



2008 Niche Transport Volume 2

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1. Overview

This, Volume 2 of the 2008 Fuel Cell Today Niche Transport Survey, covers developments across the marine/submarine and auxiliary power unit (APU) sectors. Other niche transport sectors such as aircraft and aerospace, scooters, motorbikes and other two- and three-wheeled vehicles, materials handling vehicles and trains were covered previously in Volume 1 of this survey.

Two key developments in the marine/submarine and APU space in the past year have been:

1. The growth in commercial shipments of APU for leisure and marine markets. The number of APU shipments has almost doubled this year, with several thousand units now manufactured and shipped. The growth in this sector is being driven by the need for clean, quiet, efficient power with extended run-time in the high end of the campervan and luxury boating markets. Consumers in these markets are willing to pay a premium for the advantages that fuel cells have over battery and generator technologies.

2. Legislated marine markets: there is increasing regulatory pressure on the marine sector. This is manifested as low or zero emission requirements for vessels in certain rivers and inland lakes (such as in Germany and China), and also growing pressure on regulating marine emissions in harbours and on the high seas¹. This is driving the uptake of fuel cells as APUs on board vessels (to reduce main engine emissions) and also in some cases experiments with fuel cells as the main means of propulsion.

In addition to these key trends, R&D continues on fuel cells for submarines and unmanned underwater vehicles (UUVs) and has seen some demonstration units being deployed. Research also continues on fuel cells for APU in trucks to reduce emissions from engine idling, and on fuel cell APU in aircraft (covered in Volume 1).

2. Analysis of developments 2007/8

2.1 Cumulative growth

Between 2007 and 2008 there was roughly a doubling of shipments in the APU and marine sectors. This was principally driven by the growth of commercial sales of APU for the leisure market. If 2007 represented the year commercialisation begun in this sector (which it did, judging by the jump in units shipped between 2006 and 2007) then 2008 was the year when the market became firmly established with substantial inroads being made into the leisure market. In the marine sector, growth was more limited with a flat-lining in the number of shipments of units for primary power on board vessels, despite some high-profile yacht launches such as Proton Motor's ZEMship passenger boat in Hamburg and Voller's Emerald yacht, the first fuel cell powered vessel to sail the Atlantic.

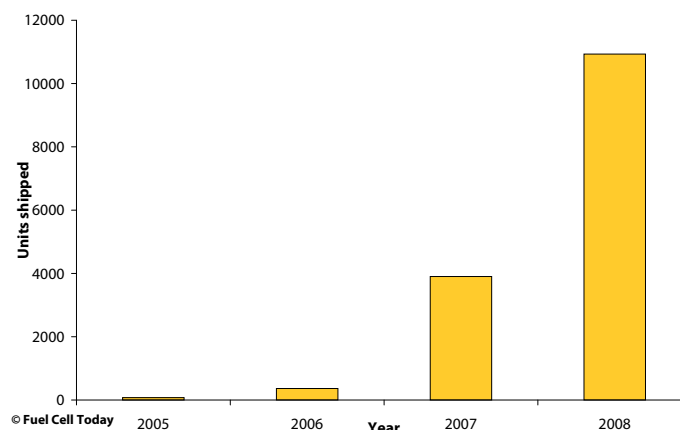


Figure 1: Cumulative niche units (APU and marine) 2005-8 © Fuel Cell Today.

¹ The term "high seas" means all parts of the sea that are not included in the territorial sea or in the internal waters of a State. Geneva Convention on the High Seas.

2.2 Annual Growth

Figure 2 shows the annual growth in units shipped over the past four years. Starting from a very low base in 2005 and 2006, there was a large increase in units shipped in 2006, driven principally by APU for the leisure sector, and then a doubling of the 2007 figure in 2008.

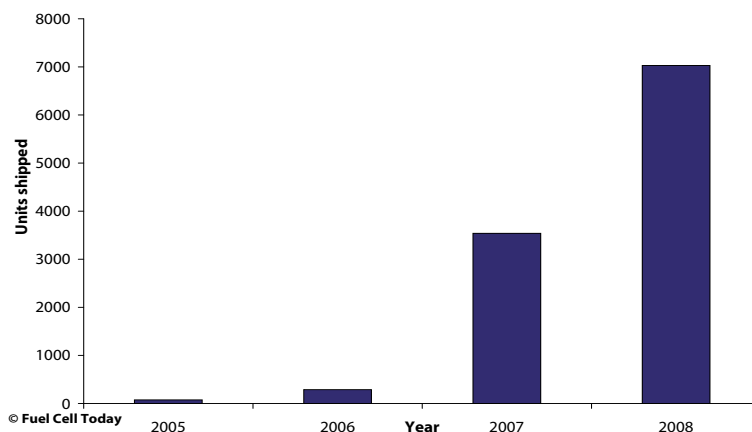


Figure 2: New niche units (APU and marine) 2005-8 © Fuel Cell Today.

2.3 Technology Choice

In terms of technology choice, the picture for 2008 is very simple: the number of units shipped in the past year have been DMFC electrolytes. These units have principally been APU for the leisure and marine markets where DMFCs offer improved durability and run time compared with battery technologies, as well as ease and flexibility of refueling. A very small number of PEM units have also been shipped this year – these have largely been PEM units for APU on board yachts where clean, silent operation and flexible refueling is a big advantage. There have also been a small number of SOFCs shipped this year. These have mainly been APU demonstration units for road vehicles and marine vessels. Once again, AFC units are absent in terms of units shipped, reflecting their declining importance in the niche transport sector.

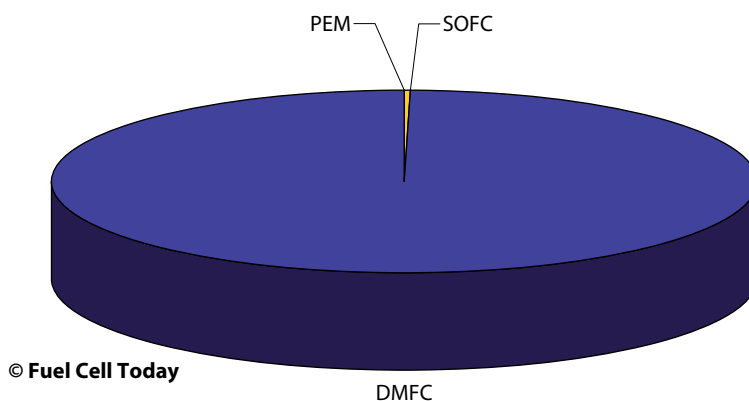


Figure 3: Electrolyte type of niche units (APU and marine) 2007-8 © Fuel Cell Today.

2.4 Region of manufacture

The lion's share of niche transport units have been manufactured and adopted in the European region, with over 99% of units shipped in the last year being manufactured in the EU region. North America is a distant second, with less than 1% of new units manufactured in that region. Other regions, including Japan, Asia and the Rest of World Region manufactured no APU or marine units this year.

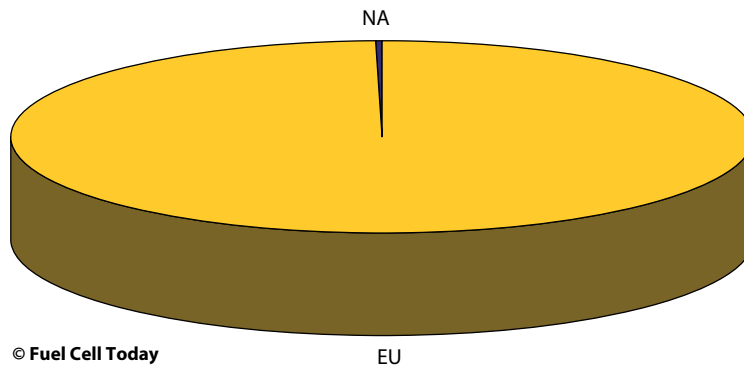


Figure 4: Units shipped by region of adoption for niche units (APU and marine) 2007-8 © Fuel Cell Today.

3. Discussion

3.1 APU market

An early niche market for fuel cells is to provide on-board power for campervans, yachts and other 'leisure' applications. Fuel cells have distinct advantages over incumbent battery technology and ICE generators for these applications in that they operate more efficiently, are clean, near-silent, and easy to refuel. They also offer considerably longer run-times than conventional battery technology. For example, a conventional lead-acid battery powering lighting and electrical equipment in a campervan needs to be recharged at least every two days and more frequently if heavy electrical loads such as air conditioning are being run. In contrast, a DMFC fuelled by a 10 litre methanol container can provide off-grid power for up to four weeks, and longer if larger volumes of methanol are used. Clearly, fuel cells fill a gap in the market for extended run-time, clean, silent power. On the evidence of the number of APU units shipped in the past two years, customers are willing to pay a premium for the advantages of a fuel cell and a growing number of campervan manufacturers and yacht developers are offering fuel cells either as standard or as optional extras.



SFC Smart Fuel Cell campervan

Case study: SFC Smart Fuel Cell is one of the key players in the APU space. Its range of 'Energy For You' (EFOY) DMFCs offer 1.6, 1.2 and 0.6 kWh output. The company's EFOY range has been integrated into a range of niche applications, from scooters and mobility assistance vehicles to portable soldier power and power for building sites. By far the biggest market is, however, the leisure market and SFC is supplier to some of Europe's largest campervan manufacturers, including Hymer, Rapido and Trigano. Rapido announced earlier this year that it will integrate the EFOY fuel cell as standard equipment in its motor home starting with the 2009 sales season. The company has shipped thousands of EFOY units to date, and looks set to continue to make inroads into the leisure market in Europe. With a dealer network of some 1,000 outlets (mainly marinas and camping supply shops) distributing its proprietary methanol containers, it seems likely that DMFC powered APUs will grow in popularity driven by longer run times, greater efficiency and ease of refuelling.

3.2 Legislated marine markets

Legislation can act as both a driver and a barrier to fuel cell adoption. In certain instances, policies can create niche opportunities for fuel cells, such as where a regulator calls for zero emissions vehicles, such as the California Zero Emissions Vehicle Mandate, which is a key driver for volume car manufacturers to manufacture fuel cell vehicles. An

example from the niche transport sector is the local banning of ICE powered vessels on certain rivers and lakes in China and Europe in order to reduce pollution – a key potential driver for fuel cell powered boats. In the UK, a fuel cell powered canal barge was launched last year and in Germany, a zero emissions passenger river boat is about to be launched. As regulations governing emissions in lakes and inland waterways are strengthened, an important niche is emerging for vessels that are powered primarily by fuel cells and fuel cell battery-hybrid systems for peak loads.

Case Study: Zero emission ships

In July 2008, Proton Motor delivered the first of two fuel cell hybrid systems that will operate as the sole form of propulsion for a fuel cell powered boat on the River Alster in Hamburg. This, the Zero Emissions Ship (ZEMship), will have two 50 kW PEM systems for propulsion and hotel loads and will be capable of carrying up to 100 passengers. The hybrid system will be used to store surplus energy and also to power peak loads such as when casting off, coming into berth, or under strong current flow conditions. The EU-funded ship will operate as a demonstration project although Proton Motor is confident that vessels such as this will find a ready market in regions where zero emissions, silent running, efficient water transport is required.



Proton Motor's ZEMship, Hamburg

Fuel cells also are a good fit for low and zero emission harbours, where low to zero point source emissions combined with low noise signatures are required. Several projects are under development to test fuel cells in harbour environments, coastal waters, and on the high seas (see below). Nedstack recently launched a design for a fuel cell-diesel hybrid powered 50 ton harbour tug boat that is claimed to reduce CO₂ emissions by 30% and sulphur oxide (SO_x), nitrogen oxide (NO_x) and particulate matter emissions by up to 98% compared with a conventional harbour tug. The hybrid fuel cell-battery system is able to provide power for around 85% of the time and it is only when substantial pulling is required (such as when berthing) that the diesel engines operate. Although this is a proof of concept design at present, there is great potential for fuel cell powered harbour tugs to reduce pollutant emissions as well as noise, and therefore meet some of the pollution reduction legislation being considered by national governments and the International Maritime Organisation (IMO).

The marine environment is the last major unregulated environment in terms of emissions reduction. Policymakers worldwide are now considering regulating shipping emissions – from the national scale such as the UK's marine bill; to the super-national such as the EU's national binding targets for CO₂ cuts as well as other pollutants; to the international, such as the IMO's plans to reduce emissions of a range of shipping pollutants. For instance, the port of Gothenburg has introduced NO_x emissions controls and a number of countries have introduced Sulphur Emissions Control Areas (SECAs) such as the English channel. All of these add up to a significant opportunity for fuel cells.

3.3 Naval developments

A number of programmes are ongoing to develop fuel cells for ships and underwater applications, funded in the main by the US Navy. Projects range from providing primary propulsion for UUVs, to providing on-board electrical power for larger vessels. One of the key issues is developing fuels and reforming technology that will allow fuel cells to run on a range of fuels, including marine diesel and bunker fuels. SOFCs are being developed by Versa Power Systems for a stealth propulsion system in collaboration with the US Navy. Units are currently undergoing testing to simulate UUV environments, which must be able to operate autonomously and undetected while conducting long-duration surveillance. Fuel cells have the advantage of being quickly refueled, are silent in operation and produce a

constant, steady output of energy – factors which are desirable for naval undersea warfare. UK based ITM Power is also said to be working with the Naval Undersea Warfare Center on power systems for UUVs.



Voller's Emerald yacht, which crossed the Atlantic earlier this year

In other developments in fuelling, the EU is funding a project to validate renewable methanol based APU for commercial vessels, based on a methanol fuelled SOFC. It was reported earlier this year that a prototype methanol-SOFC unit will be tested for performance and emissions under real-life conditions onboard a car transport vessel, with the aims of assessing the maturity of methanol-based technology and its suitability for daily use in the shipping sector. At the same time, the test will make it possible to quantify the short-term and long-term environmental impact of such a system in comparison with conventional systems. Developing reformers that will allow fuel cell powered vessels to run on a range of conventional marine and military fuels (including JP-8) and thus ensuring security of fuel supply (JP-8, for example, produced from domestic coal in the USA) is a key aim for navies. The US Office of Naval Research awarded a grant to Precision Combustion Incorporated (PCI) for a project to improve a hydrogen-producing steam reformer – the hydrogen produced will then be used on an onboard fuel cell APU. As emissions regulations tighten, innovative ways of producing cleaner fuels that can be used in fuel cells are being looked at by navies and the private sector alike.

4. Summary and anticipated highlights of the coming year

- Further significant deployments of fuel cell APU for the leisure market, particularly campervans as the benefits of fuel cells over batteries and generators becomes apparent to distributors and hire companies. This is likely to continue in the face of an economic downturn as more people look to holiday at home and the phenomenon of 'glamping' takes off.
- Deployments of fuel cell APU in yachts and the marine leisure market are likely to remain buoyant as the luxury end of the market remains largely insulated against recession. The advantages of zero emission, silent, and efficient operation is one that particularly luxury yacht owners are willing to pay a premium for.
- Legislation is likely to act as a key driver for fuel cells in the marine sphere (whether as APU or primary power). Certain regions are unilaterally deciding to mandate low or zero emissions areas (such as ports, rivers and lakes) which creates a legislated niche market for fuel cell powered craft. Certain countries are collaborating on Emissions Control Areas covering neighbouring areas of national jurisdiction, such as the English Channel's SECA. Longer term, the IMO is expected to legislate on a range of pollutants in the next few years, which would be a significant driver for the adoption of fuel cells for primary power, APU or shore-side plug-in APU.
- Further RD&D projects from national navies. Navies are driving fuel cell R&D particularly for unmanned undersea vehicles and fuel reformers. In the interests of national security and energy security, many navies are looking at developing fuel cells that are capable of running on a variety of fuels.

5. Key players

Ballard – Ballard has for some time been supplying fuel cell stacks for a number of product integrators, including Voller Energy. It has recently been consolidating some of its supply agreements, such as with Daimler, IdaTech and Plug Power. As the company concentrates on its core business of stack manufacturing since the sale of its automotive business, we are likely to see further agreements being made and consolidated.

Delphi - Delphi Corp has been selected to develop technology for the US Department of Energy's (DOE) Solid State

Energy Conversion Alliance (SECA) Program together with UTC Power and United Technologies Research Centre. The project, which includes \$22 million in funding over two years, focuses on enhancing energy security through zero-emission applications; it specifically focuses on solid oxide fuel cell (SOFC) development. Delphi has been working with the DOE under the SECA program since 2002. As part of that initial contract, Delphi and UTC Power will supply a 5 kW demonstration system with larger cells and stacks by the end of 2008.

H2Logic - H2 Logic are the company supplying the fuel cell APU on the Icelandic whale watching vessel launched in 2007 and undergoing testing in the North Atlantic at present. The vessel has the advantage of being able to approach whales silently while running only on fuel cell APU power.

NexTech – earlier this year Nextech announced it had been selected for two US Navy development projects, including one to design a fuel cell system for underwater vehicle applications and one to develop stack technology for use in a land based APU. The company also continues to develop its planar SOFC technology for large scale stationary power systems through the Department of Energy's SECA programme. Partners in these projects include the Ohio Department of Development, which provided seed funding through the Third Frontier Program, and Ohio State University who will be working with NexTech to design mechanically robust large area fuel cells.

Proton Motor – In addition to the launch of Proton's ZEMship in Hamburg (described above), Proton Motor and AVL List, a automotive engineering company, have signed a framework contract to collaborate on the development of fuel cell hybrid systems as well as related measurement and diagnostic technology.

SFC Smart Fuel Cell – SFC's main market remains APU, with several thousand units shipped this year. The company is very bullish about future growth prospects in the leisure market In addition to this. SFC has form in rapidly developing new markets and we look forward to reporting further deployments. The company already has a distribution network of over 1,000 outlets in Europe for the supply of methanol for its EFOY units, one that should expand with further niche transport growth.

Versa Power Systems – Versa is working on SOFC technology which could be used in a propulsion system for a stealth UUV being developed by the US Navy (described above).

Voller Energy – It has been an interesting year for Voller, who sailed their Emerald yacht across the Atlantic and back under fuel cell power fuelled by propane. Voller also signed a supply agreement with Ballard for integration of Ballard's stacks into Voller's 1 kW APU for the leisure and marine markets. Voller also announced that TÜV SÜD, an international certification organisation, has certified the Voller 1 kW fuel cell auxiliary power unit (APU), which operates on propane, LPG and Calor Gas.

Volvo – there has been very little from Volvo in the past year, who have previously been reported to be developing fuel cell APU for truck sleeper cabs, primarily for the US market where emissions and anti-idling legislation may be coming into force.

Webasto – Webasto is collaborating with SFC Smart Fuel Cell on equipment for leisure vehicles. The agreement will see Webasto, a tier 1 supplier to the auto industry, distribute SFC's EFOY fuel cells for use in leisure vehicles and also supply the accessories follow-up market.

About the author

Dr. Jonathan Butler works as Asia Analyst for Fuel Cell Today. His interests include how hydrogen and fuel cells fit in to the climate change and environmental sustainability debates and the legislative, policy and intellectual property aspects of hydrogen and fuel cells. He is also interested in portable and transport applications of fuel cells. Jonathan can be contacted on jonathanbutler@fuelcelltoday.com

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