



2006 Small Stationary Survey

Dr. Kerry-Ann Adamson,
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The past year has been a story of two halves for the small stationary sector. One half has been in the gleaming light of success stories and increased numbers, whilst the other half has been very low key, quietly getting on with increasing manufacturing capability, reengineering designs, bringing down costs and working to sort out codes and standards. What is really interesting is that this split is not based on companies, with companies working in this space often being highlighted and quiet at the same time. What is also clear from this years data is that UPS is becoming something of a showcase application. Like fuel cell powered forklifts, UPS, has not had the mainstream press interest but represents one of the first fit-for-purpose success stories of this new innovative industry. Companies, from the banking sector to telecoms and everything in between, are now looking at fuel cells as a genuine option when making decisions on upgrades / retrofits or new build installations. This sector is looked at in more detail later on.



Three hydrogen and fuel cell communities. From left to right: The Australian base on Antarctica which is trailing wind turbines and fuel cells, Prince Edward Island, Canada, which is also using turbines in conjunction with fuel cells, and finally a conceptual design for an off grid house from the forward looking H2PIA project

Company movements in this sector have been very public though with two companies no longer with us. At first glance. First Palcan (Canada) which was pretty much written off earlier this year with a Cease Trade Order imposed on the company by the Toronto Stock Exchange. Since then a number of things have happened to indicate that Palcan might yet rise again Phoenix like. As well as a lifting of the trading ban in late July, Palcan is in the middle of a major restructuring including canceling the license agreement with Nanjing Boneng Fuel Cell, which it claims is one of the major reasons for its current financial problems. We can wait now to see if its efforts have been enough. Fuel Cell Technologies Limited (Canada) was the second big loss of the year when it have ceased trading altogether. As Fuel Cell Technologies Limited, that is. MP Western Properties is a new name to many but its old name may be more familiar - Fuel Cell Technologies Corporation (FCTC). MP Western is producing 1-75 kW SOFC stacks, with a core product of a 5kW unit for UPS and residential use. According to the last Fuel Cell Technologies Limited (FCTL) financial results FCTL sold all of its operating assets and business to FCTC, which then changed its name to MP Western Properties. Another Phoenix?

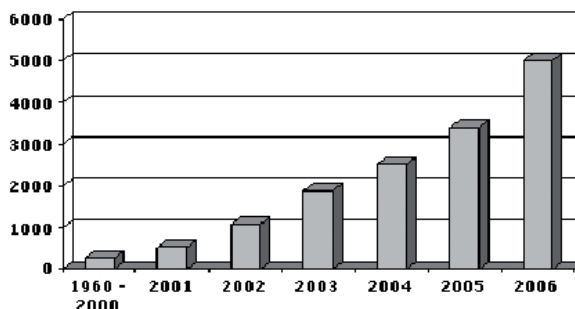


Another renewable/hydrogen project gets opened

Turning to this years data. As we forecast in the 2005 survey the number of new units is now over the 5000 mark (cumulatively). This total has been helped by both the growth in residential units in Japan and Europe and the coming along in leaps-and-bounds of the UPS market in Europe and North America. This years tally alone sits at around 1500 units. Graph 1 shows the cumulative growth curve, whilst Graph 2 splits it into new units per annum.

Graph 1

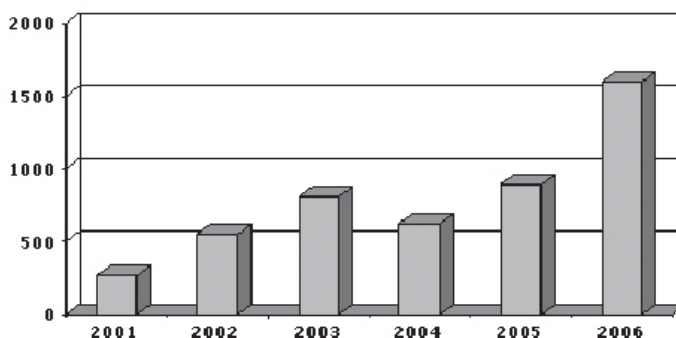
Cumulative Small Stationary Units



Though it would be tempting at this stage to add a trend line to the above graph it would potentially show a very false result. Interestingly the result would probably show a too slow growth. If we look at Graph 2 what jumps out is the leap in numbers this year, as predicted, has been.

Graph 2

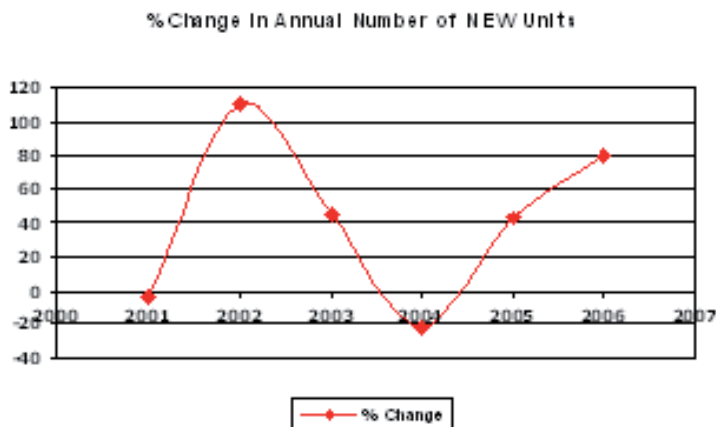
New Annual Small Stationary Units



Looking forward to 2007, we would expect to see the total number of new units to be around 3000. This is based on a growth in UPS systems in place and the planned for growth in the Japanese residential programme.

Looking at the rate of change year-on-year in this sector (in terms of % increase, or decrease, of new units installed) we can see that there has been a real up and down, but movement now seems to be going up smoothly.

Graph 3



(note that in this graph a percentage change of greater than 100% indicates a more than doubling of the number of new units from one year to the next).

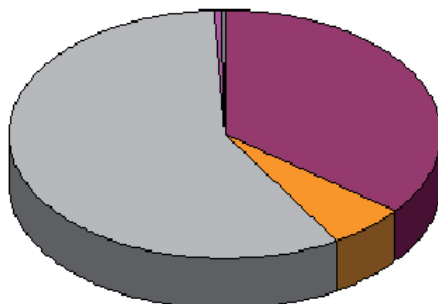
The obvious question that jumps out from this chart is what happened in 2002. Though this is not a historical retrospective of the Small Stationary Market over the last five years it would be remiss of us not to address this – especially as the answer is simply down to mathematics. When you look at Graph 1 you can see that the number of new units in 2001 was very low. By 2002 we saw this figure more than doubling but this did not in fact represent a massive jump in interest, rather a slight increase in number of units by companies. This increase, often from 2 to 3 units per company, for the companies that were at this time flirting with this size and application, had the impact of more than doubling of units. The actual cumulative number of units by 2002 is a factor of 10 smaller than today.

Region of Manufacture and Operation

As with any other industry the Small Stationary fuel cell industry is global. Stacks can be built in one country, integrated into the product in a second and then finally installed in a third. Due to this globality we have split the information into region of manufacture (of the stacks) and region of operation (of the final units).

Graph 4

Region of Manufacture 2006

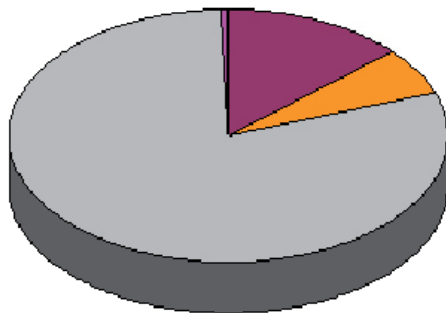


Though Graph 4 shows a dominance by Japan, in terms of units manufactured, it does also show manufacturing capability in North America and Europe. It is worth remembering that this is a snapshot of one years activity and if you look at the historical data, not shown here, then what can be seen is that all the countries are growing in relative strength in terms of manufacturing.

Moving to Graph 5 which shows the units by region of use. Again there is a current dominance by Japan, the first adopter nation, but what is hidden by the graph is the actual increase in numbers in Europe, which is a significant percentage, and a drop in numbers of units in use in the North America. We firmly believe this second point simply to be a statistical blip and next year will see an increase in units in the North America.

Graph 5

Region of Use 2006

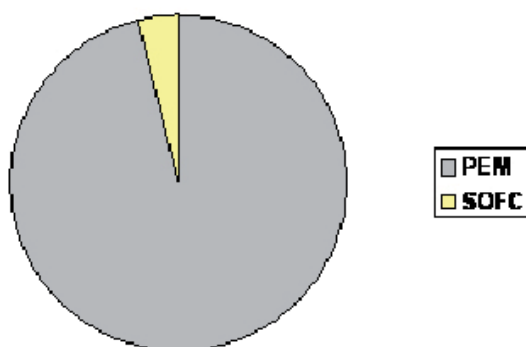


Technology

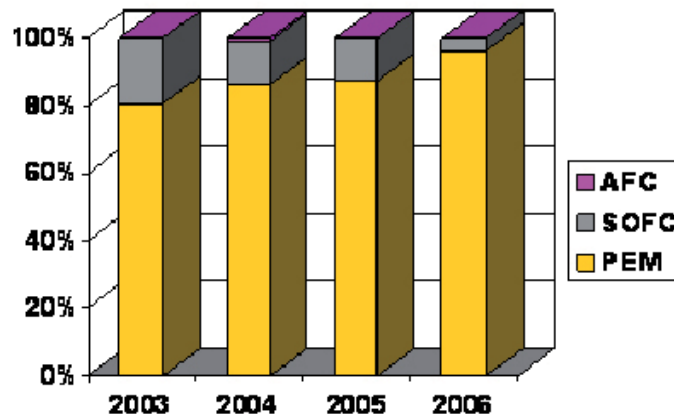
This more than just about any other application for fuel cells is a two horse race. PEM and SOFC. PEM with its longer and more sustained development period is still well ahead but with very impressive results from the US based SECA programme, and company developments, it would be very wrong of any group to write off small stationary SOFC units. All this said Graph 6 below shows that during 2006 PEM dominated. Graph 7 plots the data of technology choice over time, showing that fewer (nearly half less) SOFC units have been released over the past twelve months than in 2005.

Graph 6

Technology Type 2006



Technology Development 2003 - 2006



Unit Size

The range of unit size under development is still impressive. The dataset collected for 2006 shows units with the electrical output of 1, 1.5, 2, 3, 5, 6, 7 and 10 kW respectively. The 1kW units only make up around half of the entire 2006 dataset with the other sizes being fairly equally represented. This shows the breadth and depth of the units under development and a fundamental recognition that in this area there will not be a "one size fits" all solution.

Fuel Choice

Again in this sector fuel choice is in fact fuel options. As well as direct Hydrogen, with a substantial fraction of new units this year, both in residential and UPS, there are units with, in no particular order, natural gas, town gas, bio-ethanol, kerosene and LPG. As well as highlighting the level of innovation in this sector, that they have been able for example to develop Kerosene reformers to operate with PEM based units, it will able a quicker market penetration, once commercial, as adopters will be able to select units based on local fuel availability.

Fuel Cell "Village" Projects

Over the past few years there have a growing number of small, often rural, locations being used an integrated test bed for hydrogen and fuel cell projects. These fuel cell villages, as well as using renewably produced hydrogen (usually) have a mix of residential fuel cells and small vehicles which either run of hydrogen through an ICE or fuel cell.



The planned Hydrogen Village in Canada
(Picture courtesy of the Hydrogen Village Project)

The most extreme example of this concept is a test currently underway in Antarctica. Before talking about the project it is worth remembering that in Summer temperatures in Antarctica can get down to -20oC in the interior and around freezing on the coast and that it is protected by international law as a bastion of global science, and it is one of the last great wildernesses on left on earth and above all one of the most inaccessible places on the planet (nothing gets in or out for many months during the Winter season). Basically technology there has to be as reliable as possible, because if something goes wrong you might not simply be able to ship a replacement in.

So taking this inaccessibility, rather nippy weather conditions and not exactly close at hand to keep checking up on the units it may be surprising that this year Mawson (The Australian Antarctic Division (AAD) base) and a field camp at Béchervaise Island is installing and running a fuel cell and hydrogen project. The project will use excessive energy from the camps wind turbines to produce hydrogen, which will then be used in a stove for cooking and in a fuel cell that will run as a mini-CHP unit. The project is supported by a AUS\$750 000 (~US\$600,000) grant to the AAD from the Australian Government and financial contributions from the Swedish Energy Agency (CellKraft are sending out a small number of its fuel cell systems) and BOC. The University of Tasmania is undertaking modelling work to identify the infrastructure needed to run Australia’s stations and field camps on 100 percent hydrogen.



From left to right: The CellKraft Fuel Cell Being Tested in Australia before being shipped, a map of Australia showing Maswon and a hydrogen cooker
(Pictures courtesy of: Australian Antarctic Division 2006)

Overview

Along with a number of the other application that we monitor on an annual basis the Small Stationary sector is going through a very positive phase. Instead of facing the “valley of death” known to so many products as they try to commercialise this area appears to be bedding down quite nicely for the long term. Units are growing at a steady rate, beta-test demonstrations for residential units are increasing in size and actual sales of UPS systems have jumped significantly. With more companies this year receiving certification of their units for general sales to the telecommunications sector this trend can only increase. Japan is still leading the way in the residential area with new houses now being marketed, in some areas, as having fuel cells; obviously in these cases this is actually seen as a marketing plus. In Europe Baxi and European Fuel Cell are now doing large scale testing of its Home Energy Centre, though so far this is fairly low profile.

In terms of regulation, codes and standards work still needs to be done to remove this as a barrier to commercialisation but steps are being taken. It is questionable as to whether the industry will end up with separate standards in Japan, North America and Europe and there is a recognised need to have international standards harmonised and adhered to.

One of the most promising areas though is the increasing numbers of go-it-alone projects. Instead of waiting for full commercialisation or government provided buy-down subsidies these communities are leading the way, showing what can be done with a lot of ingenuity, commitment and will power.

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As usual the rest of this survey provides an overview of a number of key companies that have been active over the past twelve months.

Companies

Acumentrics (USA) is developing a number of products for both UPS and CHP systems, using at its heart its tubular SOFC. As well as a 10kW unit specifically targeted for the Japanese market, it is also developing CHP units for the European and US market.

This year saw the completion of a test of one of Acumentrics propane based units at the visitor centre of Exit Glacier National Park in Alaska. The unit being tested was reported to have run for over 1,100 hours with no efficiency degradation. This unit was previously working at Kenai Fjords National Park.

As well as work in North America Acumentrics is one of only two non Japanese companies which will participate in the forthcoming residential SOFC trials in Japan.

Altergy Freedom (USA) is a PEM, UPS developer. It currently has two products in its Freedom Power range. The FCM-5 is a 5kW units, and the FCM-1 is a 1kW unit. They can used in series up to 30kW. The units, which run on gaseous hydrogen, can be used outdoor and indoor (with addition of conditioning). The target markets are back-up power for telecommunications and UPS systems for institutions such as the banking industry.



**Grey is the fashionable colour of the season once more!
Here modelled by the new comer FCM-5 from Altergy
(picture courtesy of Altergy)**

Following on from the Christmas lights in Trafalgar Square being lit by a fuel cell in London in 2004 last Christmas (2005) saw the tree lights outside the Californian Environmental Protection Offices Office being powered by a Altergy unit.

APC (Denmark), uses, as an option in its InfraStruXure range, Hydrogenics stacks. The units are available in multiples of 10 or 30kW for a price range of around US\$25,000 per 10-kilowatt module, plus an installation and setup charge. Since the launch of the product the units have been installed in a number of locations, including an internet server provider in Toronto. According to Hydrogenics APC have ordered some 500 fuel cell units for its InfraStruXure range.

The unit is fuelled by gaseous hydrogen which is bottled and stored in T shaped cylinders. Each cylinder stores enough fuel for 79 minutes per 10 kW stack.

APS Energia, based near Warsaw (Poland), is an electronics manufacturing company, which has integrated a Ballard stack into its UPS system. The "Pulstar" units also have an optional Gensis methanol-to-hydrogen reformer.

Ballard (Canada), in conjunction with its joint venture company Ebara Ballard, this year released its next generation residential co-generation fuel cell. The Mark 1030 V3 1kW stack has been designed to work towards the 2008 Japanese governments targets of 10 years lifetime in the home (equivalent to 40,000 hours operation). The stack is 40% lighter and 26% smaller than than the V2. Aims now are to reduce costs, of the stack and fully integrated unit, in line with the 2008 Japanese cost targets. In terms of marketing Ebara Ballard has exclusive rights to the CHP units in Japan, whilst Ballard holds the rights to the rest of the world.

Ceramic Fuel Cells (Australia and the UK), has had another busy year following on from its 2005 field trial launch. Since then the company has announced the development of a new generation of fuel cell, new orders, plans for a new powder manufacturing facility and plans for a new fuel cell manufacturing facility. Starting with the new fuel cell, Ceramic claim to now have a unit suitable of large scale manufacturing with the important reported metrics including increased power density up to 400 mW/cm², electrical efficiency of 50% and fuel utilisation up to 85%. Here it is important to remember that the Ceramic units under development as being designed base load electrical generators, with heat output being minimised. This means that Ceramic can maximise the efficiency of the electricity generated, without having to also balance off the trade with heat.

Looking at manufacturing we are expecting to hear an announcement soon as to the location, within Europe, of Ceramics first scale manufacturing facility. Also Ceramic Fuel Cells are one of the few non-Japanese companies to demonstrate under the NEDO residential fuel cell programme. As of FY2007 Ceramic will have a number of its SOFC systems being used and monitored for a period of 4 years.



**Inside the Ceramic Fuel Cell unit NetGen
(Picture courtesy of Ceramic Fuel Cells)**

CellKraft (Sweden) have already been mentioned in this survey in relation to its units in Antarctica. The company is working with PEM based systems, which run off compressed hydrogen, in the range of 50W to 2kW.

Ceres Power (UK) has had another very busy year. As well as continuing its relationship with both British Gas (residential CHP) and BOC (off-grid applications) it has also demonstrated its fuel cell stack (the first time it has done this). The relationship with British Gas (also known as Centrica) is part funded by the UK Department of Trade and Industry to develop CHP fuel cell units specifically for the UK market. Ceres is following the same route as a number of other companies working in the residential space by exploring tie-ups with boiler manufacturers allowing them access to Ceres stacks. Sticking with manufacturing Ceres also announced this year the commissioning of a pilot scale manufacturing facility, to be up and running by mid-2007, and the start of the design for the scaled up full size manufacturing facility. It has been said by Ceres that they expect commissioning of this second facility sometime during 2008.



**The Ceres Power Fuel Cell
(Picture courtesy of Ceres Power)**

Last year we reported that **Cosmo Oil** (Japan) has stated that it will start selling its PEM unit, with an in-built LPG reformer. In 2007 a kerosene capable unit would be added to the portfolio. Cosmo Oil is developing its 700W unit with Toshiba Fuel Cell Power Systems. The aim was to lease units on a 3-5 year basis, from 2006, for a cost of 60,000 Yen (US\$500) per annum. Since the last survey Cosmo Oil has been very quiet and we have no further technical or market updates on the company.

Corona (Japan) is another newcomer to this survey. It has stated that it plans to commercialise 1kW kerosene fuelled residential fuel cells by 2010, with large scale demonstrations in 2007.

CS FuelCell (Korea) is demonstrating a 1.5 / 3kW residential PEM fuel cell.

Ebara Ballard (Japan), as mentioned above, is the offspring of Ballard and Ebara. Since its birth Ebara Ballard has played an increasingly active role within the Japanese stationary fuel cell demonstration programme. As one of only two stack manufacturers to be used in the first round, Ebara Ballard is in a strong position in what is expected to be a large, exciting market for 1kW residential fuel cells. With the new stacks, outlined in the Ballard overview, it is expected to be able to achieve production costs of 1.2 million Yen (~ US\$10,000) for the Natural Gas unit and 1.5 million Yen (~ US\$12,000) for the Kerosene unit respectively.

Electro Power Systems (Italy) is one of the few companies globally to have taken the steps to get the fuel cell product designed. Not a black box. As can be seen below the PEM based Electro7, 7kW unit is certainly striking.



**The Electro7 from Electro Power Systems
(picture courtesy of Electro Power Systems)**

The units, which have recently received certification, are going through the final stages of being commercialised with a pure hydrogen version going on sale this year. The prototype of the natural gas version will appear during 2007.

European Fuel Cells (Germany) formerly linked to Hamburg Gas Consult, now owned by the British Baxi Group, develops and produces residential PEM fuel cell heaters. The company's natural gas powered, 1.5kW beta unit is currently being field tested. EFC is developing, what it terms, a Fuel Cell Heating Unit (FCHU) which will cover 75% of the heating demand of a typical European single family home. The PEM, natural gas fuelled unit is anticipated to remain at 1.5kW electrical output and will be tested in 100 locations across Europe. The company has signed a co-operation agreement with IRD Fuel Cell for development and production of fuel cells and system components.

Fuel Cell Power (Korea) is demonstrating a 1kW PEM system.

Fuel Cell Technologies (FCT) (USA) as mentioned earlier have, apparently, shut its doors, to be re-opened as MP Western Properties.

Fuji Electric Advanced Technology (Japan) is Fuji's cutting edge R&D group. Alongside the longer standing work on PAFC fuel cells, Fuji is developing its own 1kW PEM unit, for use in small stationary applications. Since the last survey Fuji have been testing its 4th generation unit, which runs on City Gas and has a demonstrated electrical efficiency of 35% LHV (4% higher than the 3rd generation stack) and a heat recovery efficiency of 51% LHV (9% higher

than the 3rd generation stack). NB Japanese City Gas to not to confused with Town Gas (hydrogen and natural gas mix). In Japan 85% of City Gas is LNG, a further 5% is natural gas with the remaining 10% being petroleum products such as LPG.

This year has also seen **Fuji** announce a three-way R&D tie up on its CHP unit. The deal was announced with Seibu Gas and Kyushu University.

Fuji has set a commercialisation date of 2008 for its units and is targeting annual sales of 5 – 10,000 units per annum, with a price tag of 1.5 – 2 million yen (US\$12 – 16,000), and a lifetime of 40 thousand hours. By 2015 it is aiming for a further reduction in price to 300,000 – 500,000 Yen (US\$2,500 – 4,000).

GS Yuasa Corporation (Japan) is one of a very limited number of companies developing direct methanol technology for small stationary applications.



**The YFC-1000 DMFC from GS Yuasa
(picture courtesy of GS Yuasa)**

The YFC-1000 unit 1kW unit has been tested at a strawberry farm where the waste CO₂ is being used as a help promote the fertilizer. GS Yuasa's unit, which is aiming for a commercialisation date of 2007, is claimed can run for two weeks off 230 litres of methanol.

Hazeyama and Tottori Gas Industry (Japan) are working in collaboration on a LPG, 750W, home PEM fuel cell.

Hitachi Zosen (Japan) is working with Hydrogenics to test its HyPM stacks.

Since the last survey **Hokkaido Gas** (Japan) has expanded its demonstration of PEM based residential fuel cells. The units, fuelled by Natural Gas, have been increased by another ten and are especially useful in data collection due to the cold weather conditions in the chosen locations.



**A Hokkaido Gas fuel cell Installed at a customers house
(picture courtesy of Hokkaido Gas)**

There have been some big claims made this year for **Hydra Fuel Cell** (USA) but having spoken direct with the company we can report here that they all appear to be unfounded. We have seen reports that it claims to have started shipping beta test units of its HydraStax early in 2006 – not the case. Also according to a separate press release, from Hydra's parent company American Security Resources, commercial production started in September 2006 – again not the case. In terms of costs reports are floating around that it has stated a cost for its 6kW unit of US\$4500 – 5000 in volume production, with a further projected reduction to US\$400/kW with mass production efficiencies – no costs projections have been made available. According to the Company themselves they are currently finalising its business model and are planning on starting to ship units during FY2007.

Hydrogenics (Canada) has a wide ranging business plan. Not only does it supply stacks to a number of developers, such as its HyPM XR10 rack mountable unit to APC, but also produces its own in-house range of integrated products. It is currently taking part in a number of high profile demonstration projects, including the Wind-Hydrogen Village project on Prince Edward Island, Canada. Interestingly Hydrogenics has offices in both India and Russia; possibly hinting at future market direction.

The big news from **Idatech** (USA) this year was the acquisition by Investec of IdaCorp. The company has a range of PEM based small stationary units, both for UPS and residential systems. For UPS the product ElectraGen which is shown below, is now being used in a number of locations. The unit is designed to run in either grid parallel mode or sole power in case of grid failure. The PEM systems (1 – 15kW) run on industrial grade hydrogen.

For off-grid power IdaTech have developed a hybrid system employing a solar array (1kW) in conjunction with a fuel cell (1.2 kW).



The IdaTech Units, left to right, the Solar Fuel Cell Hybrid system and the Electragen (pictures courtesy of SunWize Technologies and IdaTech respectively)

Idemitsu Kosan (Japan) as well as testing a number of different co-generation units, in terms of fuel and size, is also developing fuel processing technology. Along with Corona Corporation Idemitsu is undertaking work to develop a 1kW Kerosene powered fuel cell system. The current prototype has an electrical efficiency of 33% LHV. With its work on Kerosene reformers Idemitsu is well placed to develop this system and improve the critical metrics.

As well as the 1kW unit Idemitsu Kosan is developing with **Ishikawajima-Harima Heavy Industries** (IHI) are co-developing a 5kW unit fuelled by LPG or Kerosene. Both types of units are currently being tested in the Fuel Cell Technoplaza. The companies aim for "real use" by 2008, though there are no clues as to what level of commercialisation this implies.

Ishikawajima-Shibaura Machinery (Japan) in collaboration with Shizuoka Gas Company has been field testing a number of units this year. At first glance Ishikawajima-Shibaura Machinery is an odd company to be working with fuel cells as it appears to be primarily a heavy machine company. As well as field testing a number of units the company is involved in developing a new reformer that is being based on a different form of catalyst. This new reformer is now in the process of being scaled up to being used in its 1kW unit.

As well as being involved in the Japanese stationary fuel cell demonstration study as a tester of LPG units for **Toshiba Fuel Cell Power Systems, Iwatani International** (Japan) have also branched out this year into portable fuel cell generators and production of a fuel cell powered racing car.

Japan Energy (Japan), in conjunction with Toshiba Fuel Cell Power Systems, has installed a number of LPG fuelled 700W fuel cells into homes that it serves. For testing of its "ECOCUBE" systems Japan Energy is providing the units free of charge, for installation, but are charging a 90,000 Yen (US\$720) annual maintenance fee. The users are then paid back a gratuity of 90,000 Yen as a thank you for hosting the units. The unit has a reported electrical efficiency of 33% (HHV) and thermal efficiency of 45% (HHV).

Internally the company has committed to spending a sum exceeding 6 billion Yen (US\$8,000 million) by the end of 2007 to further develop home use fuel cell technology. A further development goal is a Kerosene fuelled unit to be market ready by 2008.

Koa Gas Development Corporation (Japan) this year introduced an LPG fuelled home-use cogeneration system of 750 W output in a trial use. This unit will be used to gather data and assess the opportunities for the company in terms of future sales.

Kyushu Oil (Japan) is working with Toshiba Fuel Cell Power Systems in the testing and marketing of LPG PEM CHP units. Within the first year of the demonstration project Kyushu Oil will be testing 8 units.

Kyocera (Japan) is developing SOFC fuel cells both for residential use, 1kW, and large units for businesses. The 1kW unit is in collaboration with Osaka Gas, whilst the large unit is with Tokyo Gas and is anticipated to be commercialised in the spring of 2007.

Matsushita Electric Industrial (Japan) still appear to be one step ahead of a number of the other companies involved in the Japanese programme. Not only are they still installing units, with Panasonic stacks, they are now actively marketing houses with these units pre-installed. During 2006 it system was awarded the Good Design Award for Ecology Design. The PEM units are rated at 33% (HHV) electrical efficiency and 45% (HHV) thermal efficiency. The fuel for the 1kW unit is natural gas. Matsushita Electric Industrial aim to have a production cost of 1.2 million Yen (~ US\$10,000) and a lifetime of 10 years by 2008.



**The Matsushita Electric Industrial system
(picture courtesy of Matsushita Electric Industrial)**

Mitsubishi Heavy Industries (MHI) (Japan) are also working with PEM units and are developing reformers for seven different types of fuel. These are natural gas, LPG, naphtha, kerosene, methanol, di-methyl-ether (DME) and ethanol. The durability target is over 30,000 hours. Unlike a lot of other Japanese companies MHI is working on a 10kW, aimed specifically at small businesses.

Mitsubishi Materials (Japan) is working with Kyushu Univeristy and Kansai Electric Power on planar SOFCs. The target size of the unit ranges from low kilowatts to several tens of kilowatts for on-site power generation.

Nuvera (Italy) is currently producing its Avanti combined heat and power (5kW_e and 7kW_{th}) unit. In most applications it is anticipated that Avanti will provide base load output of thermal and electrical energy. The electric grid and conventional heating equipment are then used to support peak load demand. The system is currently in

its 3rd generation, which is claimed to offer significantly higher efficiencies, improved reliability, and lower costs than previous generations. Target applications Nuvera is currently pursuing include hospitals, hotels, dormitories, restaurants, and swimming pools. This unit is currently in Alpha testing, including units in Asia and the USA. Beta testing is slated to being in 2008.

New Japan Eco System (Japan) is one of the few Japanese companies focusing on developing small stationary units for the UPS market. Its direct hydrogen PEM unit "Mirabo 2" is a 2kW unit and has a generating efficiency of 46%. The current model costs 300,000 yen/month (approximately US\$2500 / month) and is undergoing trials in a number of locations.

Nippon Oil (Japan) has a three pronged approach to its fuel cell development. It is currently working on a 1kW kerosene fuelled PEM system, in conjunction with Ebara Ballard, called ENEOS ECOBOY; a 10kW kerosene fuelled PEM unit, being co-developed Mitsubishi Heavy Industries and a 1kW LPG fuelled PEM unit with Sanyo called ENEOS ECO LP-1.



The ENEOS ECOBOY and ECO LP-1 1kW units
(picture courtesy of Nippon Oil)

In terms of commercialisation Nippon Oil is planning on commercialising the 10kW unit at some point during 2007 and the ECOBOY unit at some level of commercialisation during 2006. For the 1kW unit the lease rate is 60,000 Yen per annum (~ US\$500).

Nippon Oil have announced that its wants to have sales of 100,000 units (combined) per annum by 2013.

Osaka Gas (Japan) and Kyocera are developing SOFC units for homes. The "NEXT 21" 1kW unit was tested for a period of 90 days in a single location and was logged to have an efficiency of 49% (LHV). Again Osaka Gas have a date of 2008 for commercialisation.

Plug Power (USA) has rarely been out of the headlines this year for a number of reasons. The big news was the very substantial cash investment by Smart Hydrogen, a joint venture between the principal Interros investors and Norilsk Nickel. The investment of US\$217 million gives Smart Hydrogen a minority, non-controlling stake in Power Plug of about 35%. Smart Hydrogen will be authorised to nominate directors (4 out of a total of 12) and committee members, have the right of veto on issues of acquisitions or sales of assets, issuance of shares, and introduction of amendments to the bylaws, as well as the right for privileged purchase of newly issued shares. Also the agreement includes a clause that in the next 5 years the Russian stake shall not be increased, nor shall be offered for sale, neither directly nor through the power of attorney, to the other shareholders or market participants, unless this is initiated by the Board of Directors.

In terms of market growth IST Holdings (South Africa) has placed a large follow on purchase order for its GenCore units. Robins Air Force Base (USA) and NASA Glenn Research Centre have also placed orders for Plugs GenSys units.

New partnership agreements this year include the **National Innovation Company New Energy Projects** (NIC NEP) (Russia) to collaborate on technology and market development efforts in Russia. Also, interestingly, Plug formed a collaborative relationship with NexTech Materials to investigate development of solid oxide fuel cell power systems. New distributors that have been brought onboard over the last twelve months are **LOGANEn-**
www.fuelcelltoday.com

ergy, Pacific Telepoint and On-Site Energy for customers in the US, South Korea and Canada respectively.

Finally this year saw Plug Power and Ballard Power Systems team up under a US\$2 million contract by the US Department of Defense to develop an advanced PEM based system specifically to support the need for Continuity of Operations in warfare. Under the contract Plug will act as the systems integrator using a Ballard stack for a backup power solution.

ReliOn (USA) have a range of UPS products. The I-1000 (1kW), T-1000 and T-2000 (2kW, 4kW, 6kW, 8kW and 12kW) are PEM based units which run off hydrogen. The units are designed to be hot swappable allowing continuous running. Both units have already been shipped to a number of locations, primarily in North America and Japan and with a growing order book look to increase its presence substantially over the next few years.

This years new distributor partners are Conley Telco (Mexico), Precision Power & Air (Caribbean), and EGC International/Unitek Group (Latin America, Spain and Portugal). In Japan Marbic are distributors of ReliOn units. The 1kW unit, which can run for 30 hours on one fuel charge, is being sold at 3.7 million yen (~ US\$30,000).



**The ReliOn T-2000 2kW PEM Unit
(picture courtesy of ReliOn)**

Sanyo Electric (Japan) is not traditionally known for its involvement in home use electrical systems. As well as developing fuel cell stacks for mobile applications it is also developing a 1kW PEM unit for the domestic CHP market. Saibu Gas (Japan) has started demonstration tests of cogeneration systems of home-use PEM systems. Using subsidies from the Ministry of Economy, Trade and Industries (METI), the company will introduce 10 systems, of different makers, into employees' houses. The data will be accumulated and they will be used for selection of system makers.

Shanghai-Shen Li (China) is an innovative and well-funded, by the Chinese government, firm that is working with PEM fuel cells. As well as developing fuel cell vehicles it is also starting to work within the small stationary arena. Its current products are a 3kW and a 10kW unit, both shown below.

Tae-Gu City Gas (Korea) is demonstrating a 2kW PEM residential unit.

Taiyo Oil (Japan) is working with Toshiba Fuel Cell Power Systems on the demonstration project of residential fuel cells. Taiyo Oil will provide the LPG fuel for a period of two years.

Toho Gas (Japan), working with Ebara Ballard, has a larger number of 1kW PEM units going in for testing than most other utilities. As part of the test it will evaluate a communication and monitoring system that has been developed in cooperation with Rinnai Corporation and Toshiba-Hitachi Electric Industrial Systems.

Toshiba Fuel Cell Power Systems (TFCPS) (Japan) is the new subsidiary formed by Toshiba for the sole purpose of commercialisation of its 1kW residential PEM fuel cells, by 2008. This is termed "Dash to 2008" when it is planning on having a unit priced on the open market at less than 1.2 million Yen (approximately US\$9500). The technical targets for the system are: a cold start time of less than 10 minutes, overall efficiency of > 77% (HHV) and 80oC waste heat. In the new company TFCPS will produce the stacks, Toshiba Home Techno assembles the systems and

the reformers are sourced externally.

The current unit, the "TMI-A" is designed to be operated in a daily start-stop mode and provides the residence with all its hot water and most of the base load electricity requirement during the day. The current unit has a total efficiency of 71% (HHV) and can be run of LPG and natural gas.

TFCPS are supplying units to Japan Energy, Taiyo Oil, Kyusyu Oil, Osaka Gas and Idemitsu Oil. It is also working in cooperation with Cosmo Oil and Cosmo Gas for testing of its units.

Tokyo Gas (Japan), in collaboration with Ebara Ballard and Matsushita Electrical are installing its LIFuel units for testing.

Toyota Motor Company (Japan) may be a surprise to many to find it listed in the Small Stationary Survey but its has publicly recognised that residential fuel cells are going to be a major market and wants to be involved. To this end they have formed a relationship with Aishin Seiki for RD&D. The company claims to have started to test a number of 1kW units in cooperation with Toho Gas.

Other companies involved in this space include: Arcotronics (Italy), Astris Energi (Canada), Axane (France), Buderus Heiztechnik (Germany), Eneco (UK), Ener1 (USA), Helion (France), GreenVOLT (Canada), MER Corporation (USA), Schatz Energy Research Centre (Switzerland), Sharp Corporation (Japan), Ztek (USA), SOFCo-EFS Holdings (USA), Topsoe Fuel Cell (Denmark).

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