some activity in Finland and the UK and the driving force remains to be a desire for more efficient consumer products with a longer battery lifetime. Europe as a whole is pushing forward to reach commercialisation and there have been encouraging sales from companies such as Smart Fuel Cell and Voller.

In Japan, numerous organisations continue the development and testing of fuel cells for use in portable applications including Sony, Casio, Fujitsu, Hitachi, NEC and Toshiba. In the past twelve months much progress has been made in terms of size reduction and companies are aiming for commercialisation of portable electronic applications between 2007 and 2010. Development of portable fuel cells in Japan is primarily undertaken by companies making and selling their own electronic devices (e.g. mobile phones, notebook PCs etc). It is interesting to note however, that nationwide maintenance capabilities for fuel cell powered products in Japan are not expected to be ready in the short term despite many companies claiming mobile phones will be available as early as 2007.

In the Rest of the World region, Samsung in Korea is one of the key players. There is also activity in China from several smaller companies whilst Taiwan is represented by Antig Technology. The Atomic Energy Council in Taipei unveiled a prototype portable system designed to power a DVD player in 2006 and this acts as a good example of the steady research work being carried out in such areas. Whilst activity in the Rest of the World is not necessarily as advanced as that in some other geographical locations, it is interesting to note that development is occurring and this could be an area of significant importance going forward. This view has been strengthened by the actions of companies such as Direct Methanol Fuel Cell Corporation that visited Chinese government officials in 2006 to discuss plans for producing methanol fuel cartridges and fuel cells in the region.

### The Technology Picture

Opinion remains divided over the use of the technology type best suited to portable fuel cell systems. The development of proton exchange membrane (PEM) and direct methanol (DMFC) units remains fairly equal although there has been a slight increase in the number of DMFC units manufactured in the past twelve months compared with the 2005 survey.



Technology type shown by number of developers involved

Some manufacturers continue to work with solid oxide fuel cells (SOFC) but the number of companies working with these systems has not changed since the previous survey. This suggests that the use of this technology has not gained in popularity over the past year. Going forward, it is looking increasingly likely that PEM and DMFC will be the chosen technology type for portable electronic applications whilst SOFC use will remain significant for military systems. Together, PEM and DMFC currently account for approximately 90% of manufacturing activity.

### Government Policy and National Strategies

Although government policy and other forms of national/international strategy have never been the driving force for development of fuels cells in portable electronic applications, they are beginning to have a greater impact on the industry. As the sector takes its first steps towards commercialisation the enforcement of rules and regulations

is beginning to help define the path.

For example, as of January 1 2007, the International Civil Aviation Organization (ICAO) will allow methanol cartridges (and some other selected fuels) onboard commercial aircraft. This will enable fuel cells based on methanol to be taken onboard aircraft as 'carry-on' baggage and used during the flight by passengers and crew. This decision is obviously of great importance to fuel cell manufacturers as it could potentially increase consumer appeal of owning a fuel cell powered laptop and removes a significant barrier in terms of practical use of the technology. (In writing this survey we have not assumed any changes to the ICAO ruling in light of recent hand baggage restrictions onboard commercial aircraft).

Furthermore, in early 2006 the International Electrotechnical Commission (IEC) published a safety specification for fuel cells powering personal electronic devices. Fuels covered by this specification include methanol, formic acid, borohydride, butane and hydrogen. Fuel cells for use in devices such as mobile phones, music players, gaming consoles, flashlights and laptop computers will be considered by the specification which will include rigorous testing and design requirements to ensure safety during use and transportation. Compliance with the specification is currently voluntary but is required of devices that would be transported on passenger aircraft under the ICAO regulation previously mentioned.

It would appear that many companies involved in the portable sector are becoming more aware of government regulations, particularly in North America. In May 2006, Neah Power Systems renewed its relationship with McBee Strategic Consulting as the company's outside government relations firm. Originally hired in February 2005, McBee will provide insight and guidance on legislative developments and regulatory processes effecting alternative energy implemented by the US government. This reflects a growing trend of companies to position themselves in line with government policy.

On a more general level, countries and organisations across the globe continue to develop roadmaps, codes and standards for hydrogen storage, PEM and DMFC systems. Whilst the targets set out in such documents do not often refer directly to portable applications and end use markets within this sector, goals remain to be set for the fuel cell types employed by the portable markets and the supporting infrastructure required to develop a fully commercial industry.

## **Conclusions**

With over 3,000 new units introduced to the market in 2006, the past twelve months have been very encouraging for the portable fuel cell sector. Despite the lack of announcements regarding firm dates for commercialisation from big electronics companies, most of the players in this sector retain the view that a tangible commercial market will begin in 2007 and will be fully underway by 2008. This market will be driven by a strong and rapidly rising demand for portable power that has already outstripped the capability of traditional batteries.

With regards to the military sector, advancements in technology and development of fuel cell systems remain to be a high priority. Several organisations continue to work closely with military partners and branches of the armed forces to produce state-of-the-art fuel cell systems for use in portable applications. Funding and investment has been maintained at a significant level and work in this area will continue to drive technological development for the sector as a whole. Going forward, fuel cells for portable power in military applications are likely to enjoy a strengthening and growing market.

Overall, fuel cells for portable applications still have some advances to make in terms of size, weight, power and cost. Manufacturers must continue working towards making their products compatible with lightweight, miniaturised portable electronic products that provide extended run-time and are affordable on a mass market scale. It is likely that early adopters will be keen to own the latest, most technologically advanced products and fuel cell powered electronic devices will find their initial markets (excluding use in military applications) within this group of people. As with any new technology, price is expected to decline over time but manufacturers should not lose sight of making early cost reductions.

Going forward, the next five years will be very exciting for the portable fuel cell community. Several key companies

are expecting to achieve commercial production and sales of their products in the timeframe 2007-2008 (and by doing so achieve first mover advantage) and beyond this point we can expect to see several more manufacturers introducing products on a mass commercial scale. Consumer pull remains strong for electronic goods with longer lifetimes and higher efficiencies than are provided by traditional batteries and military interest in fuel cells remains high.

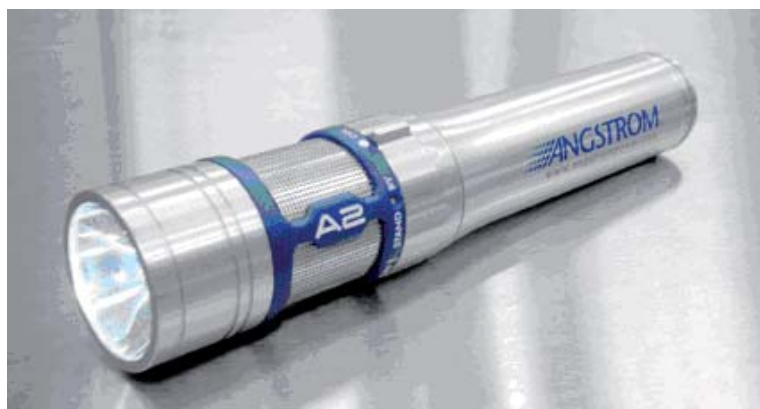
In order to achieve these commercial heights, there are several factors which manufacturers and developers must now concern themselves with. These factors also act as useful pointers to assess the position of the industry. For example, to achieve mass market commercialisation manufacturers must invest in and construct sufficient production capacity and factory facilities. The industry must also achieve a reduction in cost, standardisation of components and the development of regulated codes and standards. Whilst work is ongoing in all of these sectors, efforts must not wane in order that predicted timescales for commercialisation are met.

### **Participants in the Development of Portable Fuel Cells**

Italian fuel cell developer Ansaldo announced the manufacture of a new transportable fuel cell system developed as a mobile power supply for military installations. The system is capable of providing electrical power, heating and air conditioning to mobile military bases and, according to the company, is able to operate on any logistics fuel. Currently, the Italian developer already has three fuel cell installations operating in Europe: two in Italy and one in Spain. A fourth is expected to be operational in the Turkish capital of Istanbul by the end of 2006.

Altek unveiled a new portable alkaline fuel cell power supply system, designed primarily for military applications. According to the company, the new system is a fully self-contained portable alkaline fuel cell system, capable of providing a continuous power output of anything between 20W and 500W. Altek anticipates that the system will be particularly suited to various military applications but is also able to power laptops. Altek also announced that an independent third-party evaluation of its Gas Diffusion Electrode (GDE) and its Membrane Electrode Assembly (MEA) for PEM/Alkaline fuel cells has verified their performance and suitability for portable, residential and transportation applications.

Angstrom Power released its A2 micro hydrogen fuel cell flashlight in 2006. Running on hydrogen fuel stored in the handle and air from the surrounding environment, the 1 Watt LED flashlight delivers a continuous run-time of over 24 hours on a single charge of hydrogen. The A2 is available for purchase and is being targeted for search & rescue teams, military, disaster response units and organisations seeking fuel cell devices for public demonstrations. A larger version of the system is suitable for integration in to a variety of portable devices including two-way radios, handheld scanners and lighting.



**Angstrom Power's A2 micro hydrogen fuel cell flashlight (Courtesy of Angstrom)**

In other news, Angstrom raised US\$18 million (£9.8 million) in funding following a private equity financing deal, which will be used to further its work on high energy density micro-structured fuel cells. The company also announced that it has received approvals from both the US Department of Transportation (DoT) and Transport Canada to ship charged metal hydride systems within and between the two countries. The transportation approvals allow micro hydrogen fuel cell systems from Angstrom Power to be shipped ready for use out-of-the-box.

Taiwanese firm Antig used the CeBIT trade fair in Hanover (which showcased digital IT and telecommunications solutions for home and work environments) to announce that its fuel cells would be on the shelves of computer shops by early 2007. The first product is thought to be a 16W battery charger which can be used for MP3 players, mobile phones, GPS receivers, PDAs and portable multimedia players. Antig has also suggested that the system will act as a secondary power source for laptops extending overall battery life to nine hours. It is widely believed that the fuel cartridges will be supplied by BIC. The MEA incorporated in the fuel cell is supplied by DuPont. Along with partner AVC Corporation (Asia Vital Components), Antig has also launched a CD-ROM size fuel cell pack which runs on methanol fuel and is integrated into notebook PC.

Ardica Technologies announced in December 2006 that the company will locate in Starkville, Mississippi early in 2007. Ardica manufactures portable fuel cells for military and consumer use and intends to partner with Mississippi State, University and local officials in the development of these systems. The company is expected to release its first products at the end of 2007 and hopes to develop a regular flow of production by 2015.

In June 2006, researchers at the Atomic Energy Council in Taipei unveiled portable DMFCs that can power a DVD player for up to eight hours.

Axane, a wholly owned subsidiary of Air Liquide, continues development of its Mobixane fuel cell system for portable power generation. The company expects to launch the pre-industrial development phase by the end of 2006 with industrial production to follow in later years.



**Axane's Mobixane portable fuel cell powered system (courtesy of Axane)**

The Carbon Nanotube Acceleration Project (CNAP), part of the Carbon Nanotechnologies company, has been awarded US\$975,000 by the Texas Emerging Technology Fund for the development of single-wall carbon nanotubes designed to increase the power of micro-fuel cells used to power laptops and other small portable devices. The Texas-based company has already received an equal amount of money from the US Department of Commerce's National Institute of Standards and Technology, with a total of more than US\$2.7 million already contributed to the project.

Casio was one of the few major electronics companies to make a public announcement in 2006 heralding the development of a compact, high output fuel cell for use in laptops and other portable devices. The system is to be powered by hydrogen extracted from methanol and is expected to power a notebook personal computer for 20 hours. However, Casio also announced that it is not aiming to start mass production before fiscal year 2010 at the earliest.

In December 2005, CMR Fuel Cells debuted on AIM. In 2006 the company entered in to a non-exclusive collaboration with Russian based research consortium, ASPECT to develop fuel cells for battery chargers, laptops, power tools, portable generators and other portable devices.

Direct Methanol Fuel Cell Corporation (DMFCC) (a subsidiary of Viaspace) has had a very active twelve months. The company has made several announcements including the completion of development of a new test device for liquid fuel cell cartridges, the application for a patent for a new miniature fuel cartridge valve and cartridge design and manufacturing agreements with Nypro and Hyun Won. The agreements see the companies producing DMFCC methanol fuel cartridges designed for use in fuel cell systems powering laptops, mobile phones and other portable devices. DMFCC has stated that its goal is to establish a global network of partners to manufacture and distribute fuel cartridges. In another joint project, DMFCC extended a current contract with Elentec for the manufacture of methanol fuel cartridges. Under the terms of the agreement, Korea-based Elentec will continue to develop the fuel cartridges with DMFCC until 2011 after which time the companies hope to commercialise the cartridges. The companies claim that the device can recharge a typical mobile phone three times before requiring a hydrogen fuel refill and it is currently designed for use with DoCoMo's 3G handsets.

DMFCC also completed product development of its first methanol fuel cell cartridge in 2006 and announced plans to begin sampling with customers. The cartridge was co-developed with and manufactured by DMFCC's Korean partner, SMC. The cartridge holds 50 cm<sup>3</sup> of 100% methanol and is designed for laptop computers and similar applications. One cartridge is expected to provide five to ten hours of computer operation depending on the efficiency of the fuel cell. DMFCC plans to work with customers to develop cartridges with custom sizes and shapes for their particular applications.

In terms of patents, DMFCC exercised an option and signed two license agreements with the California Institute of Technology (Caltech) and the University of Southern California (USC) for an extensive joint patent portfolio on direct organic fuel cell technology. In addition, DMFCC announced that it exercised an option and signed an exclusive worldwide license agreement with Caltech for three issued and six pending patents on direct methanol fuel cell technology. The patents include technology on micro and miniature fuel cells for small portable applications. DMFCC filed for two additional patents on tamper resistance and authentication of fuel cartridges for fuel cell powered portable electronic devices.

DMFCC's parent company, Viaspace, announced that it is to receive up to US\$23.8 million (£12.5 million) in private financing through a deal with Cornell Capital Partners, a financing solutions company. The financing is to be used for the planned expansion of DMFCC.



**DMFCC's prototype fuel cartridges (Courtesy of DMFCC)**

In July 2006, DoCoMo announced it had jointly developed a micro fuel cell for its third generation FOMA mobile phone handsets with Aquafairy. The battery charger is only 24mm in width and thickness and 70mm in height making DoCoMo claim it is the world's smallest fuel cell with a power output of 2 watts. The product is expected to make its commercial debut "in a couple of years".

US-based DuPont was awarded US\$1.1 million in funding to begin producing methanol-powered fuel cell compo-

nents for use in fuel cells for military applications. The company is expected to begin producing MEAs for fuel cells at their plant in Pennsylvania with the funding provided under the Defence Production Act. The key customer is the US military which will use the units as a power source for communications equipment and weapons systems.

Cleaning and health product company Ecolab unveiled a new air freshener powered by a hydrogen fuel cell in 2006. The new product is designed to provide long-lasting odour-neutralisation and Ecolab claims that it will allow for 60 days of continuous operation. The product is being aimed at the hospitality, healthcare and industrial markets.

Ener1 announced that its subsidiary EnerFuel relocated its headquarters to a larger and better equipped fuel cell facility the company is leasing in West Palm Beach, Florida. The 7,600 square-foot facility will be used to develop experimental materials and fuel cell testing stations in order to bring fuel cell technologies for portable applications to market.

In 2006, Equitex announced a name change to Hydrogen Power International. The company's subsidiary, Hydrogen Power developed a 30 watt portable reactor as part of its Slow Release Programme to be used in portable soldier power applications by the military.

EWI is working with Millennium Cell under a 15 month contract (which will conclude in June 2007) to improve the manufacturing process for Millennium's Hydrogen on Demand fuel cartridges used in portable systems. The work is being funded by a National Centre for Manufacturing Sciences (NCMS)/US Department of Energy programme.

Gas Technology Institute (GTI) demonstrated operation of a high power density SOFC in January 2006. The demonstration used military logistics fuel (JP8). GTI also developed a new membrane for PEM fuel cells in collaboration with the Army Research Laboratory (ARL).

In February 2006 Gecko Energy Technologies and Millennium Cell announced a three year joint development programme for the development and commercialisation of portable fuel cell systems in military, medical, industrial and consumer electronics applications. The venture will pair Millennium's Hydrogen on Demand technology with Gecko's thin planar PEM fuel cells. Initial focus is expected to be on fuel cells for laptops, remote surveillance cameras, long run-time sensors and wireless network and data collection devices.

Genesis Fueltech started 2006 by announcing the company had tripled in size due to a contract with the U.S. Army to provide a portable 250 watt fuel cell system that can recharge batteries in remote locations. The system will weigh less than 25 pounds and prototype is thought to have been produced in 2006.

Giner Electrochemical Systems was awarded a one year US\$830,000 contract by the US Army's Communication Electronics Research Development and Engineering Centre (CERDEC). Under the agreement, Giner will develop and deliver for field testing a 250W field ruggedised DMFC unit. Giner will work with Teledyne Energy Systems on this programme.

Hitachi unveiled a prototype DMFC battery charger at the Tokyo International Forum in July 2006. Despite the fact that the unit was demonstrated by being used to charge a mobile phone handset, Hitachi claims that the prototype has been designed for use in mobile devices that are rechargeable via a USB interface. The fuel cell is equipped with a capacitor that can store electricity before charging the mobile devices and rather than using a detachable fuel cartridge, methanol is injected directly in to the fuel cell body.

IdaTech secured US\$3 million to develop fuel cells for use on the battlefield in military applications. The company has also announced details of a partnership with the Communications-Electronics Research Development Centre (CERDEC), the US Army's technology and research base, which will see it work on a 3kW Tactical Fuel Cell Generator.

Iwatani International is working on the development of hydrogen fuelled PEM systems for power generation in emergency and disaster situations in collaboration with Ebara Ballard. Iwatani supplies a low weight, high pressure hydrogen supply system whilst Ebara provides the fuel cell. The output power of the system is 850W and the dura-

tion has been shown at five hours of continuous operation. It has been reported by some sources that the units have been available for purchase since 2006.

In April 2006 Jadoo Power announced plans to expand its product line and start selling a long-life fuel cell package for powering portable electronic equipment for US\$2,000. Customers are able to buy the system (consisting of a disposable hydrogen battery, hydrogen refill station and fuel cell) through the Jadoo website and the company hopes to open the market for fuel cell use in office equipment, police walkie-talkies, heat sensors used by fire-fighters and ham radios, having historically focussed on video cameras and military surveillance equipment. In July, Jadoo selected Millennium Cell as a subcontractor for one of its military programmes to develop a fuel canister for use with Jadoo's portable systems. In August 2006 the company announced that it had won a contract from General Atomics, Space Power Division to develop and advanced fuel canister for use with hydrogen fuel cells in spacecraft and satellite applications.



**President Bush with a fuel cell camcorder which contains a Jadoo unit (Courtesy of Jadoo Power Systems)**

In other announcements, Jadoo was allocated \$2.4 million (£1.26 million) as part of the US military's Defence Appropriations Bill, the funding to be used to support the company's Socom Power programme which develops portable fuel cells for the military. Jadoo also unveiled the XRT 100-watt fuel cell system which is designed to be used by emergency response teams when stand-alone power is required. The unit can also be configured for telecommunications and laptop power.

KDDI, in collaboration with Toshiba and Hitachi, has introduced two prototype fuel cell mobile phones. The partners have been working together since July 2004 on the development of next-generation fuel cells for use in mobile devices. The phone developed by Toshiba and KDDI has power supplied by a compact fuel cell and tank at the back of the handset with an internal lithium ion battery. The model developed by Hitachi and KDDI is also a hybrid with power supplied by a fuel cell attached on the side of the phone with the LCD sub-display and an internal lithium ion battery.

In August 2006, Kuchera Defense Systems (KDS) awarded Jadoo a contract to develop advanced fuel cell system designs. The contract will focus Jadoo on developing its IFS24 military system for optimisation and weight reduction.

LG Chem and Smart Fuel Cell have entered into alliance for the commercialisation of direct methanol fuel cell systems for consumer electronics. The two companies will advance the existing DMFC technology platform for mobile applications developed by LG Chem and its methanol powered micro fuel cell system as an independent power supply for notebooks, focusing on miniaturisation, reliability, and cost reduction, as well as communications and compatibility with electronic devices.

In January 2006, Lilliputian Systems received an undisclosed amount of debt financing from Hercules Technology Growth Capital. The funding is to be used for the development of next generation micro fuel cell technology for wireless electronic devices such as mobile phones, PDAs and MP3 players.

The Material and Energy Research in Tokyo completed initial development of a portable fuel cell which can be used for emergency power sources and charging mobile phones and note book PCs. The trial products provide 200 W output and measure 25cm long, 17cm wide and 17cm high. The weight of one unit is 7kg. One charge of fuel has been shown to provide two hours of continuous operation and the hydrogen is stored in an aqueous solution of sodium borohydride. The company hopes to establish a joint venture with a Chinese firm to commence

commercial sales. The price of one unit has been estimated at between 100,000 and 200,000 yen/100 W.

Matsushita Battery, a subsidiary of Matsushita Electric has developed a new fuel supply method for fuel cells powering portable devices. The DMFC system incorporates the new fuel supply technology with Matsushita Battery's stack technology and a lithium ion battery. The company reports that the unit is a similar size to a fizzy drinks can and has an average output of 13 watts enabling a laptop PC to run for 20 hours.

Mechanical Technology has announced an exclusive partnership with Samsung Electronics to develop a power source prototype for a series of Samsung mobile phones and accessories. It is thought that the portable power-systems company's subsidiary MTI MicroFuel Cells will develop and test power sources based on MTI's DMFC micro-fuel cell technology and Samsung will commit US\$1 million to the joint effort. The joint development deal will last about 18 months until the end of the second quarter of 2007. Under the agreement the companies will jointly research, develop, test and evaluate the use of methanol based fuel cell technologies for mobile phone applications.

Mesoscopic Devices and Toto are to collaborate on the development of a new line of SOFC portable generators. Under the agreement, Japanese fuel cell developer Toto will supply miniature tubular solid oxide fuel cells to Mesoscopic for the development of its new MesoGen Orion portable fuel cell generator. The generators are designed to operate on fuels such as propane and kerosene and will be aimed at commercial, industrial and military markets.

Millennium Cell continues to target four key markets: military, medical, industrial and consumer electronics. At the start of 2006, the company announced that its soldier power programme had been allocated US\$1.7 million of funding in the 2006 Defense Appropriations Bill. The money will support procurement of Protonex 30-watt portable soldier power systems for field testing by the military. In May 2006, the company announced that it had been awarded a Phase I Small Business Innovation Research Program (SBIR) Grant by the National Science Foundation for the development of new hydrogen storage technology based on solid fuel blends. This news was followed quickly by the announcement that the Dow Chemical Company to purchase US\$1.25 million of Millennium Cell's stock under its joint development agreement. Millennium has been awarded a further two Phase I SBIR contracts in the last twelve months. The first was from the Air Force Research Laboratory to develop a sodium borohydride fuel cartridge and the second by the U.S. Army Tank-automotive and Armaments Command (TACOM). More information regarding the TACOM project can be found in the 2006 Military Survey.

Millennium also received Notices of Allowance for two patents to be used with its portable fuel cell systems, announced that Protonex exercised its option to license Millennium Cell's Hydrogen on Demand technology for industrial and medical markets and agreed to supply up to 250 of its Hydrogen on Demand fuel canisters to South Carolina as part of the Greater Columbia Fuel Cell Challenge. The canisters will be used in conjunction with Jadoo's N-Gen fuel cell power units. In 2006 the company also received a delivery order from the US Air Force's research laboratory for up to US\$4 million (£2.14 million) worth of fuel cell technology and products.

In December 2005, MTI MicroFuel Cells signed an Early Adopter Alliance Agreement with an unnamed provider of intelligence, secure communications systems, government services and homeland security. At the start of 2006, the company signed a market development agreement with SES Americom under which MTI will determine and evaluate the use and integration of its Micro Mobion technology in to Americom's products. This was followed by an announcement in June that MTI had achieved 1.3 watt hours of energy per cubic centimetre of fuel. The fuel cell runs on methanol and is designed to replace batteries in both military and consumer electronic markets. More recently, MTI announced that it has been awarded two more patents for new fuel cell technology in the US. The patents cover aspects of a methanol fuel supply system for DMFC units.

MTI has also successfully demonstrated its Mobion-30M fuel cell power system to the Air Force Research Laboratory. The prototype system, which can deliver up to 600W hours of operating time, is designed to power laptops and other portable telecommunications devices used for military purposes. Additionally, the company has delivered further prototypes of the Mobion system to two other military organisations. Recently, MTI has announced plans to extend agreement for the distribution of supporting apparatus for its micro fuel cell technology having amended its "Strategic Alliance Agreement" in order that additional third party OEMs can help produce fuel cartridges

used with the Mobion fuel cell system.

US firm NanoDynamic has won US\$2 million in federal funding for work on its portable solid oxide fuel cell (SOFC). Passed as part of the Defence Appropriations conference report for 2007, the funding agreement will see the company continue its work on the portable power packs which are designed for use by soldiers in the field. An additional US\$729,000 was awarded to the company in the form of a Phase II Small Business Innovation Research grant from the US Army for carbon nanotube production technology. The company also gained a patent on SOFC structures.

Neah Power is developing fuel cells for use in notebook PCs and other electronic devices. In March 2006, Growth Merger completed the acquisition Neah Power and changed its name to Neah Power Systems. The company then signed a contract with MTBSolutions to develop the necessary packaging technology that will enable the mass production of its fuel cells. In June 2006 the company chose Denmark's Danfoss Group fluid control and disposable fluid cartridge technology to use as part of its fuel cell development. In addition, Neah announced that it has been issued with a US patent for its new porous silicon fuel cell technology and confirmed that it will become a public reporting company with the Securities and Exchange Commission (SEC). The company expanded research and development of its patented porous silicone based DMFC system and announced that US\$3 million had been included in the Department of Defense Appropriations Bill to support this decision.

Japanese hi-tech company NEC displayed for the first time a concept see-through mobile phone which is powered by a fuel cell. Known as "Flask", the transparent sides of the phone are designed to allow users to see when a refill cartridge is required. The phone was unveiled at the CeBIT trade fair in Hanover.

Northrop Grumman and Protonex were selected by the U.S. Air Force to design and develop a new fuel cell system to power targeting, communications and other sensor equipment used by airmen on the battlefield. The one year contract (which was announced in January 2006) will see the development of a fuel cell unit based on Protonex's P2 product.

Whilst Nuvera Fuel Cells is primarily focussed on developing systems for niche transportation applications, the company sees potential for its PEM products in telecommunications and remote back-up power as a possibility for the future.

PolyFuel continues to develop membranes for fuel cell systems. In the past twelve months the company has announced development of a new, ultra-thin (20-micron) membrane for use in DMFC for micro power applications such as notebook computers and mobile phones. The membrane is said to produce 200 milliwatts of peak power per square centimetre of material at 700C. In the six months leading up to June 30th, shipments of the membrane doubled from the corresponding period one year ago, with over 1,000 pieces of PolyFuel membrane being transported. Customers include Sanyo Electric and NEC as well as military and industrial fuel cell system developers. PolyFuel also secured ISO 9000 quality management certification in 2006 for the engineering and manufacturing of its membrane products, and achieved scale up of the membrane. The company also announced that it has entered into an agreement to provide Johnson Matthey with its hydrocarbon direct methanol fuel cell (DMFC) membrane intended for fuel cells to power portable devices. Johnson Matthey will use these membranes in the manufacture of catalyst coated membranes (CCMs) and membrane electrode assemblies (MEAs) for the portable fuel cell market.

Protonex raised £8.8 million (US\$16.2 million) through a placing of more than 10 million new shares on the London Alternative Investment Market (AIM) in July 2006. The shares were sold to mainly institutional investors and the net proceeds of £7.4 million will be used to finance continued development and commercialisation of technology for commercial and military markets and acquisitions and investments in related technologies or businesses. In addition, we expect to see some big announcements from Protonex during 2007.

QinetiQ is developing hydrogen fuel cells suitable for mobile phones, cameras and PDAs. The UK firm's research is being funded by camera company Olympus and QinetiQ is hoping to produce a working prototype by 2008.



**SAIT's Mobile Fuel Cell Charger (Courtesy of SAIT)**

Samsung announced at the start of 2006 that it had developed the first prototype fuel cell for portable multimedia players (PMP) in collaboration with its affiliate Samsung Advanced Institute of Technology (SAIT). Samsung reported that the system can power a 1.5 watt player for up to four hours on a single methanol cartridge. The company plans to commercialise the unit in either 2007 or 2008. Since 2004 Samsung has invested 3.8 billion won (US\$3.9 million) in fuel cell development. Samsung also plans to introduce a second PMP-loadable fuel cell to provide 10 hours worth of power on a single charge. Previously, the company has developed a fuel cell allowing a PDA with 1.3 watt power source to run for eight hours and in November 2005 announced the development of a fuel cell for laptops which is able to supply 15 hours on a single charge.

Sandia National Laboratories and Sharp signed a Cooperative Research and Development Agreement to, amongst other things, advance fuel cells for portable power applications. The immediate focus of the agreement is on the use of methanol fuel cells for applications such as laptops, mobile phones and PDAs. Sandia will fabricate and test fuel cells for Sharp using its proprietary membranes and catalysts. Material and MEA design is already underway and the project is expected to last between 12 and 18 months.

In November 2006 SFC Smart Fuel Cell announced that it had delivered its latest portable fuel cell product to a total of eight defence ministries chiefly in Europe. The first batch of the portable DMFC power generation systems - branded 'Jenny' - has been distributed to the German federal army, along with the defence ministries of Finland, Norway, the Netherlands, Sweden Switzerland, South Africa and the UK. The fuel cell is designed to power remote equipment and applications in the military field. The company is also to develop a Fuel Cell based Lightweight Portable Power System for US Battlefield Airmen. The value of the development order amounts to US\$500,000.

Tekion announced plans to commercialise its Formira Power Pack, a micro fuel cell/battery hybrid designed to be integrated in to new portable electronic devices. The product is expected to be launched in early 2007 and potential applications include satellite and mobile phones, PDAs and notebook PCs.

Toshiba unveiled the latest prototype of its fuel cell-powered battery system for laptops in October 2006, although the company admits that the technology is still in its relative infancy and has so far given no word as to when the fuel cell power applications will become commercially available. Previously the company had conducted trials on its portable music players combined with micro DMFC.

UltraCell has announced plans to establish a high-volume fuel cell production line in the State of Ohio. The company will invest US\$74 million in setting up the production facility which will manufacture micro fuel cell systems for handheld devices. Ohio authorities are aiding the expansion by providing job creation tax credit and training grants. In addition, the company unveiled a prototype and subsequently delivered one of its methanol powered micro fuel cells for military applications. The XX25 unit is designed to provide wireless, portable power in extreme

environmental conditions. Ultracell opened a new manufacturing facility in Livermore, California to convert from prototype manufacturing to volume production of this system.

In late 2005 Voller Energy announced that the company had received a purchase order from Speedy Hire, a UK based provider of tool and equipment hire services. The order was for 300 cordless tool battery chargers and the units were distributed to Speedy Hire's depots in 2006. In January 2006, the company was granted the patent 'Mains in a Box' which concerns the technology that enables its portable fuel cell system to provide mains output (230 volts in Europe and 110 volts for North America) and work from internal canisters of stored hydrogen. In addition, Voller signed a Memorandum of Understanding (MOU) with Calor Gas in 2006 to develop the market for fuel cell generators and battery chargers. Under the agreement, the hydrogen used by Voller's portable fuel cells will be provided from Calor Gas products. Voller also signed a MOU with Conergy for the companies to work together to develop the market for fuel cell generators used in small-scale off-grid applications.



**A prototype V100 fuel cell for use in military applications (Courtesy of Voller)**

2006 saw Voller launch a fuel cell automatic battery charger. The new system is called the Fuel Cell ABC Automatic Battery Charger and is designed to charge a variety of batteries found in electronic products. The system can simultaneously charge a MP3 player, a laptop and mobile phone. Furthermore, Voller also launched a new industrial fuel cell system called the VE100 Rack Mount. This system can charge remote monitoring equipment, surveillance cameras and industrial equipment in remote locations. Interestingly, the company also announced the appointment of Australian fuel cell agent Ionix in a bid to enter this regional market.

W.L. Gore and Associates is supplying a fuel cell membrane for integration in to a system which will eventually be provided to the U.S. Army. In December 2005, Imax Industries was awarded a US\$750,000 contract to produce 120 fuel cells for the U.S. Army Armament Research, Development and Engineering Centre. The P100 fuel cells will be used to power equipment known in the Military as "fuzes" which contain the technology that determines when a fired artillery round detonates. Imax will machine and weld stainless steel casings for the fuel cells, the components of which are purchased from other Ohio companies.

## **About Us**

Fuel Cell Today publishes free annual market surveys on different fuel cell applications including light duty vehicles, buses, automotive hydrogen infrastructure, portable, large and small stationary power generation.

### **About the author**

Gemma Crawley works as a Senior Market Analyst for Fuel Cell Today. Her area of interest is the adoption of fuel cell technology in developing countries. Gemma can be contacted via [gemma@fuelcelltoday.com](mailto:gemma@fuelcelltoday.com).

(Note on the data used in this report: The graphs that Fuel Cell Today produces and uses in this, and its other reports and surveys, come from an in-house proprietary database. This database is not available for purchase or use by outside companies.

All requests for reproduction of the graphs, which are copyright of Fuel Cell Today, are treated individually and must be directed to the Editor of Fuel Cell Today at [info@fuelcelltoday.com](mailto:info@fuelcelltoday.com))

**[www.fuelcelltoday.com](http://www.fuelcelltoday.com)**