

## 2008 Patent Review Q3

Dr. Jonathan Butler,  
Fuel Cell Today,

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## Introduction

This is the latest in a series of Patent Quarterly Reviews published by Fuel Cell Today, which aim to give a reliable insight into fuel cell research and development worldwide. Covering the main geographical markets including Europe, North America and the Far East; and focusing on various fuel cell technologies and applications, the Patent Quarterly Review gives a reliable insight into fuel cell R&D worldwide and a unique analysis of the strategic focus of fuel cell companies. Good quality patent data is crucial to understanding current developments in fuel cell research and development, commercialisation and company activity. Trends in patent activity, both geographically and historically, reveal important insights into industrial and commercial activity on fuel cells and the future direction of the industry. A more in-depth quarterly review of worldwide patent activity, covering specific fuel cell manufacturing patents and patents granted as well as patents applied for, is available as part of Fuel Cell Today's Syndicated Research package. Please see <http://www.fuelcelltoday.com/consulting/syndicated-research> for more information.

In this Review, covering the third quarter of 2008 (1st July – 30<sup>th</sup> September), the total number of patent applications published worldwide is analysed together with analysis by technology focus, by region, and by company. An historical analysis into patents granted in the area of direct methanol fuel cell (DMFC) technology is also given in this Review. Patents applied for (As) may give some indication of the broad technology focus of an organisation and its desire to exercise commercial exploitation over an invention. They are generally published around 18 months after priority (submission of an application) and can be published by national patent offices as well as the Patent Cooperation Treaty (PCT), a unified procedure for publishing patent applications in over 140 member states. Patents granted (Bs) give potentially more insight into novel and useful inventions since they are granted by a national patent office generally after a long period of examination (2-10 years after the publication of the application). After being granted, the patent guarantees the right to exclude others from making, using, selling, offering for sale, or importing the patented invention for a period of usually 20 years from the date of publication of the application. Patents applied for are covered in this free version of the Quarterly Review, while patents granted are covered in the Syndicated version.

Note that due to the long time periods between application and granting of a patent, this Review provides merely a snapshot in time of what patent activity has occurred worldwide in the third quarter of 2008. The patents analysed in the third quarter of 2008 may have been first submitted around 18 months ago if they are As and up to a decade ago if they are Bs. Since every patent has a unique 'life-cycle' between application and granting, it is difficult to discern historical trends based on data from just the last quarter. Therefore an historical analysis of patents granted in the area of DMFCs is also given in this report to show how the technology has developed, by whom and where, and with what commercial implications and, most importantly, what the future may hold for DMFCs. Future Patent Quarterly Reviews published as part of the Syndicated Research package will contain analyses of other electrolytes, including hydrogen technologies and infrastructure, and other technologies that could act as drivers or barriers to the fuel cell industry.

The types of patents analysed in this review are generic fuel cell patents. Specific fuel cell manufacturing patents filed under the International Patent Classification (IPC) code H01M008 are covered in the Syndicated version of this review. The data presented here are generated using two patent databases: the Chemical Abstracts Plus (CAPLUS) database, which covers chemistry-related patents from patent offices around the world, including some of which who are not signatories to the PCT, and the MicroPatent database published by Thomson Scientific, which covers countries who file applications under the PCT. In the analysis below, each patent publication is treated as a separate entity and there is no 'double-counting' of patents. For detailed methodology, please refer to the 2007 Quarter 2 Syndicated Report.

## Worldwide fuel cell patent publications, third quarter 2008

In the period 1st July to 30<sup>th</sup> September 2008, there were 1,532 patent applications with the words 'fuel cell(s)' in the title or abstract (Table 1). This is around the same as the 1,553 patent applications that were published in the

previous quarter. The trend has continued for more individual assignees to be listed for individual patents, with over 150 separate assignees for this quarter (Table 1). The dataset was generated using the CAPLUS database, covering the patents worldwide and not just signatories to the PCT.

Rank	No. of patents	Assignee
1	199	TOYOTA MOTOR CORP JAPAN
2	45	TOSHIBA CORP JAPAN
3	44	TOYOTA JIDOSHA KABUSHIKI KAISHA JAPAN
4	39	HONDA MOTOR CO LTD JAPAN
5	33	MATSUSHITA ELECTRIC INDUSTRIAL CO LTD JAPAN
6	30	NISSAN MOTOR CO LTD JAPAN
7	25	KYOCERA CORP JAPAN
8	22	GM GLOBAL TECHNOLOGY OPERATIONS INC USA
9	21	IDEMITSU KOSAN CO LTD JAPAN
10	20	KABUSHIKI KAISHA TOSHIBA JAPAN
11	17	TOSHIBA ELECTRONIC ENGINEERING CORP
12	17	TOSHIBA FUEL CELL POWER SYSTEMS CORP JAPAN
13	16	DAIMLER AG GERMANY
14	16	TOSHIBA CORP
15	15	DAIMLER A G GERMANY
16	15	SAMSUNG SDI CO LTD S KOREA
17	15	SHARP CORP JAPAN
18	14	BRIDGESTONE CORP JAPAN
19	14	ENERDAY G M B H GERMANY
20	14	mitsubishi heavy industries ltd japan
21	14	UTC POWER CORPORATION USA
22	13	CORONA CORPORATION
23	13	TOYOTA MOTOR CORP
24	12	COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORG
25	11	MITSUBISHI MATERIALS CORP JAPAN
26	10	TOPPAN PRINTING CO LTD JAPAN
27	10	BLOOM ENERGY CORPORATION USA
28	10	CASIO COMPUTER CO LTD JAPAN
29	10	NIPPON OIL CORPORATION JAPAN
30	10	SANYO ELECTRIC CO LTD JAPAN
31	10	SUNRISE POWER CO LTD PEOP REP CHINA

**Table 1: Patents applied for 1st July 2008 to 30<sup>th</sup> September 2008, where ‘Fuel Cell’ or ‘Fuel Cells’ appears in the publication. This table shows individual assignees with more than 10 patents this quarter. All numbers are derived from data extracted from the CAPLUS database. © Fuel Cell Today.**

As usual, Japanese automotive and electronics OEMs dominate the table - with several of these companies listed a number of times under slightly different names (depending on the exact assignee name when the patent was first registered). Japanese fuel cell component companies such as Kyocera and Idemitsu are also featured highly in the table, as are non-Japanese automotive manufacturers such as General Motors and Daimler. In terms of patents applied for this quarter, there is no apparent decrease in patents applied for that may be attributed to the ongoing economic downturn. However, there is in general a 6 month to 2 year general lag-time between patents being filed and being published as applications therefore any economic downturn is only likely to affect the numbers of patents applied for after some time has elapsed. Furthermore, there is not necessarily a cause and effect relationship

between an economic downturn and a reduction in patent activity. Although some companies may reduce their R&D budgets, many projects have ring-fenced funding and are ongoing and therefore it may be several years before the effects of a downturn are seen in the patent literature. Conversely, companies may choose to increase R&D activity during economic difficulties- seeing the way ahead as not being investment in the credit markets or sales and marketing, but investment in R&D that will eventually lead to commercial products during more benign economic circumstances. We will be monitoring the trends in patent activity over the coming quarters to watch for signs of the relationship between R&D and the wider economic climate.

## Analysis by technology focus

Table 2 gives a list of the top patents applied for ranked by number of publications for a variety of technology foci (searched for using the terms 'fuel cell(s)' in the CAPLUS database). Of the 1,532 patent applications this quarter, there were eight separate primary IPC codes, shown in Table 2. Although there are a large number of patents applied for this quarter, there are only a relatively small number which are assigned a fuel cell IPC code. As often in previous quarters, IPC code (a general battery/fuel cell IPC code) is the most popular, however only around 8 patent applications have this code. There are several general IPC codes in Table 2, covering technology areas that are not specific to fuel cells but are important in fuel cell and related manufacturing – such as fuels, non-metallic elements, catalysis and testing systems. IPC codes that are related, but not specific to fuel cells, appear to have been growing in importance over the past few quarters – with more patents that are somewhat general or even peripheral to fuel cells. This may be indicative of the industry moving on to address issues of balance of plant now that the key fundamentals of many fuel cell technologies have been established and refined.

Rank	No. of patents	IPC Code	Description
1	8	H01M	Processes or means (e.g. batteries) for the direct conversion of chemical energy into electrical energy.
2	3	B01J	Chemical or physical processes, e.g. catalysis, colloid chemistry; their apparatus.
3	2	H01M004-86	Inert electrodes with catalytic activity, e.g. for fuel cells.
4	2	H01M008-00	Fuel cells; Manufacture thereof.
5	1	C01B	Non-metallic elements; compounds thereof.
6	1	C10L	Fuels not otherwise provided for; natural gas, synthetic natural gas obtained by processes not covered in other subclasses.
7	1	G01N	Testing static or dynamic balance of machines or structures, testing structures or apparatus not otherwise provided for.
8	1	H01J001-00	Details of electrodes, of magnetic control means, of screens, or of the mounting or spacing thereof, common to two or more basic types of discharge tubes or lamps.

**Table 2: Top technology foci for fuel cell patents applied for with the words 'Fuel Cell(s)' in the document**

Using Thompson Scientific's Aureka database, topographic plots can be constructed to illustrate the general technology focus of different patents, and used to identify trends in patent publications. Figure 1 shows a topographic plot of patents applied for in Quarter 3, 2008. From Figure 1, polymer membranes and catalyst metals appear to be the two key areas of technology focus over the past quarter, with another distinct peak that can be identified around the area of producing apparatus – a general area that covers a wide range of balance of plant. Technology focus over recent years appears to have focused on improving catalyst performance and durability, the reduction of costs (both by catalyst thrifiting and in the balance of plant) and also in improving membranes. In terms of membranes, a number of companies have reported developments in durability and also management of gases and liquids. Polyfuel, for example, recently reported that it has developed a DMFC membrane that allows water to be recycled in the stack, reducing the need for external pumps and cooling mechanisms, and therefore potentially reducing the size of a DMFC and allowing for easier incorporation in a portable electronic device.

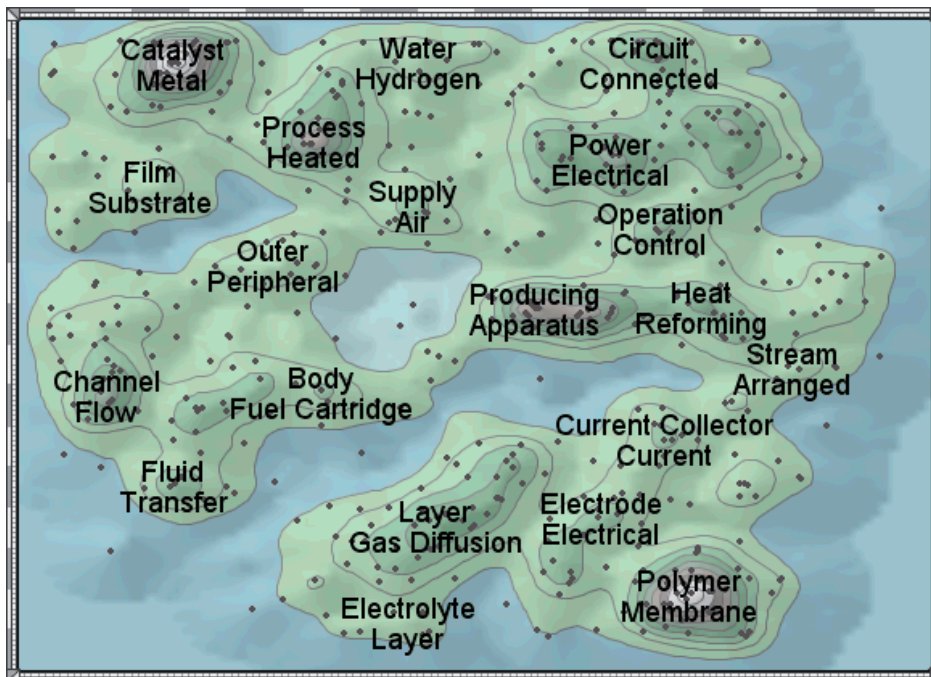
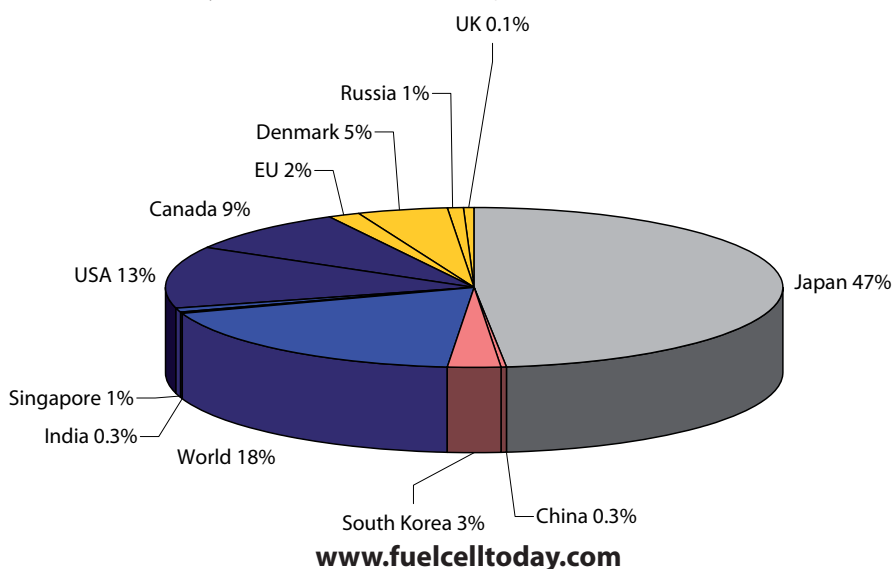


Figure 1: Topographic map of technology focus for fuel cell patents applied in the period 1<sup>st</sup> July to 30<sup>th</sup> September 2008. Each dot represents an individual patent, and contours link numbers of patents published. Blue colouring represents low and white high numbers of patents. © Fuel Cell Today.

### Analysis by region

Patents can be broken down by the country of their first publication, and this is shown in Figure 2 for general fuel cell patent applications. Note that in Figure 2, there were 1,532 general fuel cell patents published worldwide in this quarter (around the same as the last quarter), and the graph shows the number patents in each super-region (shown in different colours) and each country within those super-regions.



**Figure 2: Graph of published patent applications by country of first publication, July-September 2008 for patents with the term 'fuel cell(s)' in the document. © Fuel Cell Today.**

In terms of the region of where a patent is published, Japan continues to dominate, with almost half of the patents published this quarter being published by the Japan patent office. The dominance of Japan in terms of its patent assignees being responsible for the majority of the world's patent applications should also be noted here, and is discussed in detail in the next section. Compared to the last quarter, South Korea and China are quite significantly down in patents applied for – with China down to 0.3% from 7% of the global total and Korea down to 3% from 11%. Note that the absolute numbers of patents in Q2 and Q3 2008 are very similar – this trend may be a temporary blip from two countries whose importance in fuel cell IP appeared to be growing. The 'World' category – i.e. patent applications published under the patent co-operation treaty and therefore not through a single national office appears to be roughly the same as last year, as does the USA (only 1% down on last quarter). The national patent office which has seen the biggest increase since last quarter is Canada – up to 9% of the world total of patent applications, from less than 1%. As ever, European patent offices taken together are responsible for around 10% of patent applications this quarter, although the German patent office is notably absent from the data this month. What is most interesting is that the Singapore patent office has made it into the graph this month – Singapore is not known as a major publisher of fuel cell IP, although it is home to some important companies, including Horizon Fuel Cells, and GasHub, and is seen as a potentially important future market for fuel cell powered consumer electronics.

### Analysis by company

The following analysis contains details of companies publishing large numbers of fuel cell patents this quarter, and what this could mean in terms of their current and future activities. Where a company's name has appeared more than once in the raw patent data (such as by being spelt differently or registered by a foreign subsidiary), the patent publications have been grouped together under a single company name. Focusing on general fuel cell patents, i.e. those with the term 'fuel cell(s)' in the publication, the top 10 companies in terms of patent applications worldwide can be seen in Table 3.

Rank	No. of patents	Assignee
1	261	Toyota (1)
2	114	Toshiba (3)
3	44	Honda (6)
4	37	Matsushita (7)
5	35	Nissan (4)
6	31	Daimler (-)
7	26	Mitsubishi (-)
8	25	Kyocera (9)
9=	22	GM/Samsung/UTC (5/2/-)
10	21	Idemitsu (9)

**Table 3: Top 10 companies in terms of 'fuel cell(s)' patent applications published worldwide, July – September 2008. Parentheses denote ranking in the previous Quarterly Review, where (-) means the company was not in the top 10 in the previous quarter. © Fuel Cell Today.**

After a period of slipping somewhat in the rankings, a number of Japanese assignees now appear to be re-consolidating their position this quarter. Toyota (perennially the world number one in terms of patents applied for) is joined once again by Honda in the top three, with Nissan, the third of Japan's big three automakers, now in fifth place with around 35 patent applications this quarter. Fuel cell power trains for passenger cars and materials handling continues to be focus of Japan's automotive companies, as does the balance of plant including lithium ion battery storage system, fuel systems and engine management systems. Toshiba, Matsuhita (Panasonic) and Samsung, all stalwarts of the list of companies with the most patents, again feature highly in the table and are discussed below in the section on Japanese companies. In addition to two auto companies that regular feature in the top 10 rankings (GM and Daimler), two fuel cell component companies – Idemitsu and Kyocera are also featured. These two companies are relatively quiet about their activities on fuel cells. For a full discussion of companies by region, see below.

## Japanese companies

Table 4 shows the top 10 companies in terms of applications published by Japanese patent assignees. From this table, two companies stand out for their IP on DMFCs in particular – Toshiba and Matsushita (Panasonic). Toshiba, one of Japan’s major electronics OEMs, continues to be second in the worldwide rankings of patent applications, with and Japanese re-consolidating their position. The company recently announced that it would be releasing DMFC powered mobile devices in early 2009 (‘by the end of fiscal 2008’). While the company has presented prototype DMFC mobile phones at various trade shows over the past few years, this marks the first announcement of a commercial deployment. Toshiba has been developing DMFC technology for some time, engineering the system and balance of plant to strict size and weight specifications for various applications including phones, digital cameras, and laptops. The methanol fuel is charged with a proprietary cartridge, believed to be licensed by another company. The DMFC that Toshiba plans to deploy commercially is claimed to offer double the battery life of a conventional Li-ion mobile phone battery, with the 50 ml fuel cartridge said to be capable of refilling the DMFC around 10 times.

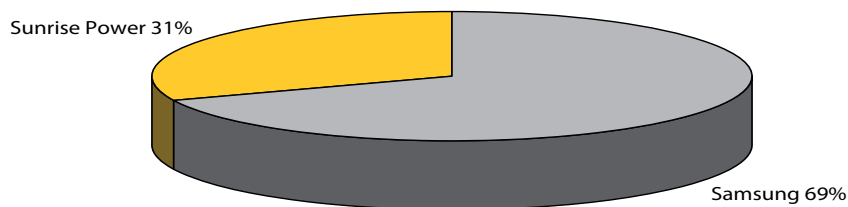
Work appears to be continuing apace on portable consumer electronics fuel cells by Matsushita (Panasonic) who announced it has developed the world’s smallest fuel cell for use in notebook (laptop) computers, reducing the size of its predecessor by 50%. The new model is sized at 270ml, which makes it as small as existing lithium ion batteries used in notebooks currently on the market. Panasonic says the fuel cell will be positioned at the underside of notebooks and provides about 20 hours of power with 200ml of fuel. The prototype weighs just 320 grams with the methanol stored in bottles. Panasonic also developed a paperback-size fuel cell for use in cellular phones and other mobile devices. The company claims that this model is powerful enough to run portable TVs and that it can charge two devices at the same time. Both products are expected to be commercialised in 2012, demonstrating that although the fundamentals may have been developed (as shown in the patent record), it is not yet consumer-ready in the way that Toshiba claims theirs is. Driven by IP, there appears to be everything to play for in the portable electronics fuel cell arena now and into the near future. For a further discussion of DMFC technology, see the historical analysis section below. Matsushita is also busy developing PEMs for home use, as part of a demonstration project that includes Tokyo Gas and is due to release thousands of commercial units over the next year or so.

Rank	No. of patents	Assignee
1	261	Toyota (1)
2	114	Toshiba (2)
3	44	Honda (4)
4	37	Matsushita (5)
5	35	Nissan (3)
6	26	Mitsubishi (9)
7	25	Kyocera (7)
8	21	Idemitsu (7)
9	15	Sharp (-)
10	11	Toppan (-)

**Table 4: Top 10 companies in terms of ‘fuel cell(s)’ patent applications published by Japanese companies, July - September 2008. © Fuel Cell Today.**

## Asia (excluding Japan)

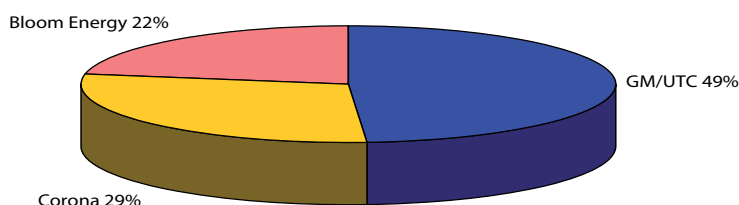
Figure 3 shows Asian patent assignees excluding Japan with greater than 10 patent applications per company. Only two companies are shown for this quarter, Samsung (with 22 patent applications) and Sunrise Power (with 10 patent applications). Samsung is developing some proprietary DMFC technology for portable electronic devices, however it is mostly looking to buy or license the technology from companies who have developed the membranes and balance of plant. Samsung also has a SOFC programme focused on residential generation. Samsung was partnering with HydroGen Corporation until the latter’s filing for bankruptcy in October 2008, having previously supplied a bridging loan in August 2008. Samsung could in future buy the assets of HydroGen, including its IP portfolio, allowing it to develop HydroGen’s SOFC technology as part of its internal fuel cell programme. Sunrise Power, a spin-out from the Dalian Institute of Chemical Physics, Chinese Academy of Sciences, is developing PEM technology, although the company is somewhat reticent about its activities.



**Figure 3: Graph of published patent applications by companies from Asia (excluding Japan), July - September 2008 for patents with the term 'fuel cell(s)' in the document. Note only companies with more ten or more patent applications are included here. © Fuel Cell Today.**

## North America

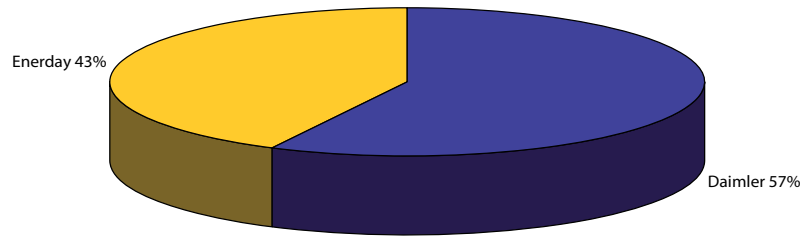
Figure 4 shows the patent applications by companies from North America with more than 10 patent applications this quarter. General Motors and UTC both have 22 patent applications each this quarter, and are collectively responsible for almost half of all fuel cell patent applications this quarter. General Motors are working on their next-generation fuel cell stack and on systems integration with their e-flex electric architecture. UTC, on the other hand, appear to be riding something of the crest of a wave with the recent resurgence in PAFC technology. At the time of writing, UTC had just announced that Samsung Everland has purchased 12 UTC Power 400 kW fuel cell systems for installation at a GS Power plant in the Town of Anyang, just outside Seoul. GS Power will use the electricity from the fuel cells to provide power for about 5% of Anyang's population, with 40,000 MW hours total annual power output expected. Earlier this year, Samsung Everland entered into an exclusive agreement with UTC Power to promote and distribute PureCell Model 400 systems in Korea with future plans to establish local service and manufacturing presence as demand for fuel cells grows. UTC are moving into the arena of being a power service provider, rather than being just a technology provider. Earlier this year, UTC Power acquired an engineering firm offering services and products to optimise the energy and environmental performance of buildings. However, UTC continues to invest in R&D and IP exploitation with a view to building future commercial markets for large-scale stationary power. A number of companies had less than 10 patents this quarter, including Ballard and Hydrogenics, however these are not discussed here.



**Figure 4: Graph of published patent applications by companies from North America region July-September 2008 for patents with the term 'fuel cell(s)' in the document. Note only companies with more ten or more patent applications are included here. © Fuel Cell Today.**

## Europe

Figure 5 shows the patent applications by companies from Europe for assignees with more than 10 applications this quarter. Only two companies feature with more than 10 patents: Daimler and Enerday. Daimler continues to develop its automotive fuel cells for light duty vehicles (including the forthcoming new generation F-Cell) through the Automotive Fuel Cell Collaboration since buying Ballard's light duty vehicle assets. Daimler is also developing power systems for buses, such as those Citaro buses which are currently operational worldwide. In July 2008, Ballard Power Systems announced that it has signed a two-year service agreement with Daimler AG, under which Ballard will continue providing a full service support package for fuel cell systems on six Mercedes-Benz Citaro buses. This is the third service contract awarded to Ballard for these buses, which are currently used in revenue producing service in the city of Hamburg, Germany. German company Enerday has also been active this quarter, with 23 patent applications covering a range of technology areas including reformers, fuel cell systems and fuel cell system operating methods.



**Figure 5: Graph of published patent applications by companies from Europe July-September 2008 for patents with the term 'fuel cell(s)' in the document. Note only companies with ten or more patent applications are included here. © Fuel Cell Today.**

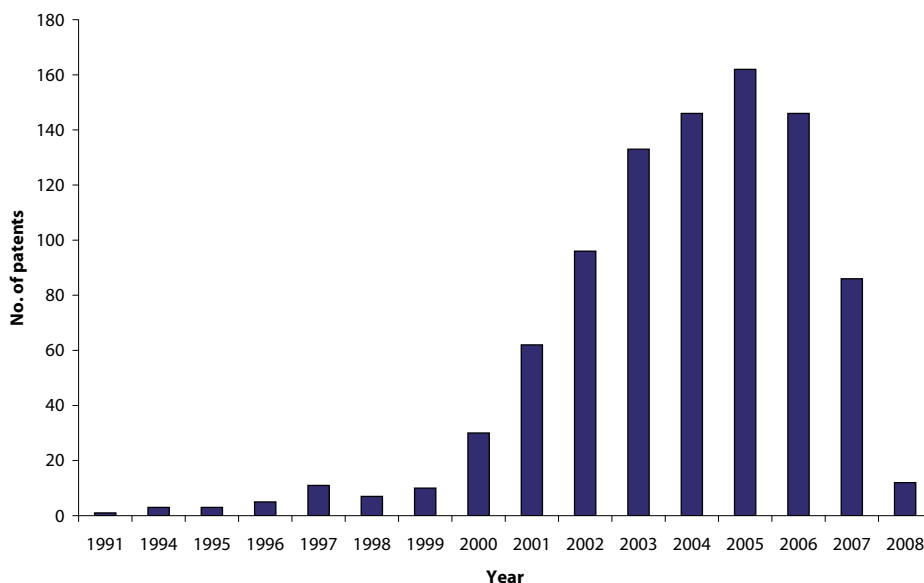
### Historical analysis: Development of DMFC technology

In this section, an historical analysis of Direct Methanol Fuel Cell (DMFC) technology is carried out. The fundamentals of DMFCs was first demonstrated in 1922 and the first applications were developed in the early 1950s, followed by the first industrial applications (mainly for powering communications equipment for oil companies) around a decade later. In the early 1980s, a number of companies began developing DMFCs for portable electronics in earnest. In the following analysis, only around the last 20 years is taken into account - i.e. that which is relevant for patent activity.

DMFCs, like PEMs, use a polymer membrane as an electrolyte. However, a catalyst on the DMFC anode draws hydrogen from liquid methanol, eliminating the need for a fuel reformer. Therefore pure methanol can be used as fuel. DMFCs lend themselves to a wide range of applications given the availability of methanol is generally greater than hydrogen, and generally have power outputs of several milliwatts to several kilowatts of electricity. Their size and power output makes them ideal for portable power applications and indeed most of the market traction seen to date in the area of DMFCs has been for small portable power units for leisure applications, as well as powering small electronic devices in certain niche applications, particularly the military. Since the first DMFC patents were published in the early 1990s, the technology has developed rapidly with well over 10,000 units now shipped worldwide to date, mainly for power in the leisure market (camping and yachting). As the power density and durability of DMFCs has improved, and their size and weight has decreased, there is great potential for DMFC powered mobile devices, from laptops to cameras and mobile phones. A number of companies, including Panasonic, Samsung and Toshiba are actively developing such DMFC powered mobile devices, with commercial launches in some cases planned for the near future. The following section explores the growth in DMFC patenting, with a more detailed analysis available in the syndicated version of this report.

Figure 6 shows the number of DMFC patents filed since 1991. Two phases can be identified. The first is from the early 1990s to the late 1990s, and the second is from the early 2000s to the present. The natural tailing off of patent activity since 2005 is an artifact of the data – it can take several months to years from priority submission for a patent to be published as an application, and several years more for the patent to be published as a granted patent. Since the years on the graph denote the year of priority, a patent from 2006 may only be included in the record several years after submission.

The first phase saw very low numbers of patents being published on DMFCs, with generally less than 20 publications per year throughout the 1990s. This was the phase in which the fundamentals of the technology was being developed. The earliest DMFCs saw PEM membranes being adapted to run on direct methanol, with generally higher catalytic loadings and balance of plant than in hydrogen PEM membranes. Both the loadings and balance of plant reduced over time, with some of the more recent DMFC patents covering novel catalysts that allow for water recycling. The early 2000s saw a real take-off in the number of patents with around 30 then around 60 then almost 100 publications in the years 2000, 2001 and 2002 respectively. This market the period when a number of start-up companies and electronics OEMs began work on developing DMFCs for mobile devices. The early to mid 2000s saw a further increase with a peak in 2006 of around 160 publications, a year which also marked the first commercial deployments of DMFCs for the leisure market. Fuel Cell Today believes that there may be a further increase in DMFC patent publications as electronics OEMs develop balance of plant and integrate DMFCs with lithium ion batteries for mobile electronic devices. **For a more detailed historical analysis of DMFC over time, including a patent thematic map and breakdown by technology, please refer to the Syndicated version of this report.**



**Figure 6: Patent filings worldwide 1991-2008 for patents with the terms 'Fuel cell(s)' or H01 M008 (fuel cell manufacturing IPC code) and 'DMFC' in the document. © Fuel Cell Today.**

For a more detailed quarterly patent review covering patents granted and fuel cell manufacturing patents, see the **Fuel Cell Today Syndicated Research Package**, which also includes Applications Surveys, Country Reports, and a quarterly legislation tracker.

#### **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](mailto:jonathanbutler@fuelcelltoday.com)

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