

Contents

About The Business
of Fuel Cells 1

Fuel Cell commercialization
- The DuPont perspective 1

European stationary market
seeking a breakthrough 2

News Round Up 4

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About The Business of Fuel Cells

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Fuel Cell commercialization - The DuPont perspective

(1/9/2002)

Like many corporations around the globe, DuPont has a vested interest in the commercialization of fuel cell technology. The business opportunity is ample and the potential markets for an alternative energy supply system is extremely attractive (\$2-10Billion in 2010).



Jean-Marc Tixhon

At the very beginning of the NASA space program, the Dupont company developed the Nafion membrane for the first PEM fuel cell used for the Gemini and Apollo programs. A complete Nafion manufacturing line was built in the late 60's to meet Nasa demand. As a consequence DuPont has developed over the years a strong experience in membranes and Proton Exchange Membrane for fuel cell applications. All chemicals needed to produce Nafion were developed internally and all by products are used by other DuPont businesses like Teflon, Krytox and Viton fluoroelastomer.

Based on the above experience DuPont decided to enter the fuel cell market announcing in FEB 01 a business unit dedicated to produce FC components such as MEAs and bipolar plates. The MEAs are a logical extension of the Nafion membrane know how. Various elements and combinations will be added to the membrane to meet customer demand and to add value to the offering. All technologies will be developed internally using the existing resources of the DuPont company. Currently, hundreds of partners are working on fuel cell components. A large majority of the team is working in R&D. To illustrate existing the synergy, the bipolar plates will be based on a unique technology developed by DuPont Engineering polymers where a special compound and process will be assigned to the production of bipolar plates. This was obtained by using existing know how and process geared towards a new emerging market with defined needs.

One of the major concerns for fuel cells in general is the high cost/price vs alternative energy supply system and on many occasions Nafion was accused of being priced extravagantly. DuPont has reacted strongly to such concerns in implementing a program that has allowed a Nafion price decrease of 50% over the last 3 years and it is anticipated that another 45% price drop will be accomplished in 3-4 years time. Needless to say a volume effect would aid in cost reduction. Currently, if 1Kw is approximately priced at \$3-4000, the automotive industry is looking at \$150/Kw to be competitive with a traditional ICE engine. This price target can be achieved but the volume effect is needed to drive the cost down.

As we all know the FC market has not yet taken off but to illustrate the DuPont commitment to the fuel cell industry, programs are in place to produce in the very near term FC components ie MEAs insignificant quantity there by moving from hand made prototypes to almost mass production. In deed it is a risk as the market does not exist yet but the belief is there and DuPont will be ready to meet large customer demand with the right price at the right time.

continued on page 2

continued from page 1

As mentioned above the FC market does not exist yet but the belief is 2004-5 will see the commercialization of FC technology. The FC market has been on probation for the last 30 years! Therefore it is a must that a commercially viable industry develops by 2004-5 as major corporations will not indefinitely pump internal financial resources into the industry. It is extremely encouraging to see some applications developing from the R&D stage into the market place with a clear business model in place and defined dates for a complete market adoption.

A vast panel of fuel cell technology is now offered to government bodies, private investors and to customers. It is urgent to align consumer needs to the technology and fine-tune the offer to meet these needs thus creating demand.

Education programs, test programs, regulations, code and standard, credibility, alignment, sense of urgency are some of the key elements that will require a complete change to allow the Fuel cell market to commercialize. This has to be done within 2-3 years, and will require a significant effort to be successful.

At DuPont we believe the opportunity is attractive and it will be extremely rewarding for those who have the passion to build markets and convert leading edge technological innovation into commercial products for mass market adoption.

This article was submitted by Jean-Marc Tixhon, European Fuel Cells Director, DuPont. For further information on projections and figures please see Jean-Marc's presentation given at "The Business of Fuel Cells for Stationary Applications" now available in our Premium Content area.

European stationary market seeking a breakthrough

Fuel cells are enjoying an enhanced profile, but despite this undoubted potential there is a slight sense of concern amid the optimism, as Klaus Huhn reports



Klaus Huhn

The gloom of 11 September, worldwide recession and stumbling capital markets have slightly dimmed the sanguine outlook of the stationary fuel cell business, but the market is determined that its superb long term prospects will not be jeopardised. However, both actual and potential market players need thorough, realistic and credible strategies, good business plans, and a level playing field of unambiguous market conditions.

Moreover, governments must create these conditions if fuel cell technology is to be pushed forward to commercialisation.

This was the message from a two-day conference "The business of fuel cells for stationary applications", which was organised by EyeforFuelCells and took place in Brussels at the end of November 2001.

Though significant progress was reported in many aspects, six issues were considered crucial in triggering the take-off of the market. These were technological maturity, choice of applications, strategic choice, implementation, funding and political support.

Technology

Technical development towards reliable and affordable products is apparently on track, helped by solid oxide fuel cells being able to use stainless steel instead of expensive ceramic materials, as is the experience of Global Thermoelectric. Ida Tech believes that fuel processing technology is going to improve in size and complexity, while Johnson Matthey, putting the case for component suppliers, reported progress in both size and complexity. These improvements will significantly contribute to cutting the capital and operating costs that still constitute the major hurdle to commercial market penetration.

Both SOFC and PEM, the two major technologies represented, claimed particular advantages depending on the application for which they are used. With a market potentially large enough for all suppliers of intelligent solutions at a reasonable price, cut-throat competitions is not expected to be a major problem in the foreseeable future.

The increasing need for uninterruptible power supply (UPS) is expected to produce the greatest demand for stationary fuel cells in the early stages of commercialisation. This sector will be boosted by comparatively low system complexity and price-insensitive demand. Because power-only applications do not need heat exchangers and use inexpensive control systems, manufacturing costs are kept down. In addition, typical users of UPS (the IT and telecoms industries, offices, supermarkets, hospitals etc) are expected to be interested in system reliability and be prepared to pay a premium price for it. Both these factors would help to close the gap between costs and achievable prices when introducing the product to market.

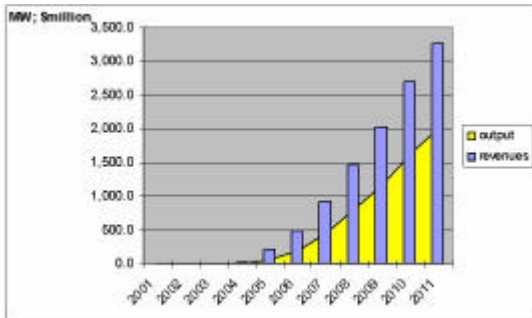
However, the consensus was that only cogeneration applications can create a mass market. The greatest potential was attributed to residential micro-combined heat and power (CHP) systems, but these still have some way to until competitive prices cover manufacturing costs.

In terms of strategy, representatives of banks and financial institutions pointed out that the era of the technical playground was over, that only the best and most powerful strategies would now be able to enter the market. Collaboration and pooling resources between companies is considered crucial to overcoming the possibly expensive dilution of resources and competencies, establishing efficient distribution channels and building a strong position in relation to investors, fund providers, policy-makers and end-users.

Financing conditions have become tougher, the shares of fuel cell OEMs tend to under-perform, and IPOs are often postponed indefinitely. This has made it harder for fuel cell and system developers to raise the funds that would help them get through a long period of low sales and negative

continued on page 3

“the era of the technical playground is over, and only the most powerful strategies would now be able to enter the market”



European Market for Stationary Fuel Cell Systems
Output and Revenue Forecast (Europe), 2001-2011
Source: Frost & Sullivan

continued from page 2

income. Credible figures, mile-stones, watertight strategies and solid financial planning are essential tools for persuading the financial community.

For the stationary market to take off and thrive, a supportive legal and regulatory framework is seen as indispensable, and the conference was dominated by the urgent need for unambiguous, reliable and transparent conditions. EU regulations were blamed for continuing to lack consistency, and the actions of some national institutions, such as the UK's New Electricity Trading Arrangements (NETA), were highlighted as counter-productive to establishing distributed generation patterns.

In summary, however, the conference was still quite confident of fuel cell technology making a long-term breakthrough into an inevitably changing landscape of energy generation, distribution and consumption.

Generally, the delegates' analysis and discussions were more sober than usual. As well as reflecting the some what tougher market climate, this also marks the transition from the high-flying development of basic technology to a market-orientated adaptation and efforts to bring about continuous improvement.

In many cases, the fundamental technological development has been completed and most companies now know precisely which technical solutions they are pursuing. According to the conference, a commercial product's main features are now their potential for R&D related cost cutting, standardised off-the-shelf parts and components, miniaturisation, and the incremental improvements of performance parameters.

Of these, the cost problem is at the centre. For a viable commercial product, system prices should not exceed €1,120/kW for larger machines (ie with an electrical output greater than 50kW), and €1,680 for micro-systems, below 10kW. These benchmarks have been set by the key end user group formed by the majority of European utilities. Certainly, the bulk of savings will arise from increasing production volumes, but counting on economies of scale and learning curve effects could easily become a vicious circle, because a significant cost reduction is required to achieve volume sales in the first place.

This puts the emphasis on the potential for R&D related cost-cutting. With tougher financial conditions, companies depend more than ever on internal funds, which may well lead to delays in commercialisation. As technical changes are much more expensive to implement once production has commenced, developers have become increasingly cautious in scheduling launches.

The turning point into this era of realism has been marked

by the fuel cell market's first casualties. Zetek of the UK aimed to supply the first commercialised fuel cell technology since IFC's P25 system. Probably due to over ambitious expansion strategies and premature investments in series production facilities, the company is now in administration, resulting in serious drawbacks for alkaline technology. It is a bleak situation for a company that successfully brought back alkaline fuel cells from oblivion to become a promising and competitive technology.

European Business

Under the greatest threat are small, one-product companies, for which a deterioration of financing conditions or a delay in the launch of a commercial product may prove fatal. However, most market players meanwhile are part of, or backed by, powerful corporations ranging from automotive and engineering concerns to residential boiler manufacturers looking for a next-generation replacement product, and these are the companies most capable of mobilising enough funds to get through a lengthy period before breaking even.

Without doubt, the potential for stationary fuel cells in Europe makes a real mass market possible. Frost & Sullivan predict an annual European market size of 2000MW worth €3.6 billion within 10 years.

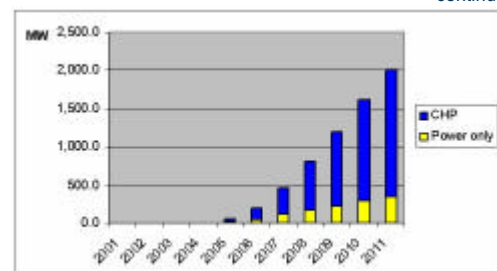
However, unlike the US market, the European market provides only limited opportunities for power only applications. Public electricity grids work well throughout Europe, and with heat output wasted, fuel cell systems will hardly get privileged treatment when it comes to tax exemptions or other direct or indirect subsidies. So UPS, quality power, mobile phone transmitter towers and other power only applications are, and will continue to be, relatively small niches that may help establish a market, but will not be able to create the critical mass required for a breakthrough.

The largest single potential area of growth comes from CHP applications in the residential sector, known as micro-CHP. This market will be nurtured by a huge replacement need for efficiently produced heat and power and will provide the balance of the cogeneration market for fuel cells.

Admittedly, cogeneration is in a lull at the moment, caused by low electricity prices and relatively high gas prices that discourage on site generation. However, the energy price structure is very likely to develop in favour of distributed cogeneration, and fuel cells have the best chance to achieve a significant share in the market.

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continued on page 4



European Market for Stationary Fuel Cell Systems
Output Forecast by Application (Europe), 2001-2011
Source: Frost & Sullivan

European Market for Stationary Fuel Cell Systems: Overview of Major Products and Projects, 2001

OEM	System Integrator/Packager/Distributor	Technology	Output	Application	Expected Commercialisation
IFC (PC 25)	HGC, Ansaldo	PAFC	200kW	CHP predominant	since 1996
Astris Energi	diverse NN	AFC	4kW, <50kW later	Micro-CHP, back-up, UPS, CHP	2005
Ballard	Alstom-Ballard (T2B)	PEM	250kW	CHP	2005
Ballard	Alstom-Ballard	PEM	60kW	UPS, back-up	2006
PlugPower	Vaillant	PEM	4.6kW	Micro-CHP	2005
DAIS Analytic Corp.	EFC GmbH/HGC	PEM	3kW	Micro-CHP	2006
SGL Carbon, Sachsenring	Viessmann	PEM	2kW	Micro-CHP	2008
Nuvera	RWE	PEM	4kW, <50kW later	Micro-CHP; <50kW not yet determined	2005-2007
IFC	Buderus	PEM	5kW	Micro-CHP	2006
FCE	MTU Friedrichshafen	MCFC	250kW, <3MW later	CHP predominant, baseload power	2005
Ansaldo	Ansaldo	MCFC	500kW, <5MW later	CHP, baseload power	2006
ECN, Sulzer Hexis	Sulzer Hexis	SOFC	1kW	Micro-CHP	2004
Siemens-Westinghouse	Siemens-Westinghouse	SOFC	100kW	CHP	2007
Siemens-Westinghouse	Siemens-Westinghouse	SOFC + GT(CC)	300kW	Baseload power	2007
Ceramic Fuel Cells					
Alstom Power	Alstom Power	SOFC	25kW	CHP, baseload power	2007 or later
Rolls-Royce	Rolls-Royce	SOFC	1MW	Baseload power; CHP later	2006 or later

Key: SOFC - Solid oxide fuel cells; PEM - Proton exchange membrane; MCFC - Molten carbonate fuel cell; AFC - Alkaline fuel cell. Source: Frost & Sullivan

continued from page 3

News Round Up

~ Automotive

Bush Administration Pulls Back Support for High-Mileage cars

The Bush Administration announced that it is ending subsidies, that have amounted to nearly \$1.5 billion, aimed to help automakers develop high-mileage, family-size cars. This is a signal that the administration wants to spur the growth of fuel cells to power the next generation of motor vehicles.

The news came as Energy Secretary Spencer Abraham addressed an auto show in Detroit Wednesday to tout hydrogen fuel cell development as part of a broader strategy to reduce the country's dependence on foreign oil and help the environment by reducing carbon dioxide emissions and other tailpipe pollution.

Department officials reported Abraham would be joined by auto executives in unveiling the new program, called "Freedom Car." It is expected to emerge as the Bush administration's response to critics who are calling for a phase-out of gas-guzzling cars and sport utility vehicles.

Automobile fuel economy is likely to be a major issue when the Senate takes up energy legislation this month. Democrats are calling for the government to require increased auto fuel efficiency, especially as it applies to the popular SUVs.

The move signals an about face for the Energy Department and senior White House policy officials in the Bush administration, who have expressed little enthusiasm for the Partnership for a New Generation of Vehicles, an ambitious government-industry effort aimed at quadrupling

automobile fuel economy by the middle of this decade.

The department said the new fuel cell program would supersede the new-generation vehicle partnership, which had pushed industry development of hybrid gasoline-electric cars now just entering the market. The old program had focused industry attention on finding ways to improve fuel economy without reducing car size and zip.

Begun in 1993 and championed by the Clinton administration - especially Vice President Al Gore - the joint venture between the federal government and the Big Three domestic automakers was seen as a way to put family-size sedans that get 80 miles per gallon into showrooms by 2004.

Using advanced aerodynamics, new engine technologies and lighter composite materials, the automakers in the program developed prototypes of vehicles capable of getting more than 70 mpg, three times better fuel economy than most cars now on the road. But commercial development of large numbers of these cars in the next few years, as once envisioned, was not expected.

Although Abraham supported the program as a senator from Michigan, shortly after he became energy secretary he said the highly touted program had outlived its usefulness because the auto industry was going in a different direction.

The administration proposed slashing funding for the program as part of its first budget a year ago. Nevertheless, Congress continued to keep it alive, even as some environmental groups and the watchdog Taxpayers for Common Sense called the program an unnecessary subsidy for the car industry.

Instead, the administration intends to focus on speeding up development of hydrogen fuel-cell powered vehicles, a technology that has attracted intense interest in recent years. This new government-industry partnership "will further the president's national energy policy, which calls for increased research in hydrogen technology to diversify and

continued on page 5

continued from page 4

enhance America's energy security," the Energy Department said.

It is hoped that the new federal push for development of fuel cells will spur industry efforts to develop motor vehicle engine and power systems that eventually will replace the internal combustion engine.

Although several automakers, including DaimlerChrysler, Ford and General Motors, have said they expect to have fuel-cell vehicles in showrooms within the next four or five years, wide availability of such cars is probably a decade or more away.

GM Rolls Out "Autonomy" Car of the Future



General Motors took to the North American Auto Show, in Detroit to take the wrappers off its concept car of the future. Dubbed the Autonomy, the auto features electric motors at all four corners of the car's chassis. There is no internal combustion engine, no axles, and no exhaust system for this hydrogen-powered platform.

The six-inch thick chassis was developed to allow different vehicle bodies to be placed on the platform, which would use a fuel cell to convert hydrogen into electrical power.

It also would incorporate drive and steer-by-wire technologies to make it easier to use interchangeable bodies.

CEO Rick Wagoner said GM hopes to see hydrogen-powered vehicles on the road within the decade.

Research and Development chief Larry Burns said a drivable version of the Autonomy should be ready by the end of this year.

~ Stationary

Ballard Fuel Cells Getting Smaller and Smarter

Ballard Power Systems affiliate EBARA took the wrappers off a new fuel cell power generator aimed at the Japanese home market that is 40 percent smaller than previous models and operates at a higher efficiency.

The second-generation prototype of the natural-gas powered generator, under development with Tokyo Gas, has been upgraded to include an electrical inverter to convert direct current to usable alternating current power, the Burnaby, British Columbia, company said in a statement.

Improvements on the prototype include a 40 percent reduction to the unit's size, making it feasible for the unit – which comprises a Ballard fuel cell, a water tank and a reformer made by Tokyo Gas and EBARA – to operate in small homes.

Commercial sales are expected to begin in 2004, with the generators providing electric power for homes, as well as heat for space heating and hot water, said the companies in a statement.

Ballard is now testing fuel cells for use in automobiles and as power plants for homes, with the first test market in Japan, where its partner Tokyo Gas is the largest natural gas company with 8.9 million customers.

Shares of Ballard Power closed at C\$48.66 on after the announcement, more than double their Sept. 14 low as investors see fuel cells soon becoming a viable alternative to nonrenewable fossil fuels.

Global Thermoelectric Receives \$500,000 Grant to Develop Propane Fuel Cell

The introduction of fuel cells to the propane market took a step closer to reality as Global Thermoelectric Inc, reported it had received a grant, valued at \$500,000, from the U.S. Propane Education and Research Council ("PERC" or the "Council") to fund the development of a propane fuel processor.

Fuel cells require hydrogen which is readily available from hydrocarbon fuels such as propane and natural gas. By developing a propane fuel processor, Global and PERC are paving the way for the introduction of fuel cell products to propane markets. Global is believed to be the first SOFC company to undertake such a venture with PERC.

"This initiative complements our relationship with Suburban Propane L.P., the third largest propane distributor in the U.S., and positions Global to be a key supplier of propane fuel cell products in North America," stated Jim Perry, Global's President and CEO.

"We are confident that we can rapidly advance the development of propane fuel processors and subsequently propane compatible SOFC products. We believe that our technology is a better match with propane than other fuel cell technologies as the SOFC can more easily, cleanly and efficiently operate using hydrocarbon fuels," added Mr. Perry.

The purpose of PERC (www.propanecouncil.org) is to promote the safe and efficient use of propane as a preferred energy source. Through the Council, which was established in 1996, the U.S. propane industry has committed itself to a multi-year, multi-million dollar effort to improve consumer and employee safety, to fund research and development of new and more efficient propane equipment and to expand public awareness of propane and its many uses and environmental advantages.

A key objective of the Council's technology strategy is to develop new end-use technologies to draw in new customers and increase sales to the existing customer base, and in this regard PERC has identified the development of a propane processor as a key enabling technology.

On a separate initiative, Global has entered into a 2-year

continued on page 6

continued from page 5

C\$957,000 joint development program with the Institute for Chemical Process and Environmental Technology ("ICPET") of the National Research Council Canada ("NRC"). This program is cost-shared equally between Global and NRC and is designed to investigate research issues applicable to next-generation SOFC components.

ICPET researchers have made a number of significant research and development achievements relevant to the emerging fuel cell industry in Canada that impact upon the operation, efficiency and production of fuel cells.

The Company also previously announced that it had signed several agreements (Memorandums of Understanding or Letters of Intent) with Suburban Propane L.P., Citizens Gas, Advanced Energy Systems and Dana Corporation with a view to proceeding to definitive agreements in 2002.

Global reports the company's prototype development is ongoing. A modified 2 kW residential prototype was recently tested at the Company's facilities in Calgary. The system test met Global's performance targets and demonstrated several design improvements and additional features. Development of a new generation of prototype is also well underway.

The Company anticipates fuel cell engineering development expenditures for 2002 of approximately C\$25 million in addition to approximately C\$10 million for capital expenditures. At September 30, 2001 the Company reported cash and short-term investments of C\$125.9 million.

~ Portable

Sanyo, Samsung Join Hands to Speed Development of Fuel Cells and Slash Costs

Fuel cell development continues to move front and center as Japan's Sanyo Electric Co and Samsung Electronics Co Ltd are expected to join hands in order to speed development of next generation fuel cells and slash high costs.

A Sanyo Electric spokesman said the two were considering such an alliance but that nothing had been decided.

Sanyo has been moving aggressively into the Asian market, announcing this week a marketing deal with China's Haier Group, the country's largest consumer electronics maker.

Like many other Japanese makers, Sanyo is putting rivalries aside within the region to boost its presence in China for a slice of its vast market.

~ Financial

Big Three Launch Conduit Fuel Cell Investment Fund

In an attempt to kick start the commercial fuel cell industry, oil multinational Royal Dutch/Shell, Japanese

engineer Mitsubishi Corp, and British precious metals and chemicals firm Johnson Matthey, unveiled Europe's first investment fund to focus purely on fuel cell companies.

The fund, dubbed Conduit, will focus funding on promising fuel cell companies in Europe and North America. With the help of other investors they expect to raise up to \$100 million for the Conduit Ventures Limited fund.

Johnson Matthey is building a fuel cell components factory in the UK, and both Shell and Mitsubishi are involved in fuel cell initiatives around the world.

The firm will be managed by two former investment bankers: John Butt, former director of European mergers and acquisitions at Schroder Salomon Smith Barney, and John Knight, its former head of European oil and gas.

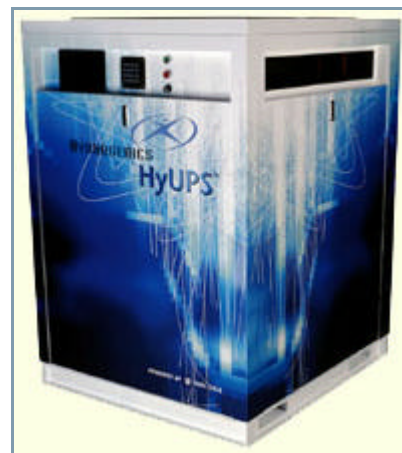
Hydrogenics selected for Canada's TSE 300 composite index

Standard & Poor's has selected Hydrogenics Corp for Canada's TSE 300 Composite Index. S&P noted the designer and manufacturer of proton exchange membrane fuel cell systems will be added to the index effective as of market opening on Friday, January 18, 2002.

"We are very pleased with Hydrogenics' recently announced inclusion into the TSE 300," said Pierre Rivard, President and CEO of Hydrogenics. "This is official recognition that Hydrogenics has joined the ranks of leading public companies in Canada. As well, it represents recognition by the equity markets that alternative energy, in particular fuel cell technology, warrants solid credibility as a sustainable and growing industry."

S&P created the TSE 300 Composite Index in 1977. It comprises approximately 71% of market capitalization for Canadian-based, Toronto Stock Exchange listed companies. The size of the TSE 300 and its broad economic sector coverage has made the TSE 300 the premier indicator of market activity for Canadian equity markets. The TSE 300

Composite Index serves as the benchmark for Canadian pension funds and mutual market funds. Hydrogenics is being added to the TSE 300 Composite and TSE 300 Capped Indices in the Industrial Products Group and to the S&P/TSE Canadian SmallCap Index in the Industrials Sector.



Hydrogenics HyUPS (TM) fuel cell power generator