



## **2009 Niche Transport Survey**

Dr. Kerry-Ann Adamson,  
Lisa Callaghan Jerrram  
Fuel Cell Today

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## **Glossary**

AFC – Alkaline Fuel Cell

APU – Auxiliary Power Unit

ARRA – American Recovery and Reinvestment Act

BAU – Business as Usual

BNSF - Burlington Northern Santa Fe

DARPA - Defense Advance Research Projects Agency

DLR - German Air and Space Centre

DMFC – Direct Methanol Fuel Cell

EU ETS – European Union Emissions Trading Scheme

FCT – Fuel Cell Today

FZJ - Forschungszentrum Jülich

ICE – Internal Combustion Engine

HP - horse power

JTI - Joint Technology Initiative

Li-Ion - Lithium Ion Battery

LPG – Liquefied Petroleum Gas

LNG – Liquefied Natural Gas

MCFC - Molten Carbonate Fuel Cell

MW - Megawatt

NATO - North Atlantic Treaty Organisation

NiMH - Nickel Metal Hydride Battery

NYK - Nippon Yusen Kabushiki Kaisha

OEM – Original Equipment Manufacturer

PEM – Polymer Electrolyte Fuel Cell

RoW – Rest of World

RV – Recreation Vehicle

Scramjet - Supersonic combustion RAMjet

SOFC – Solid Oxide Fuel Cell

TEU-mile: Unit for the carriage of one TEU a distance of one mile

US DOD - United States Department of Defense

US DOE – United States Department of Energy

US DOT – United States Department of Transport

UASs - Unmanned Aerial Systems

UAV – Unmanned Aerial Vehicle

UCAV – Unmanned Combat Aerial Vehicle

## 1. Overview

Since the last survey the Niche Transport market for fuel cells has been something of a tale of two halves. Some applications such as e-bikes, which only a couple of years ago were seen as the next big thing, and trains have slowed down considerably. On the other hand three applications have become what the FCT analysts refer to as “breakout markets”, markets which are experiencing solid market pull whether from government, military or direct consumer demand. These are materials handling vehicles, Auxiliary Power Units (APUs) and Unmanned Aerial Vehicles (UAVs). Whilst of these three only materials handling has seen any growth this year, this has been somewhat artificially impacted by US government funding through the American Recovery and Reinvestment Act (ARRA). Support for forklift installations through this US\$789 billion economic stimulus programme has not only improved shipment numbers but has also changed the mix of electrolytes and a shift upwards of North American share of global niche transport shipments from 9% in 2008 to 25% in 2009.

Over the next decade we believe that the impact of the ARRA on the materials handling sector will be such that the sector exhibits a 10 year annual growth rate (AGR) of 80%, with annual growth in the next two years being in excess of this.

The APU sector, which covers five distinct markets, will become less reliant for growth on the leisure sector, though this will still see over 50% of the APU market, as fuel cells for trucking become commercially available alongside fuel cell APU units for materials handling. Whilst we forecast that non-leisure Marine APUs will only represent some 2% of the APU market by 2019 these do make up the majority of the MWs as the majority of these will be the 300 kW+ size.

UAVs, which to date have been a sleeper market, are starting to come out of the shadows. The market is being driven by military interest, but is also attracting increasing interest from civilian groups for search and rescue and wildlife monitoring. The past year has seen an increase of fuel cell UAV shipments of over 100%. This growth rate is anticipated to slow down but

still spur annual shipments of over 20,000 units per year by 2019. Note that as our model is a Business as Usual (BAU) model it does not assume any increase in global military activity, which, if it occurred, could produce a step change in UAV shipments.

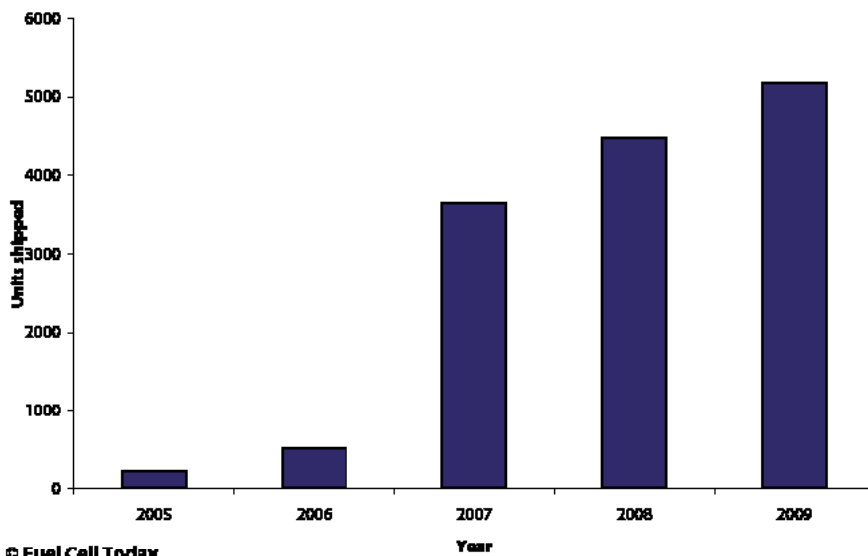
## 2. Analysis of Developments

### 2.1 Annual Growth

By the end of 2009 we forecast a repressed growth over 2008 of only 7%, reaching just over 5,000 new niche transport units shipped. Please note that due to the global economic slow down we have downgraded our previous 2008 forecast by some 2600 units.

The global recession has impacted the sales of fuel cells into the leisure sector, which is dominated by sales into the RV market and the small yacht sector. According to statistics reported by SFC Smart Fuel Cell registrations of new RVs have dropped 24% in Europe and 19% in Germany in the past year. As most fuel cells are being fitted into newly registered RVs, not retrofits, this drop in registrations has seen a parallel drop in fuel cell sales. This we believe is somewhat temporary as there has been a simultaneous increase in so called "glamping" (glamorous camping) with older RVs which are suitable for retrofit. Targeting this secondary market by fuel cell suppliers could see an increase in sales by the end of the year.

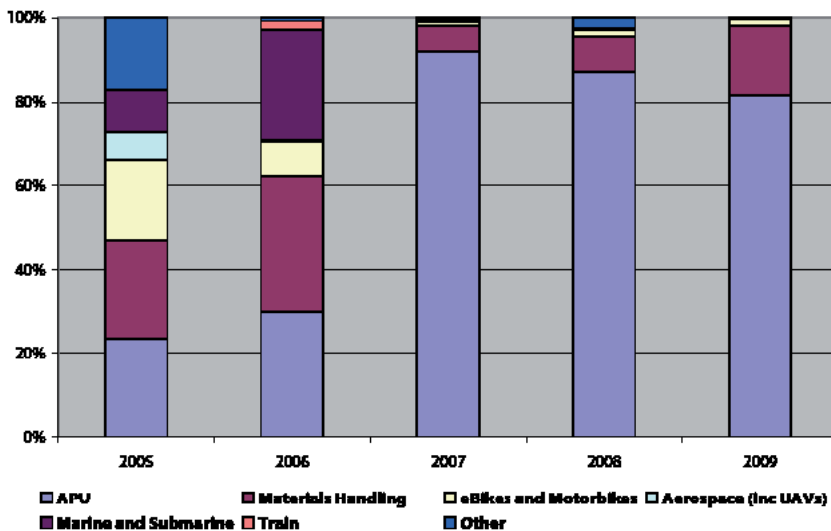
**Graph 1: Annual Units Shipped 2005 - 2009**



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As can be seen in Graph 2, since 2007 there has been a significant shift in the niche market from overall dominance by APUs to an increasing share of materials handling units. Together these two markets account for some 95% of all shipments to the end of 2009. What can be seen from the graph is that markets that were originally seen as close to commercial, specifically e-bikes and motorbikes, have not seen any increase in market traction. This lack of traction has had the impact of a drop in number of stack developers and systems integrators working in this area in favour of areas where market pull and market signals are clear and potential income looks more secure.

**Graph 2: Shipments by Application 2005 – 2009**

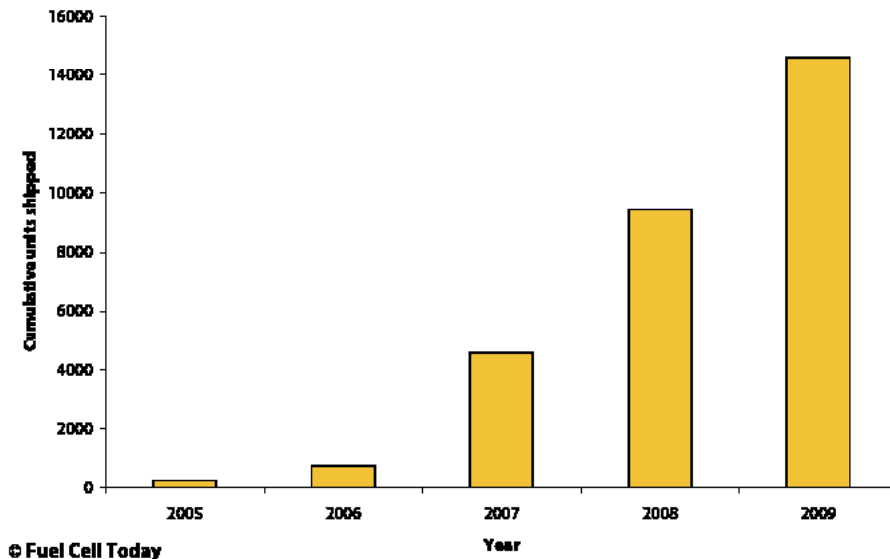


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## 2.2 Cumulative Growth

Cumulatively we have seen, since the 1960s, more than 14,000 units shipped in the niche transport sector, with over 80% of these having been shipped in the past three years.

**Graph 3: Cumulative Shipments 2005 – 2009**

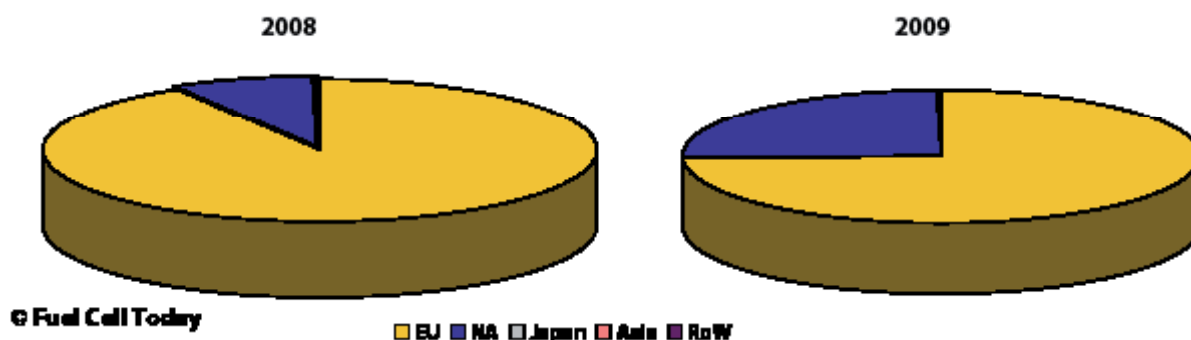


## 2.3 Region of System Manufacture

Each year the Fuel Cell Today analysts monitor the region of system manufacture. Note that this is not the region of stack manufacture or region of adoption. As this is already a global industry stacks are often shipped out of the country of manufacture to be integrated into a system in another country and then sold for use into yet another region.

Graph 4, below, shows the shift in region of system manufacture from 2008 to 2009. What this graph shows is that Europe is still a very strong region of manufacture with three quarters of all systems produced in Europe. North America, primarily on the back of the increase in forklift shipments, will see an increase in its percentage share of global units from 9% in 2008 to 25% in 2009. What is also clear from the graph is that Japan's dominance in other fuel cell sectors is not replicated in the Niche Transport sector. Japan, Asia (omitting Japan) and the Rest of World (RoW) make up less than 1% of shipments in 2008 and 2009. This is not to say that these regions are not active in this area but that developments are still in the prototype stage or in limited trials of fewer than ten units. Looking forward we do not expect any of these regions to gain significant (>10%) market share as Europe and increasingly North America are building up first mover advantage.

**Graph 4: Region of System Manufacture 2008 and 2009**

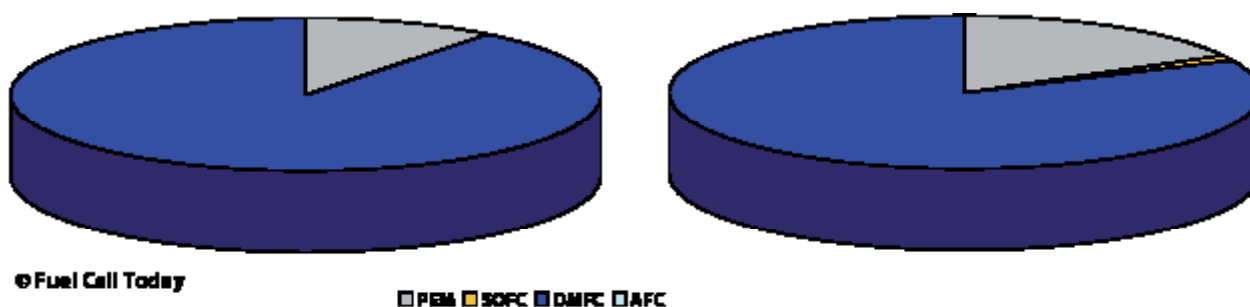


## 2.4 Electrolyte Adoption

The types of electrolyte used in the Niche Transport sector are varied, from MCFC as APUs for ocean going ships, to PEMs for APUs in trucking, to, longer term, SOFCs in UAVs.

Graph 5 shows the 2008 and 2009 electrolyte adoption mix, which, as is to be expected, is dominated by low temperature fuel cells, especially DMFCs.

**Graph 5: 2008 and 2009 Electrolyte Adoption Mix**



DMFCs still take the lion's share of the market, not just due to their dominance in the leisure sector but also now due to expansion into new markets, including, for example, DMFCs as APUs for materials handling, a market being pursued by Oorja Protonics. These small fuel cells are capable of being retrofitted into battery powered materials handling units and obviate the issue of having to install a new refuelling infrastructure as with direct hydrogen based fuel cells.

Other markets for DMFC captured in this graph include vehicles such as the Velo Taxi being developed by SFC Smart and Veloform and other three wheeled vehicles. Also a number of companies are still trying to lock down a design for a fuel cell powered wheelchair and are trialling both DMFC and PEM. One thing to note is that if units are still lab prototypes we do not include them in our dataset.

Due to the overall increase in the market for DMFCs, the share for PEM units has not grown as much as claimed by some other industry "commentators". We have seen good growth of PEM from 11% to 17% and this has the potential, on the back of markets such as UAVs, to reach 28% of overall market share by 2019.

SOCs also have large potential in the sector for a number of different applications but as they are still not shipping in any large numbers they represent a very small percentage in 2009 with a forecast 17% market share by 2019.

## **Premium Content - 3. Market Drivers and Barriers**

### **4. Breakout Markets**

#### **4.1 Forklifts**

This past year has seen solid growth in the fuel cell forklift market, with shipments in 2008 up almost 100% from 2007, and projected 2009 shipments on track for an equal rise. Materials handling has been touted as a promising early market for several years, and these shipment trends suggest that promise is coming to fruition. As Fuel Cell Today noted in last year's Survey, this industry was waiting for large scale deployments to move into early commercialisation and low-level mass production. While it is becoming clear that the early markets where fuel cells provide a value proposition are fewer than originally thought, one of those key early markets did provide the large-scale deployment FCT was looking for. In May, wholesaler Central Grocers opened its new warehouse in Illinois with an all fuel-cell fleet: 220 vehicles including pallet trucks, reach trucks, stand-up counterbalanced trucks, and sit-down trucks. Plug Power supplied the fuel cells systems, taking advantage of its ability to offer a range of forklift products since acquiring Cellex and General Hydrogen in 2007. The fuel cell maintenance contract is with forklift OEM Yale – another sign that this market is entering a more commercial phase by adopting a conventional contracting model.

While this is an important step forward, government support still plays a key role in this market right now -- certainly in the US where market growth is strongest. Late last year the fuel cell investment tax credit was increased to \$3,000 per kW or 30% of the unit price, whichever is less. Forklift OEMs offering fuel cell options have indicated that the tax credit is critical to creating the value proposition for end users at current hydrogen prices. As discussed under Market Drivers and Barriers, the US DOE Market Transformation programme is also supporting many of the new forklift shipments. DOE's initiative to demonstrate fuel cell equipment at Defense Logistics Agency (DLA) sites continued, with around 100 forklifts planned for shipment to five DLA sites in 2009 and 2010. DOE also used \$10.8 million of the federal stimulus package funding to support deployment of 314 forklifts with five commercial partners, including FEDEX and Anheuser Busch. These are a critical test for fuel cell companies and fuelling providers, as all the commercial partners have said they will continue fleet conversion if the initial deployments are successful. The fuel cells are replacing battery equipment, so the key driver isn't emissions, but cost and performance.

While this market is showing promising growth, it is also being hampered by the economic downturn. Several materials handling equipment suppliers have noted that orders of conventional equipment have slowed dramatically since the last

quarter of 2008. This downturn may have played a role in the scaled down shipment projections made by some fuel cell providers, notably Ballard which is the predominant stack supplier in the North American market. At the beginning of the year, Ballard had projected shipping 1,000 forklift powerplants in 2009; at mid-year, the company said the market had been slower than anticipated and projected fewer shipments, although it declined to give a new estimate.

In spite of the slowed economy, or perhaps because of it, forklift OEMs and distributors are showing greater interest in fuel cells. Crown Equipment recently introduced itself as a player in this arena, after it received a \$1 million grant to qualify commercially available fuel cell systems for its portfolio of forklifts. Crown is working with PEM suppliers Plug, Hydrogenics, Deka/Nuvera and DMFC supplier Oorja Protonics. South Carolina distributor LiftOne has a relationship with Hydrogenics and says it is demonstrating lift trucks at six sites in South Carolina. Yale Equipment has more quietly been positioning itself as a key supplier. Raymond has been a strong advocate for several years and continued to tout its partnerships with Plug, Nuvera, Hydrogenics, and Deka Nuvera. It also has a partnership with Ballard to research purpose-built fuel cell forklift truck designs with the goal of developing a prototype incorporating Ballard stacks.

It is interesting to note that this model would bypass the fuel cell system providers like Plug Power, which is the dominant player in this sector. The company was the big winner in the stimulus package forklift awards, which will support shipment of 304 Plug fuel cell forklifts. This also gives Plug an advantage going forward, as one of the best near-term markets for fuel cell forklifts will be sites that have already deployed fuel cells. This may seem like stating the obvious, but it is important to note that, at most sites, equipment turnover happens incrementally, and this poses a barrier for fuel cells since end users will be forced to maintain two sets of infrastructure while they transfer their fleet to hydrogen. Therefore, the two key early targets are "greenfield" sites like the new Central Grocers warehouse and sites that have already begun the transition.

In the US, the other major stack providers for this sector are Nuvera and Hydrogenics, both PEM providers, and DMFC manufacturer Oorja Protonics. Nuvera has been partnered with East Penn Manufacturing to produce the Deka ReadyPower fuel cell products – 30 more of these are being shipped through the Market Transformation Programme. But Nuvera has now unveiled its own fuel cell / battery hybrid package for forklifts called the PowerEdge. Nuvera is marketing itself as a one-stop shop for end users, offering the PowerTap hydrogen generator and station along with the PowerEdge. Grocer distributor H-E-B purchased 14 forklifts along with the fuelling infrastructure using DOE Market Transformation funds. By comparison, Hydrogenics has been quiet this year, but is continuing to ship small orders of forklifts through the DOE programme as well. Oorja continues to go its own way, selling the 'Oorjapac', an on-board DMFC fuel cell charger. The value proposition of Oorja's business model is slightly different as it involves using a DMFC as an APU for the materials handling vehicle's existing lead acid battery. The DMFC unit constantly trickle charges the battery and removes the need for swapping out the battery for complete recharging. The selling point is avoiding the hydrogen infrastructure costs. In 2009, Oorja reported that it had received several purchase orders in North America, although the precise number of shipments is unknown.

While market growth is not as robust in Europe, there are several manufacturers showing interest in capturing this region. Danish company H2Logic is developing Class 1 and 2 materials handling vehicles and is currently partnered with Ballard. Unlike the majority of the North American sector, H2Logic is focused on replacing LPG or diesel forklifts, not battery powered ones. The company sees CO<sub>2</sub> reduction as a primary driver for the Danish market, where it is focusing its initial efforts before expanding throughout the EU. The company has a small number of vehicles in service already and is looking to ramp up slowly over the next year. Like Nuvera, H2Logic also supplies hydrogen fuelling stations to its customers.

Proton Motor has been continuing to demonstrate its own fuel cell forklifts. Last year, however, the company was fairly quiet on this market and appears instead to be focused on its marine applications, as well as new niche vehicle products such as a street sweeper and utility vehicle. Germany research firm Julich Forschungszentrum Jülich (FZJ) works on DMFC materials handling vehicles. Julich has developed a Class 3 vehicle with German warehouse logistics firm Jungheinrich using a 5 kW DMFC. Several are currently being trialled in various warehouse locations in Europe, including in a Tesco warehouse in the UK. Julich has been fairly quiet this past year.

Looking ahead, there are some key areas fuel cells will need to address to capture a significant share of the forklift market:

- Suppliers need a full line of fuel cell forklifts to enable a warehouse to eliminate all battery or ICE forklifts. Fuel cell suppliers and OEMs are clearly working toward this already.
- The industry needs to be able to sell end users a turnkey solution of forklifts and fuelling. End users need a seamless transition to hydrogen without becoming hydrogen experts. One advantage for forklifts as opposed to other fuel cell vehicle technologies is that hydrogen suppliers are very engaged with this market. Linde and Air Products are bullish on the forklift sector.
- In the long-term, this sector may need purpose built fuel cell forklifts, as current models are designed around the weight and volume of the battery pack.
- This market needs some codes & standards attention, not only for hydrogen installation but also for vehicle shipping. Manufacturers are accustomed to shipping forklifts among end users – for example, transferring out old forklifts to another site – so there need to be clear guidelines for shipping forklifts equipped with fuel cells and hydrogen tanks that are not prohibitive to the market.

## 4.2 APUs

The APU sector was the first of the Niche Markets to be commercial but now the APU sector is clearly disaggregated into four separate markets – Leisure, Trucking, Marine and UAVs.

### 4.2.1 Leisure

Small fuel cell APUs for RVs and yachts have been available commercially from SFC Smart for over two years now. During that time no other company has managed to successfully enter the space, with some such as Voller having closed down operations.

In the past the biggest development has been Protonex announcing that they were to enter the market in North America with their M250-B, a 250W DMFC. The M250-B has a fairly short warranty of 1 year or 1,000 operating hours and has a fuel consumption of 1 litre of methanol every 2 hours. Recently though Protonex has decided to defer the 2009 launch of the M250-B. The statement made by Protonex regarding the move is to provide time for a set of cost reduction efforts on the product which should make it more economically attractive when it does enter the market. The company will continue with planned OEM and beta site evaluations of the M250-B with a new launch date of 2010.

### 4.2.2 Trucking

Using a small fuel cell to provide the electricity and potentially heat for the hotelling of a cab in a truck is not a new idea and has been worked upon by a number of research groups over the past five years. With the anti-idling legislation in many States in the US forbidding trucks from idling the engine overnight for power, alternatives are being explored.

This is not a clear winner for fuel cells though as increasingly in the US, where the largest share of this market is projected to be, a network of electrical hook points are being installed at truck stops. Fuel cells could be seen to be losing ground in this area with no new public developments over the last year.

The biggest two companies working on this concept are Webasto and Powercell. Powercell's 5 kW PEM unit is being initially targeted at the North America trucking market but the company is also analysing the marine market. Going forward PowerCell is planning to release the first commercial generators in 2011 for the Volvo truck in North America. Following this release, the European and Asian markets will follow.

Webasto, which is working on APUs using SOFC now possesses the 1kW prototype of its unit that runs stably, operates autonomously and can be switched on or off cyclically. Series production is planned to start in 2010 with future plans to develop units in the 500 watts to 5 kW range.

### 4.2.3 Marine

Small sub kW fuel cells for marine APUs have been available from SFC Smart for over two years now but they are the only company shipping under commercial terms this size of fuel cell for this application. An increasing amount of attention is being focused on large (>200kW) fuel cells for ships such as cruise ships.

Whilst there has been an increasing amount of attention this has yet to be translated into shipments. The projects outlined in last year's Niche Transport Survey are still underway but no new ones have been announced yet in 2009.

## 4.3 UAVs

**Premium Content - Special Section: UAVs – The Rise of the Machines**

## 5. Other Niche Transport Markets

### 5.1 Bikes / Motorbikes

Growth in the two and three-wheeled vehicle sector slowed this past year. Although shipments held steady, this is in sharp contrast to the doubling of shipments that occurred from 2007 to 2008. Activity also shifted from two-wheeled to three-wheeled applications, with DMFC manufacturer Smart Fuel Cells in particular having success with its three-wheeled electric assist "tricycle", the Pedelec. The fuel cell acts as both range extender and onboard charger. SFC seems to be mainly targeting the European market, where much of the scooter and motorbike shipment activity was centred over the past year.

The electric-assist bike application, which showed new shoots of growth as of last year's survey, was much quieter in the past 12 months. Still, this market has promise in countries with heavy dependency on polluting motorbikes or in urban areas where electric bikes offer the ability to commute comfortably and for longer distances. In markets like China, where fuel cell manufacturer Shanghai Pearl launched in 2006 to sell its fuel cell bicycles, fuel cell bikes can replace conventional bikes or the popular but polluting small, 2 stroke motorbikes. They face stiff competition from battery bike options, however, which have seen significant market penetration in China. In developed countries where cycling is popular, fuel cells can offer a value proposition for users that for physical or practical reasons are looking for an "easier" cycling experience or that want to commute comfortably over long distances. In contrast to battery bikes, fuel cells may appeal more to customers who don't have ready access to an outlet at either end of their trip. Depending on the customer's commute lengths, fuel cell bikes can be used for a week to one month before needing to refuel. Fuel cells also offer value for customers needing to bike longer distances than possible with a battery bike. Also, as last year's survey noted, these characteristics also make mail delivery, bicycle courier service and enclosed "campus" transport potential markets. This is still a market that looks to have potential, but may require a push from governments looking for relatively low cost applications to demonstrate and promote fuel cell technology.

By contrast, while companies such as SFC and Intelligent Energy continue to use their striking looking scooters to attract attention at expos and with the media, this sector has not shown signs of ramping up growth. Greek technology company Tropical S.A. introduced its entry into this market last year, a battery powered scooter equipped with a 500 W fuel cell system that charges the 48V battery and extends the scooter's range to over 150 km, according to the company. This is still a demonstration model, although the company believes it may have applicability in the same environments where neighbourhood vehicles succeed – resorts, universities and other enclosed spaces.

## 5.2 Marine

The marine sector is another niche transport sector that only last year appeared to be gaining ground and then this year has once again pulled back.

Using fuel cells as propulsion for inland waterway craft such as the Hamburg based Alsterwasser, which was covered in the 2008 Niche Transport Survey, is seen by many as a logical first step. With the Alsterwasser project gaining valuable experience in the regulatory aspects of using fuel cells onboard ships and with the propulsion system now a standard item in the Proton Motor product line it should be only time before more ships are built or retrofitted with this system.

Although this sector, like all the others, is not recession proof, it is somewhat surprising that no concrete new projects have been announced. This may be related, in Europe at least, to a desire for JTI funding to back such a project but if so then this dependence on drip feed funding from government is not going to build a sustainable business.

In the open ocean using fuel cells for propulsion is a different proposition as there are a number of technical and regulatory aspects still to be worked out. One not so trivial example is that the fuel cell will have to be able to operate whilst being buffeted about by ocean swells. In reality this translates into making fuel cells far more robust than they are at present or developing some form of gyroscopic cradle for the unit which will hold it level.

The past year has seen the launch of one concept design, but it should be emphasised that there is no plans to build such a ship.

The "Super-Eco Ship"

### Image 1: The NYK SuperEco Ship Model © NYK



Nippon Yusen Kabushiki Kaisha (NYK), one of the world's leading transportation companies, has released an initial exploratory design for its NYK Super Eco Ship 2030. The energy-efficient ship is modelled at emitting 69% less carbon dioxide emissions than current container ships. The design was created by MTI, a wholly owned NYK subsidiary charged with making use of advances in technology, along with Garroni Progetti s.r.l, an Italian designer of ships, and Elomatic Marine, a Finnish marine-

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technology consultant.

The ships propulsion will be form Liquid Natural Gas (LNG) fuelled fuel cells, solar cells and wind power and the design of the ship includes a significant decrease in the weight of the hull, thereby also decreasing the amount of power required.

NYK have provided the table below which compares the NYK Super Eco-ship 2030 with a conventional 8,000 TEU container vessel.

**Table 1 – Characteristics of the Super Eco-Ship 2030**

	Conventional Vessel	Super Eco-Ship 2030
<b>Overall Length (Meters)</b>	338	353
<b>Breadth (Meters)</b>	45.8	54.6
<b>Draft (Meters)</b>	13.0	11.5
<b>Main Power</b>	Diesel Engine	Fuel Cell
<b>Fuel</b>	C heavy oil	LNG
<b>Power Output (MWs)</b>	64	40
<b>Renewable Energy (MWs)</b>	None	Solar – 1- 2
		Wind - 1 - 3
<b>CO<sub>2</sub> Emissions (g/TEU-miles)</b>	195	62

TEU-mile: Unit for the carriage of one TEU a distance of one mile

### 5.3 Aerospace

Of all markets for fuel cells using them onboard commercial aircraft is the area with the longest development path. Light duty vehicles may seem like a long way off but they are around the proverbial next corner compared with using fuel cells for aircraft propulsion.

Not only are there a raft of technical aspects that need to be considered, such as reducing the weight of the units, producing a highly dependable fuel reformer and building a unit designed to fit into the aircraft but also there are the non-trivial issues of consumer acceptance.

The past year has seen the take off of a piloted aircraft, the Antares DLR-H2, built by the German Air and Space Centre (DLR) in conjunction with Danish Fuel Cell company Serenergy as well as Lange Aviation, BASF Fuel Cells and European aircraft manufacturer Airbus. The aircraft’s maiden flight was a 10 minute trip from Hamburg airport with a top speed of 170 km/h. Prof. Dr. Johann-Dietrich Woerner, chairman of the board at the German Aerospace Center, DLR was quoted at the launch as saying "The power and efficiency of fuel cell technology has been improved to such an extent that a manned airplane can now take off". Whilst we agree that fuel cell technology has increased in power and efficiency we still do not see this market as close to commercial for at least the next two decades.

### 5.4 Trains

Of all the sectors covered in the Niche Transport survey, trains is the only one with a dedicated annual conference – Hydrail (<http://www.hydrail.org/>). The existence of this conference highlights the growing belief that trains are one of the areas in which fuel cell technology makes sense.

The benefits of using fuel cells on trains include:

- Electrification of trains without the need for overhead power lines;
- Increased torque and power available;
- Reduced emissions and reduced risk from adverse weather knocking down power cables;
- No weight penalty for fuel cells;
- Back to base model for calculating fuel required

Interestingly this is one area where potentially cost is not the barrier. To put this in perspective the recent upgrading of the West Coast Main Line in the UK, some 645 km (401 miles), cost some £8-10 billion (this figure is not a typo!) and this did not include the initial outlay to install overhead cables.

The past year has seen the release of one new project: a 1.2 MW fuel cell powered locomotive designed by Vehicle Projects LLC and Burlington Northern Santa Fe (BNSF), one of the largest haulers of goods on tracks in the US. The locomotive has hydrogen stored onboard in tanks and is a hybrid with onboard batteries. It has been rated at 2,000 hp for traction and is expected to be “two to three times more efficient than a standard US diesel locomotive”. The vehicle is expected to begin on

track operations during 2009.

The reason behind the interest is that BNSF, which operates and owns 6,400 locomotives and some 85,000 freight cars, estimates that its diesel locomotive fleet burns more than 15 million litres a day, comprising about 26% of its operating cost as of 2008 and about 2% of all US diesel fuel usage. From this it can be seen that developing more fuel efficient technologies is high priority.

A second push in the US comes from the White House which has released details of a US\$14.3 billion package to help upgrade infrastructure for the development of high speed rail networks. Emphasising the need to switch to more efficient and cleaner rail travel the money available includes US\$1.3 billion for Amtrak, a five year package of US\$5 billion for high speed rail upgrades in the 2010 budget and a further US\$8 billion in ARRA for railtrack improvements. The US Department of Transport (DOT) is looking into fuel cells for rail propulsion but is not looking to have a test vehicle on the tracks until 2012 – 2014 at the earliest. The increased focus on rail in the US could well bring this forward. In Europe it is yet to be seen if the JTI or any of the reconstruction and development banks will support projects to further develop the technology in Europe, especially the former Eastern Bloc countries which are now in the process of upgrading rail infrastructure.

## **5.5 Other**

The other section of the Niche Transport Survey covers areas such as mobility assistance vehicles and exotics such as robots. This year has seen less than 5 new projects or shipments globally. As the industry in general becomes more commercial these smaller niches are increasingly falling quiet as companies focus on larger, more short term markets with potential for near term cash flow. Mobility assistance vehicles still have a lot of potential but these are increasingly seen as medium term after the development of such products as three-wheelers and velotaxis.

Looking forward we do anticipate a pick-up of shipments in this area, especially around the time of the London 2012 Olympics with small fleets of these vehicles being available to rent. This is a somewhat artificial market though and does not represent long term consumer demand. Due to this we expect a spike in shipments in 2011 and 2012 and then a decrease after that until around the 2015 timeframe.

As to robots -- to date all the work done in this area has been in Asia for applications such as security but with little market pull – what is the benefit of putting a fuel cell in a robot? – development has slowed down if not stalled. In the last twelve months there is no record of any shipments of fuel cell powered robots or even university projects. There may be some work being done at school level but as this is outside the scope of this report it is not recorded in our dataset.

## **6. Key Players**

Each year the Fuel Cell Today Surveys provide a brief overview of key companies working in each sector. This is not an exclusive list of companies working in this sector and does not represent any level of endorsement by Fuel Cell Today of the companies and their activities. Companies are indicated by headquartering country and primary Niche Transport sectors in which they are involved.

### **Ballard (Canada: materials handling)**

Ballard continues to be a major supplier of PEM stacks for the forklift market. Plug Power, the market's dominant player, uses Ballard for its range of forklift vehicles, which are primarily marketed to North America. Ballard also signed a 2-year supply agreement with H2Logic in January 2008, giving Ballard an entry into the European forklift market. However, in its recent mid-year report, Ballard scaled back its 2009 shipment projections due in part to the "weaker than expected performance in the material handling market." The company had originally projected shipping 4,000 fuel cells, including 1,000 for materials handling. It did not provide revised shipment figures. Shortly after, Ballard announced it was laying off 20% of its workforce.

### **H2Logic: (Denmark: materials handling, marine)**

H2Logic is targeting its marketing efforts on Europe and on fuel cells as a replacement for warehouses using LPG or diesel, not batteries. The company has signed in January 2008, signed a two-year deal with Ballard. H2Logic is looking to CO<sub>2</sub> reductions as the primary driver for its fuel cell forklifts in Europe.

### **Oorja Protonics (US; materials handling)**

Oorja Protonics are believed to be the only North American DMFC manufacturer in the materials handling space, marketing its 'Oorjapac' on-board DMFC fuel cell charger to extend range on battery forklifts. Oorja is developing units in the range of 400 W – 1.6 kW for inclusion into Class 1, 2 and 3 materials handling vehicles (24-48 V) and has achieved European CE certification for its OorjaPac. In late April 2009 the company announced that it received a purchase order from Super Store Industries (SSI) for installing its OorjaPac on SSI's entire material handling fleet at SSI's Lathrop facility. In addition to supplying the DMFC, Oorja also supply a vehicle adapter kit (with mounting brackets and junction box with matching SBX connectors), and a

refuelling unit containing a methanol pump, 55-gallon drum, and secondary containment.

### **Nuvera (US; materials handling)**

Nuvera recently unveiled its own line of hybrid fuel cells for the forklift market. Called PowerEdge, the fuel cell line currently has products suitable for Class 1 and Class 2 trucks. Nuvera continues to work with East Penn Manufacturing, supplying forklifts equipped with what is now Nuvera's previous generation fuel cell system for the US Defense Logistics Agency through the US Department of Energy's Market Transformation programme. Nuvera was also a beneficiary of US Recovery Act funding, with a test fleet of forklifts, produced with partner East Penn, to be deployed at East Penn's facilities. To date, however, Nuvera has not reached the level of production seen by the other fuel cell companies.

### **Protonex (US; APUs, UAVs)**

For 2009 Protonex announced a strategic move away from introducing its commercial M250 product for the US leisure RV market and toward the military application of the M250. The company is following major new funding available from the military as well as backing off the RV market during the current economic slowdown. Protonex says it is now looking to a 2010 launch of the M250-B for RVs, when the recession may have abated. Meanwhile the company is aggressively moving into development of high power fuel cell systems for small UAVs, securing US Department of Defense funding. Protonex also develops portable military applications.

### **Proton Motor (Germany; marine, utility vehicles, materials handling)**

PEM developer Proton Motor is active in a range of niche applications. Since its high-profile launch last year, the fuel cell Zemship passenger ferry is being deployed in Hamburg to demonstrate performance. This past year Proton Motor also launched a light duty truck developed in conjunction with Karmann, and announced development of a fuel cell powered street sweeper, which will be tested in various European municipalities over 18 months. In the materials handling sector, Proton Motor has focused mainly on a small number of demonstration units. The company is also developing a fuel cell system integrated into a Skoda bus (to be covered separately in the 2009 Bus Survey later this year). Proton Motor recently announced it had entered into a 5-year deal with Deutsche Mechatronics to produce its PEM fuel cell system. In the near term, the two companies will work on producing short run high quality systems; longer term the goal is a 5,000-unit annual capacity.

### **SFC Smart Fuel Cells (Germany; APUs, bikes, scooters)**

German DMFC company SFC Smart Fuel Cells has continued to have the greatest success with its APUs for the leisure markets, but this sector has been affected by the global recession. The company did unveil a new product this year – the EFOY 2200 which SFC says has over 37% more output than the EFOY 1600 and a charging capacity of 2,200 watt hours per day. The EFOY's suggested retail price is EUR 4,999. The company has also spread its bets by developing and marketing its EFOY products for other markets like two- and three-wheeled vehicles and military portable power supply (dealt with separately in the 2009 Portable Survey). In all, sales of SFC's fuel cell portfolio, which consists of the EFOY 600, EFOY 900, EFOY 1200 and EFOY 1600, have topped 14,000 units worldwide.

### **Tropical S.A. (Greece; motorbike/scooters)**

Greek "green technology" company Tropical S.A. unveiled its hydrogen scooter this year; it was shipped to the Athens based Centre of Renewable Energy Sources for ongoing demonstration. The fuel cell actually recharged the battery, rather than providing primary power. Tropical has announced ambitious plans to market its fuel cell scooter to a range of end users including golf courses, airports and universities. At present it is not clear whether it has the resources to pursue these markets although its home country would appear to be a good market for a fuel cell scooter. The company is pursuing EU funding through the JTI.

### **Volvo (Sweden; APUs)**

Volvo announced a major new investment in its fuel cell technology venture, Powercell, which is owned by Volvo Technology Transfer. The company also secured funding from the Swedish Energy Agency and Midroc and OCAS, for a total investment of 16 million GBP to develop fuel cells for trucks. Powercell has developed a system with an onboard reformer that fuels its 5 kW PEM fuel cell. It is intended to provide a cleaner more efficient alternative to a diesel APU. Volvo is initially targeting the US trucking market.

***For more information on purchasing the full version of this report please contact the either of the authors.***

About the authors

**Kerry-Ann Adamson** is the Principal Analyst and Manager of Fuel Cell Today and has interests in the socioeconomics of distributed generation and alternative fuels / technologies for vehicles. She can be contacted at [kerry-ann.adamson@fuelcelltoday.com](mailto:kerry-ann.adamson@fuelcelltoday.com).

**Lisa Callaghan Jerram** is based in North America and specialises in fuel cells for transportation. Her focus also includes legislation and regulations affecting fuel cells and hydrogen at the state, regional and national levels in North America and activity in Latin America. She can be reached at [lisacallaghanjerram@fuelcelltoday.com](mailto:lisacallaghanjerram@fuelcelltoday.com)

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