

The Fuel Cell Industry Review 2014

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LIST OF ABBREVIATIONS

AFC – Alkaline Fuel Cell	LGFCs – LG Fuel Cell Systems
AFCC – Automotive Fuel Cell Cooperation	MCFC – Molten Carbonate Fuel Cell
APU – Auxiliary Power Unit	MW – Megawatt
ARB – Air Resources Board (California)	N.ERGHY – New European Research Grouping for Hydrogen and Fuel Cells
BC – British Columbia	New-IG – New Energy World Industry Grouping
CARB – California Air Resources Board	NRG – NRG Energy (US)
CEC – California Energy Commission	OEM – Original Equipment Manufacturer
CFCL - Ceramic Fuel Cells Limited	PAFC – Phosphoric Acid Fuel Cell
CHIC – Clean Hydrogen In European Cities	PEMFC – Proton Exchange Membrane Fuel Cell
CHP – Combined Heat and Power	PPA – Power Purchase Agreement
DMFC – Direct Methanol Fuel Cell.	PSC – Public Service Commission (New York State)
EPS – Electro Power Systems	RoW – Rest of the World
EU – European Union	SAFC – Solid Acid Fuel Cell
FCCJ – Fuel Cell Commercialization Conference of Japan	SCC – Santa Clara County
FCE – FuelCell Energy (USA)	SGIP – Self Generation Incentive Program (California)
FCEV – Fuel Cell Electric Vehicle	SOFC – Solid Oxide Fuel Cell
FCH JU/FCH 2 JU – Fuel Cells and Hydrogen Joint Undertaking (EU)	UAV – Unmanned Aerial Vehicle
FCT – Fuel Cell Today	UK – United Kingdom
FY – Fiscal year	UPS – Uninterruptible Power Supply
HRS – Hydrogen Refuelling Station	US – United States of America
ICE – Internal Combustion Engine	W – Watt
IPO – Initial Public Offering	WGES – Washington Gas Energy Systems
kW – Kilowatt	

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Executive Summary

The fuel cell industry is still very much in the process of formation. The year 2014 has brought the loss of several high profile companies, such as Topsoe Fuel Cells, Lilliputian and ClearEdge Power, losses balanced by the entry of Korean conglomerate Doosan and a newly public commercialisation effort by General Electric. The year has also seen significant successful capital-raising by companies including Plug Power and FuelCell Energy, and the successful IPO of Intelligent Energy. Overall unit shipments are up compared to 2013, though the megawatts shipped are down. The industry remains predominantly focused on PEM and SOFC technologies, but other types remain strong, particularly MCFC in larger stationary power plants.

Although the MW of units shipped has decreased, we don't interpret this too negatively. The number of units shipped is driven in large part by the Japanese residential fuel cell programme, Ene-Farm, and by very small portable products. The industry is small enough that a few big shipments one side or other of the New Year can still make a noticeable difference. In some cases, such as with cars, releases still tend to be in blocks, with subsequent pauses for learning and testing. Only when real commercial shipments occur in more sectors will some smoothing of the data occur.

The more successful sectors in terms of headline numbers remain the same as in prior years: in total, 100,000 Ene-Farm micro-CHP units in Japan have now been installed, and fuel cells outsell all other micro-CHP technologies. Korea, and particularly POSCO Energy, is ramping up installed MW of MCFC and increasing future orders. Bloom Energy remains an important contributor to installed SOFC capacity, though numbers look to be down compared to 2013, when last year's very large Delmarva Power installation was booked.

Portable unit shipments and small battery charger-type systems seem to be gaining traction. While they have always been important for the likes of Horizon and SFC Energy, Neah Power, MyFC and Intelligent Energy also have big ambitions in the sector. Intelligent Energy has announced its intent to ship 50,000 units by year-end 2014, though shipments were not confirmed by press time.

In transport, the picture is varied. Outside of Europe, fuel cell buses seem to be losing ground, with BC Transit announcing the end of the 20-bus Whistler project, and AC Transit apparently also wavering in its support. In Aberdeen, Scotland, however, a ten-bus fleet is being assembled, whilst London plans to have eight by autumn 2014, and other projects are taking place across Europe. Hyundai shipped some fuel cell cars, Toyota and Honda are preparing for their official launches in 2015, but other companies – Daimler, GM, Ford, Renault-Nissan – are perfecting their technology for a later date. Special vehicles of different types remain in vogue, with Plug Power shipping increasing numbers of lift trucks, and various other utility vehicles entering real world demonstrations.

PEMFC is the main contributor to unit shipments, and significant in MW too. While shipments are on a slight upward trend, the launch of cars in 2015 could make a substantial difference to numbers. MCFC is dominant in MW shipped, due to FuelCell Energy (FCE) and to POSCO in Korea. SOFC of course has large units shipped by Bloom Energy, and other companies have been selling into residential micro-CHP. General Electric's announcement of an SOFC plant in the US, while not relevant to shipment numbers now, is an interesting signal of possible things to come. While PAFC numbers suffered a setback with the demise of ClearEdge Power, Doosan has picked up the technology and is aiming for major shipments in 2015.

The big political picture seems most positive in Japan, where the Government's energy strategy specifically discusses the importance of hydrogen and fuel cells and its ongoing support. European support is stronger than it has been in some time, both in the form of the European Commission's renewed public-private partnership, the FCH 2 JU, and with national governments including the UK, France and Germany all continuing funding. In the US, research and demonstration budgets have declined but appear to have stabilised, and there is considerable new financing at the state level. California has affirmed strong backing for hydrogen refuelling station roll-out which should underpin the much-anticipated sales of cars.

2014 has not been an easy year for the fuel cell industry. While it is far from guaranteed, 2015 is shaping up to be a better one. Continued policy support in major jurisdictions, coupled with the coming of the fuel cell cars, big power park deployments in Korea, and hints that Japan may continue to underwrite its residential programme all suggest that shipments could be up significantly on 2014, and perhaps bring some new funding and confidence to consolidate this nascent industry.

Highlights

- A dramatic increase in hydrogen refuelling station deployment in Japan and California
- The first fuel cell vehicle lease to a customer in the US
- Increasingly large fuel cell power parks
- Japan's explicit support of fuel cells and hydrogen in its energy policy
- The renewal – and expansion – of the EU FCH JU programme
- The spread of H2Mobility clones



The need for an objective Fuel Cell Industry Review

In January 2014, Fuel Cell Today (FCT) announced its closure. Up to that point, FCT had provided a free annual review of industry developments, based on actual and projected shipments of fuel cells during that calendar year. The data were seen as objective and used extensively within and outside the emerging industry, for example in financing decisions and journalistic commentary. We at E4tech also used the data sets in the report.

Following discussions with many actors in the industry, the E4tech-led team decided to launch a publication designed to provide a similar overview of industry progress, available without charge to all interested readers, with data sets as close to FCT's as possible, to ensure that year-on-year trends would be easy to examine.

This publication is the first of what we hope and expect to be a continuous annual series. Like FCT, we will also rigorously maintain data confidentiality, only presenting aggregated

results, and never allowing the underlying data outside of our team. To complement the raw figures we have added some thought pieces, reflecting on important events or influences in the fuel cell industry over the year. We plan to continue to do this each year.

Although E4tech has led this work, we have been strongly supported throughout by Jonathan Lewis Consulting, and by Bob Rose of Breakthrough Technologies Institute who has been kind enough to contribute some of his editorial thoughts and some contacts. Many companies have willingly given valuable time and data, for which we express our gratitude.

We are all proud to be a part of the emerging industry, in different ways, and hope this publication supports it as intended. Should you wish to contact us to discuss it, make suggestions for future editions, offer data, or indeed talk to us about any other aspects of the industry, we would be delighted.

About the Review

Applications

To make year on year data comparisons as simple as possible, we have continued to use the same categorisation of shipment data as FCT did. For applications these categories are Portable, Stationary and Transport, and are defined as follows:

Application type	Portable	Stationary	Transport
Definition	Units that are built into, or charge up, products that are designed to be moved, including auxiliary power units (APU)	Units that provide electricity (and sometimes heat) but are not designed to be moved	Units that provide propulsive power or range extension to a vehicle
Typical power range	1 W to 20 kW	0.5 kW to 400 kW	1 kW to 100 kW
Typical technology	PEMFC DMFC	PEMFC SOFC MCFC PAFC AFC	
Examples	<ul style="list-style-type: none"> • Non-motive APU (campervans, boats, lighting) • Military applications (portable soldier-borne power, skid mounted generators) • Portable products (torches, battery chargers), small personal electronics (mp3 player, cameras) 	<ul style="list-style-type: none"> • Large stationary prime power • Large stationary combined heat and power (CHP) • Small stationary micro-CHP • Uninterruptible power supplies (UPS) 	<ul style="list-style-type: none"> • Materials handling vehicles • Fuel cell electric vehicles (FCEV) • Trucks and buses

Portable fuel cells encompass those designed to be moved, including auxiliary power units (APU); Stationary power fuel cells are units designed to provide power to a fixed location; Transport fuel cells provide either primary propulsion or range-extending capability for vehicles. We have slightly extended the FCT 'typical' portable power range, starting at 1W rather than 5W. This is simply for clarification and does not change the shipment data, as smaller units were in any case included in the past.

Fuel cell types

Shipments by fuel cell type refer to the six main electrolytes used in fuel cells: proton exchange membrane fuel cells (PEMFC), direct methanol fuel cells (DMFC), phosphoric acid fuel cells (PAFC), molten carbonate fuel cells (MCFC), solid oxide fuel cells (SOFC) and alkaline fuel cells (AFC). High temperature PEMFC and low temperature PEMFC are shown together as PEMFC.

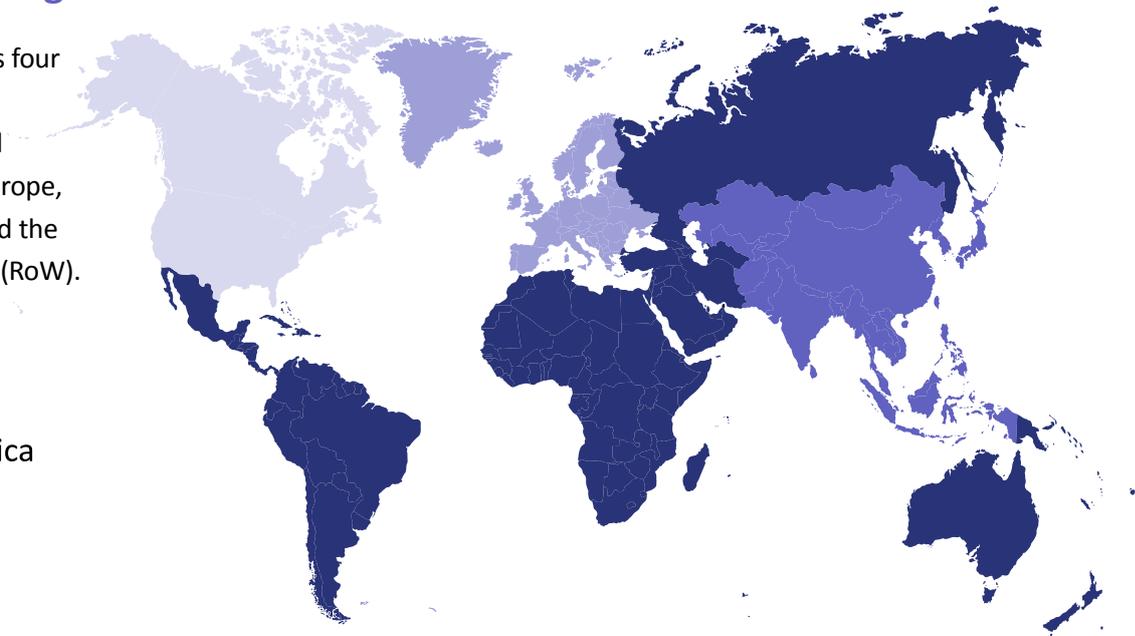
Explanations of these six main types of fuel cells can still be found on the FCT website:

<http://www.fuelcelltoday.com/technologies>

Geographic regions

We maintain FCT's four main geographic regions of fuel cell adoption: Asia, Europe, North America and the Rest of the World (RoW).

- ROW
- Asia
- North America
- Europe



Reported shipment data

Tables of data can be found at the back of this Review, including historical information from FCT dating back to 2009. Data are presented for each year in terms of annual system shipments and the sum total of those systems in megawatts, both divided by application, region and fuel cell type as described in the section below.

Shipments are reported by numbers of units (systems) and by total megawatts shipped annually. Shipment numbers are rounded to the nearest 100 units and megawatt data to the nearest 0.1 MW. Where power ratings are quoted, these refer to the electrical output unless stated otherwise.

The reported figures refer to shipments by the final manufacturer, usually the system integrator. The regional split in our data refers to the countries of adoption, or in other words, where the fuel cells have been shipped to.

In accordance with previous reports by FCT, we do not include shipments for toys and educational kits.

Data sources and methodology

For the years 2009 to 2013 we show figures as published in the Fuel Cell Today Industry Review 2013. The 2013 figures in that report were a forecast to the full year 2013. While some of the actual 2013 shipments differ from the 2013 forecast, we have no access to the underlying data and have hence not revised their 2013 numbers. However, it is worth noting that fewer SOFC systems were shipped than forecast for 2013, as JX Nippon Oil did not in the end ship as many as announced for the Japanese Ene-Farm project.

Our 2014 figures are a forecast for the full year. Data for 2014 has been collected directly from fuel cell manufacturers where they were able to share it; through interviews with industry experts; careful review of publicly available sources such as company statements, press releases, reports of public companies and demonstration and roll-out programmes.

We include an error bar for 2014, based on the quality of our data sources and our views on the uncertainty in the forecasts. We will revise data for 2014 in our 2015 edition as appropriate.

Perspectives on the fuel cell 'industry' in 2014

The fuel cell 'industry' is actually not yet fully formed as an industry. Rather it consists of a number of diverse companies with different technologies, applications, market ambitions, routes to market, and supply chains. Company birth and death rates in this 'industry' remain high, and this is likely to continue for another year or so as the true value propositions for fuel cell applications emerge.

Despite this, life signs are broadly improving. The year 2014 saw several successful finance-raising events, including the initial public offering (IPO) of UK-based PEM manufacturer Intelligent Energy – the first fuel cell IPO in several years. Although supply chains remain thin and fragile, they are strengthening, and some global industrial corporations are even beginning to view fuel cell component manufacturing as a new growth opportunity. While the valuation of the few publicly quoted fuel cell companies is volatile, increasing orders, shipments and of course profitability, will help to increase market liquidity and smooth some of that variability. Importantly, government remains generally supportive in the same places it has in the past, and the finance sector is once again cautiously active, not only with the Intelligent Energy IPO but also with start-ups and growing companies.

While PEM and SOFC companies remain by far the most numerous, other chemistries retain important industry positions. MCFC shipments for large-scale power parks are a large part of the industry, while DMFC, AFC and even solid acid fuel cells (SAFC) all retain their place, each addressing specific customer requirements. And even though some major companies have left the sector, high-temperature PEM remains an important part of that branch of the fuel cell tree.

Our assembled and projected data show 2014 unit shipments as only marginally higher than

2013, and MW shipped as lower, which we discuss in more detail inside. In these early commercial years it is not at all surprising that the growth curve will be non-linear, as large occasional orders will dominate some market segments, and imperfect data availability will cause apparent swings. What is more important is that the building blocks being placed are genuinely supportive of growth.

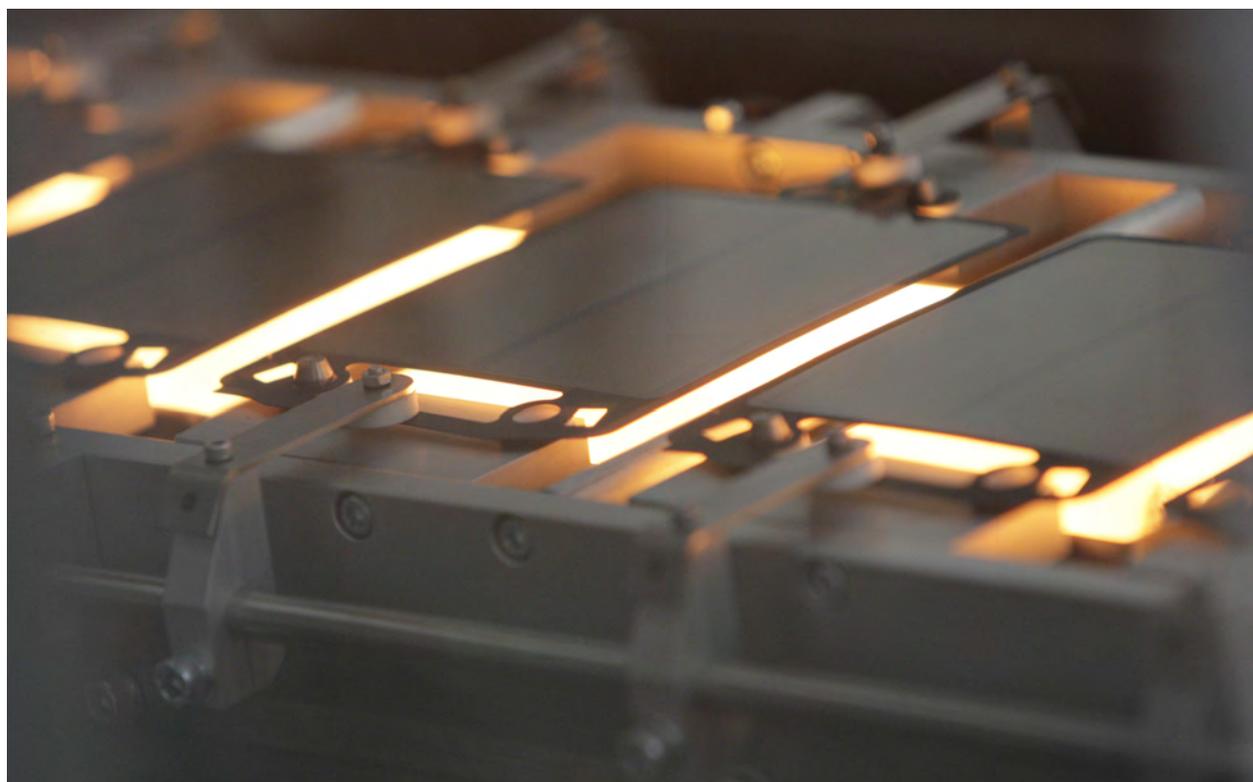
On that note, the different players seem increasingly focused on their individual areas of strength. The largest potential markets, including residential combined heat and power (CHP) and automotive applications, are some of the hardest to enter due to low price points, strong incumbency, and a need for coalition approaches, including supportive policy. These markets are mostly being attacked by big companies, with deep pockets and the support infrastructures required for servicing and market expansion. The smaller markets are of less interest to these big players, but addressed by smaller companies who are increasingly specialised in their offerings – into materials handling, telecommunications backup, small-scale portable devices and similar. No company is trying to do everything, a significant weakness of the past.

Practical and sometimes innovative business models continue to emerge: instead of the historic approach of trying to sell fuel cells as fuel cells, companies are focusing more and more on the problems that fuel cells can solve, and the service revenues that come from offering ongoing solutions. Plug Power has for several years offered its customers a better economic opportunity than competing solutions for materials handling, while Intelligent Energy's portable chargers allow more mobile phone usage and more revenue for mobile network operators in areas with weak or no electricity grids. Heliocentris' energy management

systems reduce current operating costs and pave the way for fuel cells to be integrated into future system configurations, for further savings and increased environmental benefit.

The data we present suggest that the total number of units shipped is expected to be larger in 2014 than in 2013. This growth is driven largely by portable products, such as mobile phone chargers and small auxiliary power units¹. However, total MW shipped have declined from 2013. We believe that five companies account for more than 80% of the

MW of systems shipped in 2014: FCE and Bloom Energy shipping into stationary prime power markets; Panasonic and Toshiba into residential CHP markets; and Plug Power shipping into the material handling market. Growth in shipments of relatively small-sized portable and transport units and the associated MW has not been sufficient to compensate for a dip in the shipments of large stationary systems.



¹ Please note that all numbers are subject to estimates, and final 2014 shipments may be higher or lower than announced. We will adjust 2014 figures as appropriate in our 2015 review.

Is the fuel cell industry relevant?

Markets for fuel cells to date have been completely dominated by policy and regulatory drivers. In Japan, a long-time leader in residential CHP installations, fuel cells enjoy enormous levels of government support. This government support is now increasing in time with impending roll-out of 'commercial' fuel cell cars. Korea, an equivalent leader in larger-scale stationary installations, drives this market through its aggressive renewable portfolio standard. And the reason there are fuel cell cars on the road in the first place, with more to come, is first and foremost a response to ever more stringent emissions regulations. This started with the California ZEV mandate and is now particularly driven by greenhouse gas policies.

Even with the support to date, the total number of fuel cells sold, and the capacity installed worldwide, is invisible on any overview of global generation capacity. Many major industry players – including some who previously had substantial programmes – remain well outside of the fuel cell world. China and India, for different reasons, remain interested but have other priorities. Large-scale generating capacity and transport will continue to be dominated by conventional fossil-powered solutions for decades to come. The fuel cell industry remains brittle, with high profile companies still failing or pulling out, and fragile supply chains.

However, outside of toys and education (which we exclude from our statistics) and small consumer electronics chargers, a few fuel cell applications do compete almost purely on economics. They usually favour small systems (<10 kW) and have not yet moved from niche to mainstream, though they are in that transition phase. The two most-cited examples are for telecommunications power and for material handling, with portable products also of interest. Unit shipments in these markets are amongst the most important in our figures,

though detailed information on some aspects is lacking from the public domain.

Despite the limited number of immediate large commercial opportunities, and the still-nascent industry, the finance world is once again showing interest in the sector. The rise of the 'connected world', and the generally unforeseen implications of its spread into emerging economies, has important knock-on effects for novel technologies – such as fuel cells – in what appear initially to be less than obvious markets. India, a number of countries in Africa and the Middle East, parts of Latin America and South-East Asia are all home to fuel cell units shipped to respond to particular consumer needs, rather than to pick up local subsidies.

While only a handful of pure-play fuel cell companies are listed on stock markets, much major development is happening inside the larger organisations that have either retained or recently started a business. Specialist suppliers of ceramic powders, coated steels, novel polymers, and expert manufacturers of other materials and components are not only passive players in the supply chain but increasingly trying to understand how they can influence public support and end-user demand for fuel cells. They may order and install systems for their factories, aggregate technologies using their own global supply chain strength, or become vocal advocates of supportive policies.

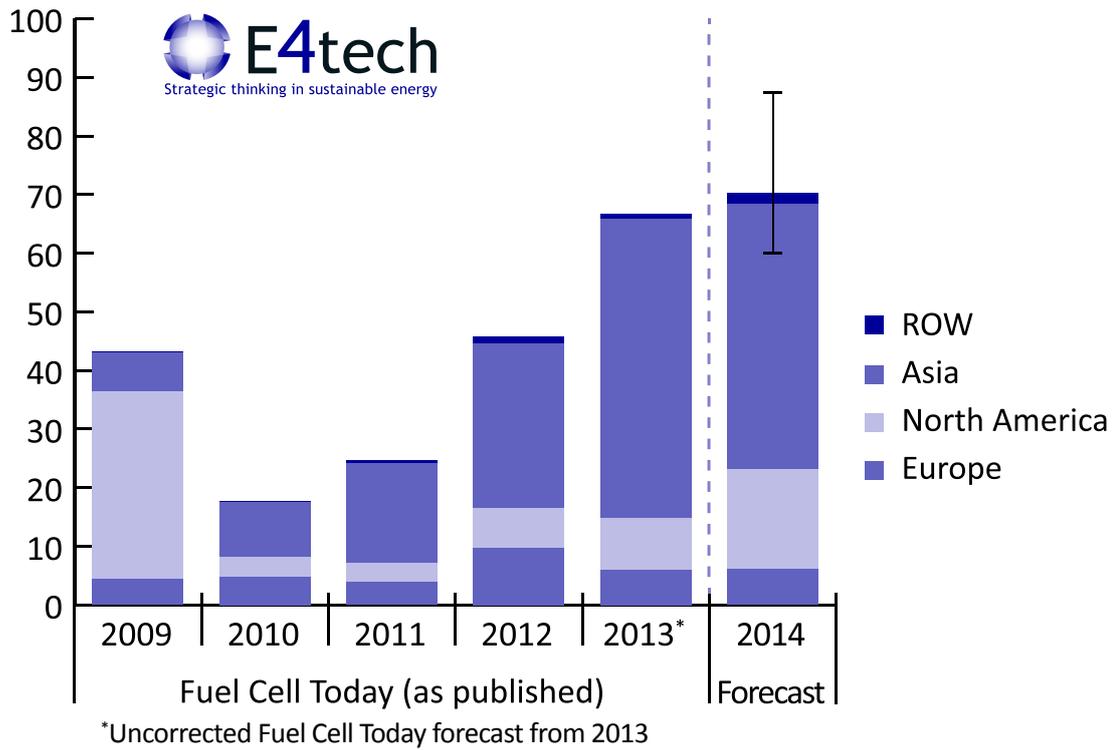
New technologies – especially in energy – take decades to become relevant. But the pace of change in energy today is higher than ever, as is the uncertainty. Opportunities will continue to arise, and companies who understand fuel cells will increasingly create their own, as we see from some of the novel approaches already discussed. For fuel cells to become 'relevant' in terms of their relative percentage contribution to the energy and transport mix will take many years. Becoming relevant in other

ways – providing opportunities in emerging economies, enabling autonomous distributed generation solutions, helping people join the connected world – could be much quicker. But fuel cells are already relevant to a substantial and growing number of customers who have begun to write repeat orders or to expand their portfolio of fuel cell purchases.

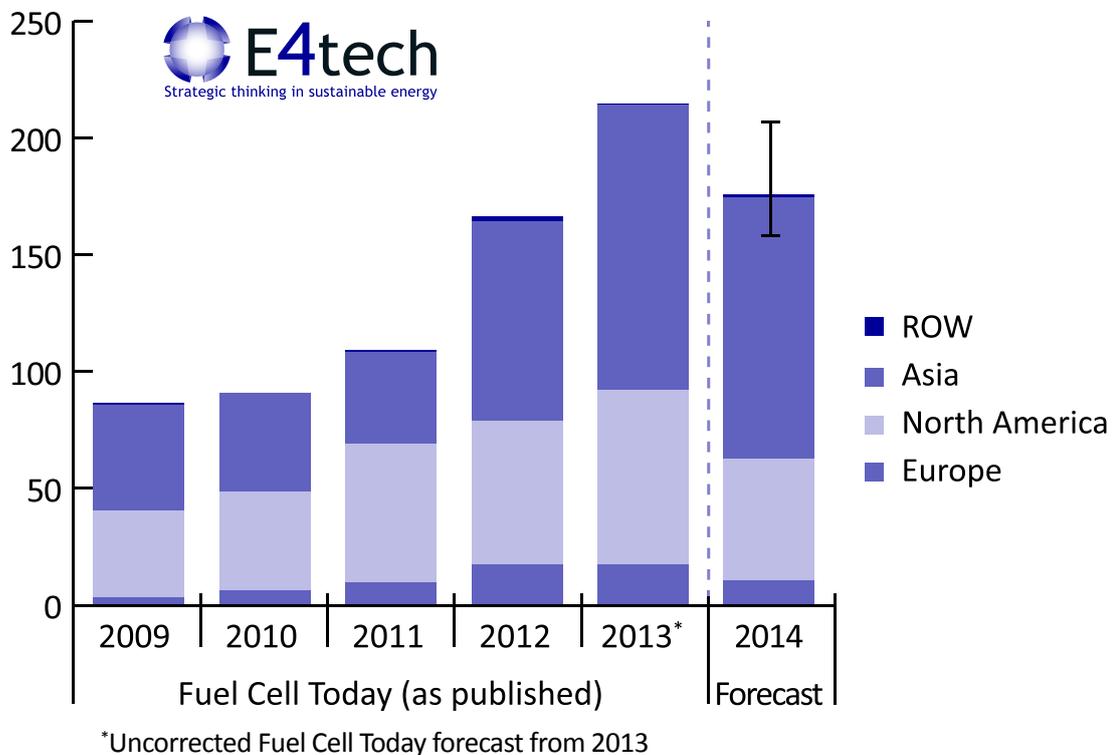


Shipments by region

Shipments by region 2009 - 2014 (1,000 units)



Megawatts by region 2009 - 2014



Footnote to charts: Data from 2009-2013 are as published by FCT, including their forecasts for 2013; 2014 is our forecast for the full year. We include an error bar for 2014, based on the quality of our data sources and our views on the uncertainty in the forecasts.

The global fuel cell market is focused on three primary economic regions: **Asia**, most notably Korea and Japan, but increasingly China, India and Indonesia; **North America**; and **Europe**, where Germany tends to have most activity despite growth in the UK, Scandinavia and the Netherlands. In the Rest of the World there is some activity in Africa for backup power and consumer electronics, as there is in the Caribbean for telecoms backup and off-grid power. Australia has some small uptake for a range of applications, and in South America Brazil has an ongoing fuel cell bus programme, some telecoms backup activity, and some indigenous fuel cell supply.

Asia, as in previous years, remains the leading market for fuel cells. In terms of units, this is dominated by Japan with more than 40,000 residential CHP units likely to be shipped during 2014, and several thousand units for backup power installed throughout Asia. In terms of MW Korea remains the leading market, mostly due to the ongoing installation of large fuel cell systems for prime power in dedicated fuel cell parks.

North America has been the growth market in 2014 for fuel cells going into material handling applications (both units and MW shipped). Elsewhere in the transport sector, fuel cell bus deliveries have been very

limited, whilst the end of the Whistler, British Columbia demonstration programme was announced in early 2014. Hyundai started the delivery of their Tucson ix35 fuel cell electric vehicle (FCEV) to final customers in Southern California in 2014. Looking ahead, shipments of FCEVs in 2015 should increase, based on the announcements of various automotive original equipment manufacturers (OEM) regarding California, the leading North American market for the roll-out of fuel cell cars. In the stationary power sector, North America will likely see fewer MW installed in prime power applications in 2014, as fewer larger power output fuel cells are delivered, although 2015 should see an increase. On the other hand backup power continues to be an important market for fuel cells in the region, especially for the telecoms segment.

Europe has the smallest final markets of the three regions, although it has a large, diverse and vibrant fuel cell industry. In terms of units, fuel cells for consumer electronics, backup power and stationary are the main applications. Stationary CHP units as well as fuel cell buses and cars are the main contributors to the MW shipments. Germany is the lead market for stationary fuel cells, and also accounts for a significant share of the transport and portable sectors.

The Japanese Roadmap and hydrogen's "central role"

Japan's newest energy plan gives hydrogen "the central role" in Japan's energy future, providing power for homes, vehicles and industry, while both serving as an energy carrier for and facilitating a transition to distributed and renewable energy sources. This 4th Strategic Energy Plan was approved on April 11, 2014, almost the third anniversary of the 2011 earthquake and Fukushima nuclear disaster. Fukushima reshaped Japanese attitudes towards energy, and forced the government to abandon its then brand new 3rd Strategic Energy Plan, which called for half or more of Japan's future energy to come from nuclear power.

While nuclear is still in the mix, at least officially, the new plan calls for minimising reliance on nuclear, accelerating energy conservation and increasing imports of shale gas and coal from the US to buy time for a shift to renewable and distributed energy. But the new plan retains Japan's commitment to its CO₂ reduction pledge – it calls for a "new energy model" that emphasises resilience, open access and consumer choice. It also calls for a shift to alternative fuel vehicles; for 50%–70% of the new car fleet to be "new generation vehicles" by 2030, including natural gas, battery and hydrogen fuel cell.

The success of the Ene-Farm programme, which saw demand more than double after March 2011, and the commitment of the three largest Japanese auto makers to hydrogen fuel cell vehicles, apparently encouraged the government declaration that "Hydrogen is expected to play the central role, as well as electricity and heat" in Japan's future energy system. After test driving fuel cell cars in July, Prime Minister Shinzo Abe pledged a subsidy of at least ¥2 million per fuel cell vehicle; this is still being formalised, along with a budget for infrastructure and hydrogen station operating expenses.

The Japanese infrastructure plan calls for 100 stations by 2015, a goal unlikely to be met, although stations are going up rapidly. Although Japan's Ministry of Economy, Trade and Industry has proposed to spend US\$110 million in fiscal year (FY) 2015 on top of the US\$118 million committed in FY 2013-2014, the private sector companies installing systems are unlikely to be able to build stations that fast, both for practical reasons and because of the cost share burden. The plan calls for 54 stations in all by the end of 2014, including 13 existing research stations that will continue to operate and 41 "commercial" stations built by several private sector teams.

The plan also calls for 1.4 million residential fuel cell units by 2020 and 5.3 million by 2030. Equally, the highly successful programme supporting Ene-Farm may possibly be extended beyond its scheduled 2015 expiration. "Active support" is pledged for fuel cell vehicles, including steps to promote cost reduction, modify codes and standards and support infrastructure deployment. Passenger vehicle developments will be linked with forklifts and buses. Fuel cells will be showcased at the 2020 Olympics.

The government will increase research on hydrogen combustion, which is seen as a way for hydrogen to contribute to large scale low/zero carbon electricity generation, in partnership with long-distance, high-volume transport and delivery and large scale storage. At least two Japanese companies are examining the feasibility of importing bulk hydrogen in chemical hydride or liquid form from renewable sources in the US, Middle East and Europe, to substitute for current imports of oil and gas and diversify supply, which comes from only a few regions currently.

As is the case with most such documents, Japan's energy plan has many other provisions

aimed at coping with the loss of some or all of its nuclear capability, increasing renewable generation and redesigning the energy delivery system to make it more resilient and more amenable to consumer choice. But the hydrogen sections are the most detailed

and arguably the best thought out. If Japan implements the plan in anything like its current form, it will change the face of the fuel cell and hydrogen energy industry just as surely as it will change the face of Japan's energy economy.



Europe's Fuel Cell and Hydrogen Joint Undertaking

The most important policy development in Europe in 2014 was the formal approval of phase two of the Fuel Cells and Hydrogen Joint Undertaking (FCH 2 JU), with funding of about €650 million over seven years.

Approved first by the European Parliament and the Council, the European Commission announced it formally in July, reflecting Europe's belief in the considerable potential for fuel cell and hydrogen technologies to help meet EU energy policy goals of reducing emissions and increasing efficiency and energy security. The technology is considered strategically important enough to sit alongside seven other technology sets, including wind, solar and electricity grid initiatives, in Europe's Strategic Energy Technology Plan.

FCH 2 JU will continue the innovative public-private partnership comprising the European Commission, private sector businesses (represented through New-IG²), and Europe's research community (represented by N.ERGHY³). It is intended to provide a focused strategy to help consolidate a historically fragmented sector, and also provide sustained and committed funding to support the sector in Europe through technology research and development, and through demonstration projects. The first phase, funded to the tune of nearly €500 million, put funding into over 150 privately-led projects in transportation; stationary power and heat; early markets such as backup and portable power; and hydrogen production. 'Cross-cutting' projects support regulations, codes and standards development and market evaluations.

A very important component has been the backing of public transport bus demonstration projects in European cities including Milan, Oslo, Aberdeen and London, making Europe the

world leader in fuel cell bus commercialisation activities. Further projects have advanced the case for mobility, demonstrating cars and hydrogen refuelling stations (HRS) alongside national programmes in Germany, Scandinavia and the UK, for example and improving the attractiveness of Europe as an FCEV roll-out location for the world's car manufacturers. In stationary power and heat generation the FCH JU has supported micro-CHP projects, notably Ene.field and SOFC-Pact, again complementing national projects such as Callux in Germany and helping to pioneer the introduction of micro-CHP fuel cells, alongside larger units, in Europe's power and heating markets.

FCH 2 JU sees this strategy developed further: more support will go on the next steps towards commercialisation, notably for demonstration and pre-deployment activities. But there is still room for further targeted support for technology research and innovation. The focus has been simplified to two 'innovation pillars': transportation and energy, which will be supported by cross-cutting projects. The creation of the energy pillar is in part a response to the critical role that electrolyzers, hydrogen storage and fuel cells could have in successful integration of intermittent renewables into the energy system, through buffering production and opening-up different end-uses and markets.

With 50% private sector cost share, the FCH 2 JU will have a total public plus private budget of €1.33 billion for 2014 to 2020, an increase of 45% on the initial phase of the FCH JU, and a hopeful suggestion of growing European momentum. The budget is likely to be split 50/50 between the two pillars. The first call for projects came in July 2014; others will follow annually. Perhaps this major effort will help Europe to accelerate its local uptake and match some of the rest of the world.

² New Energy World Industry Grouping

³ New European Research Grouping for Hydrogen and Fuel Cells



Who owns the fuel cell industry?

The fuel cell industry appears to be internationalising even faster than it is commercialising. In the US, every major fuel cell company in the market today is partly or entirely foreign owned.

As discussed elsewhere, Korean conglomerate Doosan bought the assets of bankrupt ClearEdge in July, and also bought a small Korean company called Fuel Cell Power, a developer of residential systems. ClearEdge, a maker of residential and small commercial PAFC systems, had acquired the PAFC technology of UTC Power in 2013. Doosan established Doosan Fuel Cell America and said it was aiming at Korea's power generation market, where renewable generation targets and fuel cell generation subsidies add up to an attractive opportunity.

Korean industrial and electronics giant LG owns 51% of what was Rolls-Royce Fuel Cell Systems of Ohio, now LGFCS, and is reported to be making a major investment in the venture. Part of the technology comes from Rolls-Royce's UK-based developments over the past couple of decades; some can be traced to an Ohio company called SOFCO, a division of McDermott International founded in 2003.

Korea's largest private utility, POSCO Energy, owns about 11% of FuelCell Energy and is by far its largest customer, with orders totalling 270 MW to date. POSCO has established a manufacturing facility in Korea based on FCE's technology.

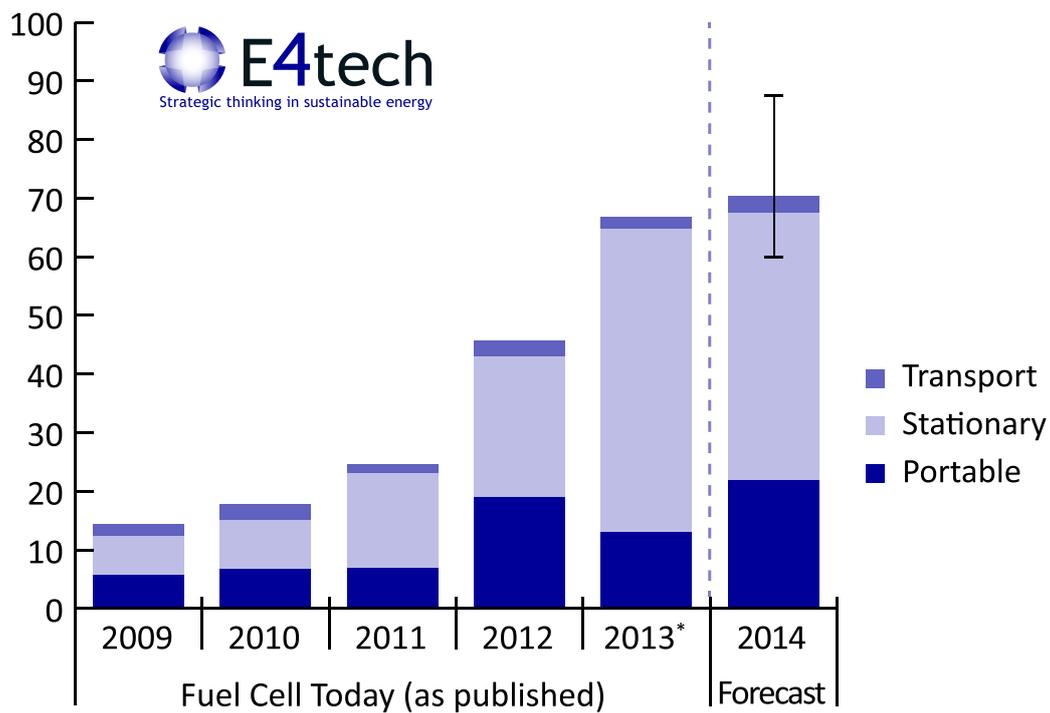
Bloom Energy's portfolio includes a significant percentage of non-US investors. E.ON, the German energy provider, invested US\$100 million and Credit Suisse another US\$30 million in 2013. A New Zealand pension fund invested US\$50 million through Alberta Investment Management Corp. (AIM) lists Bloom as its number one equity investment, as does SoftBank.

Air Liquide rescued Plug Power in 2013 with a US\$6.5 million investment, including purchase of preferred stock that it converted to nearly 11 million shares of common stock in May 2014. Air Liquide has since sold about half those shares, for US\$32 million, but still has a significant stake in Plug Power and a seat on its board.

Ballard, with headquarters in Vancouver BC, Canada, bought the backup power system technology of IdaTech in 2012. IdaTech was based in the US but its major investor was South African. In 2014 Ballard also bought a portfolio of intellectual property from UTC Power.

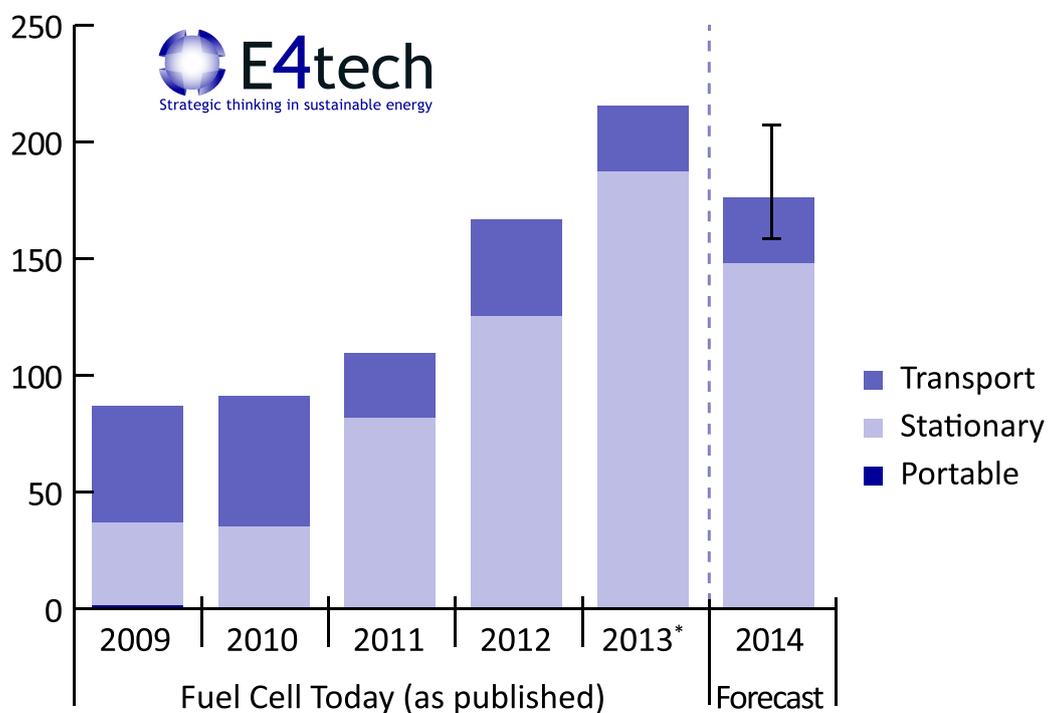
Shipments by application

Shipments by application 2009 - 2014 (1,000 units)



*Uncorrected Fuel Cell Today forecast from 2013

Megawatts by application 2009 - 2014



*Uncorrected Fuel Cell Today forecast from 2013

Footnote to charts: Data from 2009-2013 are as published by FCT, including their forecasts for 2013; 2014 is our forecast for the full year. We include an error bar for 2014, based on the quality of our data sources and our views on the uncertainty in the forecasts.

Transport

2014 has seen growth in units as well as in total MW shipped for material handling applications, mainly driven by strong growth in Plug Power's shipments. The economic case for fuel cell forklifts fuelled by hydrogen in large warehousing and distribution centres (generally at least 100 vehicles) is growing stronger and will drive further shipments in 2015. Reduced costs and novel business models should increase the market opportunity, as the economic case becomes proven for smaller distribution centres.

Cars and buses have contributed to the growth in MW shipments for transport: Hyundai delivered a number of their ix35 fuel cell electric cars worldwide in 2014, and several fuel cell buses, more than 20 in Europe alone, were supplied to various fuel cell demonstration bus projects.

If the world's automotive OEMs maintain their plans to make 2015 a key year in the roll-out of FCEVs, then 2015 will see a significant increase in shipments of both units and MW.

Stationary

Residential CHP shipments have continued to grow in 2014 over 2013, mainly due to Japan's Ene-Farm programme, though final numbers remain unclear. Deployment estimates for Japanese FY 2014 vary between roughly 40 and 50 thousand units. Additional uncertainty exists around global stationary backup power installations due to the recent market entry of several new players. As such the final 2014 numbers may be revised upwards in the next

edition, which could show overall growth in stationary markets.

Shipments of large stationary systems for prime power declined in 2014, in part because 2013 saw particularly strong demand in Korea and North America. However, 2015 could see further increases as POSCO's Pohang plant begins production and further large scale fuel cell parks are developed and commissioned in Korea, in addition to potential higher shipments by FCE following its announcement of production capacity increases in the US.

Stationary backup power continues to be a key market where fuel cells can be cost-competitive with incumbent technology; although it is true that various incentives are available, for example tax credits in the USA. Several thousand units have been shipped globally, and a number of newer players, such as Pearl Hydrogen, M-Field and Foresight Energy are becoming more prominent. One of the leading players in Europe, FutureE, was taken over by Heliocentris, and ReliOn, a North American leader in backup power systems, was acquired by Plug Power in 2014. Ballard has entered stack supply agreements for stationary systems with Asian companies such as M-Field (Taiwan) and Azure Hydrogen (China).



Portable

The strong growth in shipments in the portable fuel cell sector from 2013 to 2014 is mainly because of larger numbers in the consumer products segment (e.g. mobile phone chargers). The main players in this segment are Horizon Fuel Cell Technologies and MyFC, with aggressive announcements also by Intelligent Energy. As these companies have published only limited shipment data for year 2014 at time of press, our forecast for the full year is likely to need revision in the next edition. But the typical size of these devices is between 1 and 10 W, and hence tens of thousands of units do not contribute much to the megawatts shipped.

2014 also saw a strong growth in shipments of portable units in the auxiliary power supply segment. Portable fuel cells are for example used at wind generator sites to supply power to anti-collision lights during turbine construction. A key player in the auxiliary power supply segment is SFC Energy, which published shipment figures for the first half of 2014 of nearly 1,500 units. Several other companies have partnerships for development of portable military products, for example, but orders are irregular.



Stationary fuel cells

Most of the MW of fuel cells shipped have been in stationary units, many of them for large installations. The stationary sector demands long lifetimes and low prices, so is hard to enter, but the signs are generally positive.

Large systems and the growth of the Korean fleet

Korea and the USA continue to dominate shipments and installations of large fuel cell units. Korea's leading position was strengthened when the world's largest fuel cell park, 59 MW, opened at Hwasang early in 2014. This "Gyeonggi Green Energy" facility comprises 21 FCE MCFC units running on natural gas, part of a 122 MW multi-year order placed previously by POSCO and augmented by 5.6MW in 2014. Further parks have been proposed, including 19.6 MW at the Godeok Rolling Stock development to provide power to the depot and the local grid, part of 230 MW of fuel cell installations planned for the Seoul region. September 2014 saw a further proposal for a multi-hundred MW fuel cell park in Pyeongtaek city, with POSCO energy working alongside Doosan and Korea Gas Corporation providing part of the investment. Operation is targeted for 2018.

Korea is also proving to be a potentially important market for other large scale fuel cell developers: in mid-2014, UK-based alkaline fuel cell developer AFC Energy signed an agreement with Chang Shin Chemical for up to 5 MW of AFC units; whilst Hydrogenics entered into an agreement with Kolon for a 1 MW PEM unit to be ready for operation in 2015.

These developments are underpinned by POSCO's increasingly major role in fuel cell unit production. This will be further boosted in 2015 when their Pohang manufacturing plant starts up, with its capacity of 100 MW of MCFC modules per annum, built under licence from FCE. This tandem development with FCE has

helped make FCE the world's largest producer of fuel cells (in terms of MW). FCE reports that 300 MW of units are installed or ordered for 50 locations worldwide, and FCE's Torrington manufacturing plant was reported to be operating at an annualised rate of 70 MW of its 100 MW capacity mid-way through 2014. FCE will expand that facility over the next four years, with support from the state of Connecticut in the form of up to US\$20 million in loans and tax credits. This could add 325 jobs to the current local workforce of 538 employees.

US utilities pick up on fuel cells

Several US energy companies announced investments in fuel cells and fuel cell companies in 2014. The interest is significant and marks a shift: US utilities have generally rejected fuel cells or other distributed technologies, preferring larger systems that fit more easily into their traditional models. But changing regulatory requirements, customer interest in resilience, the growing capacity of fuel cells in multi-MW installations and the success of fuel cells in limited distributed markets all are contributing to a change in attitude.

NRG Energy (NRG), one of the largest US utilities with 53 GW of generating capacity, dramatically increased its stake in FCE in 2014. It had owned 2.4 million shares; in July it bought 14.6 million more, for about US\$35 million, and now owns 6% of the company. NRG also established a US\$40 million revolving construction and term loan facility for project development, with interest of 8.5% during construction and 8.0% thereafter. NRG also agreed to market FCE's fuel cell power plants to its customers. But it's not all US utilities – the POSCO Energy engagement with FCE described above also includes ownership: 11% of FCE belongs to POSCO; their relationship began in 2003.

Back in the US, also in July, Exelon Corporation announced it is providing equity financing for 21 MW of Bloom Energy fuel cell projects at 75

commercial facilities for customers in California, Connecticut, New Jersey and New York. One customer is AT&T, a repeat buyer of fuel cells for telecommunications sites, offices and other facilities around the US.

Utilities are also operating some of the nation's largest fuel cell systems. Delaware's Delmarva Power runs 30 MW of natural gas-powered Bloom Energy Servers at two of its substations, enough to power 22,000 homes, and the largest deployment of fuel cell technology in the US. WGL Holdings, Inc., through its subsidiary, Washington Gas Energy Systems (WGES) announced a 2.6 MW fuel cell project using Bloom Energy units in Santa Clara County, California (SCC). WGES will finance, build, own and operate the facility and sell all energy generated to SCC under a 20-year power purchase agreement. United Illuminating, in Connecticut, announced that it will install 2.8 MW of fuel cell power plants at two sites – Bridgeport and New Haven. Bridgeport will also have 2.2 MW of solar power, to create a renewable energy park. The utility said both fuel cell installations will have a much smaller footprint than alternatives. The 2.8 MW Bridgeport installation needs 0.25 acres of land; the solar array requires more than 8 acres.

Resilience

One of the recent energy industry buzzwords, 'resilience' is used to reflect the ability of a system to absorb unexpected events and continue to deliver power to customers. Fuel cells are increasingly of interest to improve resilience in operations where continuous power is critical. In Japan, where grid power remains fragile three years after the Fukushima-Daiichi disaster, fuel cells

operating on the comparatively robust natural gas grid are able to provide the power to ensure 'mission critical' activities. Resilience is also behind Bloom's 6 MW Energy Server deployment at eBay's data centre in Utah, USA, where downtime would adversely affect the business, and behind the smaller 200 kW PAFC unit at Transport for London's Palestra House in London, UK, where the fuel cell power supports critical control and communication functions.

One of the original users of fuel cell units for data centres was the First Bank of Omaha in Nebraska USA, now back in the market. The bank installed a 200 kW PAFC unit to power its data centre in 1999 and at the end of 2013 announced that it would purchase a PureCell 400 kW PAFC unit from what was then ClearEdge Power. ClearEdge purchased stationary fuel cell production assets from UTC Power in 2013, becoming the third large stationary fuel cell developer and producer in the USA. Unfortunately in early 2014 it ran into difficulties and closed its doors. In July the business was acquired by Korean company Doosan, which also purchased Korean-based Fuel Cell Power, a manufacturer of residential CHP units. The new 'Doosan Fuel Cell America' has plans to expand the former ClearEdge operations in South Windsor, Connecticut based on the PureCell 400 PAFC technology, as discussed elsewhere.



Business models and service revenue

Simply selling fuel cells is not yet guaranteed to be a profitable option. Companies are developing more sophisticated models and service offerings to help them capture as much value as possible from the market.

FCE is developing a full-service offering to deliver product, service and operation through the fuel cell system's life. The service-based model is also a cornerstone of Bloom Energy's strategy: 'Bloom Electrons' is essentially a 'power purchase agreement' model for customers who sign up to long term contracts.

Developments elsewhere

Large fuel cell developments elsewhere in the world are modest, though likely to ramp up slowly over the next few years. Within Europe,

AFC Energy is preparing to deliver a 500 kW alkaline fuel cell unit to the European Power Up Project in Stade, Germany, to operate on locally surplus hydrogen. Also using by-product hydrogen, Nedstack's 70 kW pilot PEM power plant remains in operation at Azko-Nobel's chlor-alkali plant at Delfzijl in the Netherlands, with four different stacks reported to have achieved over 20,000 hours of runtime. FCE's European joint venture with Germany's Fraunhofer IKTS, Fuel Cell Energy Solutions GmbH, is part of a strategy to broaden MCFC's appeal into Europe. Bloom has sold its first units into Japan, where Softbank is one of its investors. In the USA and Europe, LG Fuel Cell Systems (LGFCS), formerly Rolls-Royce Fuel Cell Systems, continues its pressurised SOFC system development and plans to test a 220 kW integrated system in early 2015. In Japan, MHI has shown plans to develop tri-generation SOFC plants at multi-MW scale, though the timeline is not fully clear.

Service Revenue

The growth in service revenue is another sign of the changing business model for fuel cell power generation. The original model relied on sales and shipments to customers willing to assume the operating and maintenance obligations of the units. But customers for distributed power, accustomed to getting their power from a wall plug, showed little enthusiasm for owning or operating an expensive, unfamiliar and untested product.

The fuel cell industry responded first by adopting the solar industry's ownership approach, power purchase agreements, where a third entity established for the purpose would generally own the unit. The fuel cell companies began

offering contracts as an alternative to third party servicing, and thus established a new and continuing revenue stream.

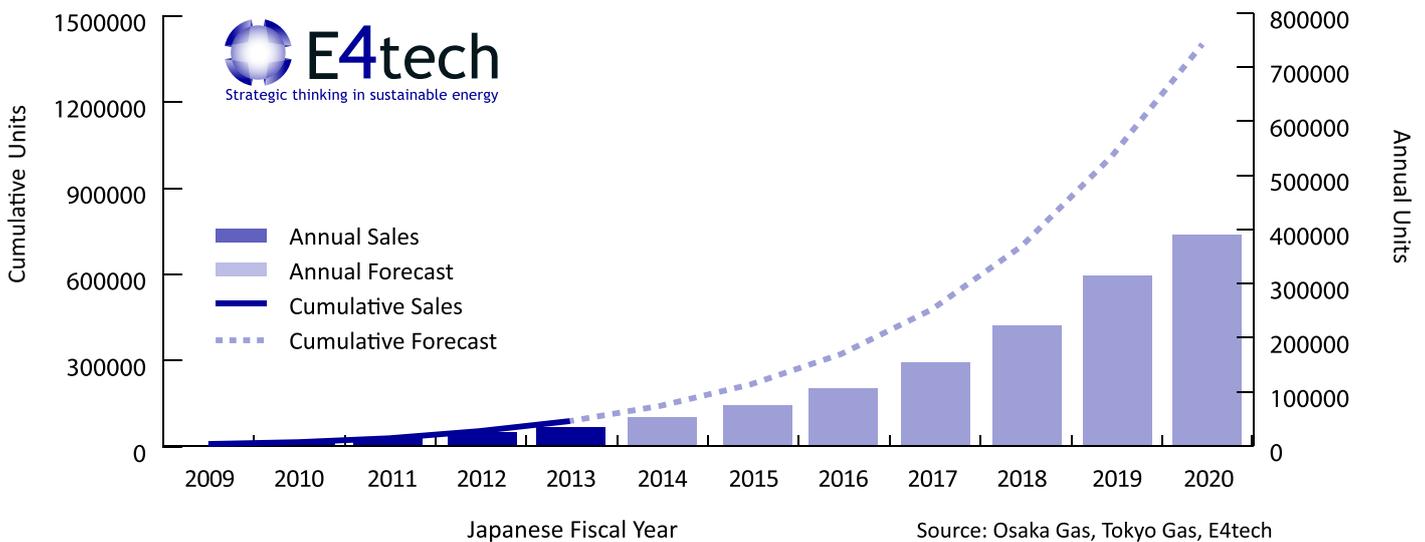
FuelCell Energy reported in September that service revenue for the third quarter doubled year over year to US\$7.1 million. Service backlog amounts to US\$201.8 million, driven by utility service contracts for larger installations. The service backlog far exceeds the product sales backlog of US\$137.3 million.

Service revenue is also important outside of stationary systems. Plug Power saw its service revenue double in Q2 2014 compared to Q1, to a six-month total of more than US\$6.5 million – as much as was reported in all of 2013.

Micro-CHP: Japan leads the world

Almost all of the fuel cell micro-CHP units installed globally are in Japan, which recently passed the 100,000 units milestone. With a typical sub-1 kW electrical power rating, they are mainly for domestic use. But the numbers are sufficiently large that fuel cells are now the biggest-selling micro-CHP technology worldwide. This has been due to the Ene-Farm initiative, bringing together Japanese fuel cell developers and the gas companies that distribute to their markets

under a common brand for better consumer recognition. These commonly branded units in 2014 comprised PEM micro-CHP developed and manufactured by both Panasonic and Toshiba, and SOFC micro-CHP units from Aisin. JX Nippon, previously selling SOFC systems, announced in October 2014 that it would stop making fuel cells in-house and concentrate on selling systems bought in from others – though it would continue to support systems it had already sold.



Forecast Ene-Farm deployment 2015–2020 based on announced government targets

The deployment investment by government has been substantial. Total funds supporting deployment were ¥25 billion in 2013 and ¥20 billion in 2014; they are scheduled to drop to ¥15 billion in 2015. With customer prices between ¥1.8 million and ¥2.2 million per unit,

these funds have helped make the units more affordable, subsidising ¥0.43 million to ¥0.38 million of the unit price. Installation costs are also dropping, down from ¥1.65 million per unit in 2013 to ¥1.49 million in 2014.

Market drivers

Despite its major contribution, the subsidy scheme is responsible for this large deployment. Even with subsidies these micro-CHP units rarely provide a positive return to customers, even over ten years. But micro-CHP received an important boost following the power shortages experienced in Japan since the Fukushima nuclear disaster; autonomy is increasingly seen as important. Novel marketing and sales approaches have also helped, with units sold as an integral part of a house or apartment, not standalone.

The manufacturers have benefited from the economies of scale provided by the ramp-up of production, but these are not sufficient to deliver fully competitive systems. They continue to reduce cost through better design and engineering, cheaper and better components and materials – and to seek additional markets through partnerships, such as in Europe.

European–Asian collaboration

The success of the Japanese micro-CHP experience and technology, and the Japanese manufacturers' desire for bigger markets, has been translated into joint ventures with European partners. Toshiba is working with Baxi, Panasonic with Viessmann, and Aisin with Bosch. Furthermore Ceres Power reports partnering with Korean business Navien and two unnamed Japanese OEMs with its SOFC technology; these are in addition to the long running relationship with British Gas.

European projects

The deployment of fuel cell micro-CHP in Europe has been muted in comparison to Japan. Several national and European projects have begun demonstration and commercial pre-deployment, but with considerably smaller subsidies available. The largest deployment to date is through Germany's Callux programme,



with three European based manufacturers: Hexis, Baxi and Vaillant. Numbers of up to 350 units are reported to date, with 500 expected by mid-2016. Ceramic Fuel Cells Limited (CFCL) is working with power businesses in Germany in a separate, but loosely linked effort deploying SOFC micro-CHP units. Although domiciled in Australia, CFCL has its manufacturing base in Germany, and has been the most active of the European-focused developers over the past few years. To the year end June 2014 it had sold 247 units, a 43% increase over 2013, and 580 units in total, all across Europe. Up to 60 units are planned for the UK, Netherlands and Germany as part of the SOFC-PACT project, supported by the FCH JU; CFCL is also delivering 45 of its BlueGen SOFC units to the Ameland Virtual Power Plant Project in the Netherlands. Costs are reported to have dropped by 29%, with degradation rates also down. Outside of Europe, CFCL recently installed two BlueGen micro-CHP units in China: a first for the company.

The Ene.field project, supported by the FCH JU, is Europe's most ambitious, targeting the deployment of 1,000 PEM and SOFC micro-CHP units across twelve member states, with a suite of developers: Hexis, Vaillant, Bosch, SOFCPower, Elcore, Baxi, RBZ, Ceres Power and Dantherm Power. Although the ramp-up has been slower than planned, progress in 2014 includes GdF Suez installing two Baxi units in France, whilst in Germany Buderus has installed an initial SOFC Logapower FC10 energy centre unit, and Vaillant has worked with Sunfire to install a unit in Germany.

Other projects in Europe include the Danish Vestenskov project, described as the world's first hydrogen community⁴, which has operated 1.5 kW micro-CHP units from IRD on pure hydrogen for a number of years.

Government support

As in Japan, deployment is dependent upon public sector support. The FCH JU is playing a leading role in pan-European projects, but elsewhere it is national and regional governments providing support. In Germany, both national and state level support is available for CHP in general, and fuel cell micro-CHP in particular. Four states have announced or implemented schemes subsidising the capital cost of units: North Rhine-Westphalia and Saxony have been joined by the states of Hesse and Baden-Württemberg in 2014.

In the US, California's Self-Generation Incentive Program (SGIP) is arguably the most valuable fuel cell incentive programme. Enacted in 2001 as a peak-load reduction programme, SGIP has changed considerably over the years and now supports various combined heat and power generation options as well as energy storage projects. The current incentive for fuel cells is more than US\$ 1,800 per kW. SGIP has been a major source of financing for Bloom's installations in California and a significant contributor to FCE. California approved an extension of SGIP in 2014, with funding of US\$ 83 million annually through 2019. Several other states, notably Connecticut, New York and New Jersey, offer incentives for fuel cell generation.

Arguably as influential to the progress of fuel cells for power generation is a regulatory proceeding initiated in New York State in 2014 called Reforming the Energy Vision. The New York State Public Service Commission (PSC) argues that "The energy industry is in transition" due to technological innovation and an increase in renewable energy generation on the one hand and an aging and fragile power grid on the other hand. The regulation of

utilities needs an overhaul to cope with these changes, PSC argues.

The objective is to "promote more efficient use of energy, deeper penetration of renewable energy resources such as wind and solar, wider deployment of "distributed" energy resources, such as micro grids, on-site power supplies, and storage. It will also promote greater use of advanced energy management products to enhance demand elasticity and efficiencies. These changes, in turn, will empower customers by allowing them more choice in how they manage and use electric energy.

Regulations and electricity rates sufficient to support this transformation will need to be worked out, but PUC argues that "... customer-side resources can become a primary tool in the planning and operation of the utility system." That would be an opportunity for fuel cells as for other distributed technologies.

Telecommunications

Powering telecom towers either with fuel cell units for backup or simply primary off-grid power has been the focus of a number of fuel cell developers. Market deployment of fuel cell units of 1 kW to 20 kW has occurred in both developed and developing economies worldwide.

Ballard has been one of the more successful players in these markets with its ElectraGen methanol reformer-based fuel cell products. It has continued to deliver units for the telecoms market through 2014, announcing new orders such as 13 units for Digicel in the Caribbean. It also announced in mid-2014 an agreement with Azure of China for licencing its telecom products for the Chinese market, also a target for FutureE, now part of Heliocentris. Another large potential market is India, a particular focus of Intelligent Energy. In 2013 Intelligent Energy established Essential Energy as a route to market for its products in the Indian distributed power and generation space,

⁴ Other places also claim 'hydrogen towns', for example Fukuoka in Japan.



Off-grid power

Off-grid, fully autonomous systems are increasingly of interest. Italian company Electro Power Systems (EPS) has been one of Europe's more successful fuel cell developers with 579 units in service, primarily in telecoms, and a reported cumulative 15.5 million hours' operation. EPS has been working on a new product for the off-grid power market: the ElectroSelf. With output of up to 20 kW per unit and a modular approach to systems, the ElectroSelf combines a PEM fuel cell and electrolyser. The electrolyser can generate hydrogen from renewable power; this is stored and used to fuel the PEM unit when required. Sales are reported for 2014, with deliveries presumably in 2015. In a similar vein, Taiwan based M-Field is intending to incorporate 400 kW of Ballard's FCgen 1300 stacks into a complete hybrid energy system with renewable power sources such as wind turbines.

initially in telecoms infrastructure. In 2014 Intelligent Energy entered into agreements with India's Microqual Techno Limited to provide support for Microqual-installed telecom base station equipment, and with Ascend Telecom Infrastructure to provide what the company called "cost effective, clean energy solutions and management" for telecom towers. These towers will first be operated by Essential Energy using existing equipment (typically diesel gensets) and new energy management strategies, before fuel cells are introduced during the replacement cycle.

In South Africa, Anglo American is field-trialling an off-grid hybrid power system using Ballard ElectraGen fuel cell units to provide power to thirty-four rural homes. The fuel cells can provide 15 kW of power, and in conjunction with the hybrid batteries can deliver peak power of 70 kW.

Elsewhere in Asia, First Element Energy signed a multi-year agreement with a major telecom operator in Indonesia to provide 300 base load methanol reformer fuel cell units for off-grid rural areas. These units are likely to use Nedstack fuel cells, with First Element Energy entering an agreement with Nedstack for at least 300 of its FCS XXL stacks. Jiangsu Communications Services in China is also evaluating First Element's products. In other markets, Acta Power of Italy announced three follow-up sales of its 2.5 kW fuel cell units, using ReliOn stacks, to its Australian distributor for one of Australia's largest mobile phone operators.

At a much smaller scale, SFC Energy of Germany has used its DMFC technology to develop the EFOY Cube to power the anti-collision lights of wind turbines, whilst its Simark Controls business has developed the EFOY Pro unit to power remote oil and gas control and monitoring systems.

The new availability of bank finance in the US

A power purchase agreement (PPA) is a contract between an energy supplier and customer; it has been used successfully to support solar or fuel cell installations that otherwise could not be financed. In a PPA, an electric power customer agrees to buy power at a fixed rate from a power generator for a specified number of years, generally from 10 to 25 years. This guaranteed

revenue stream in turn allows the power provider to find financing. And the customer need not take ownership of the generation equipment, an important benefit from his perspective. Previously, financing for fuel cell installations under these arrangements was obtained from private individuals or companies who can also benefit from US federal tax credits. Now US banks are stepping in.

Bank of America Merrill Lynch, a Bloom Energy customer, announced it will finance fuel cell installations through a leasing programme, beginning with two Bloom projects in California. And in September, this time in the mobile sector, Plug Power President Andy Marsh told a journalist that M&T Bank will now provide financing for Plug's fuel cell forklifts and fuelling systems GenKey package.

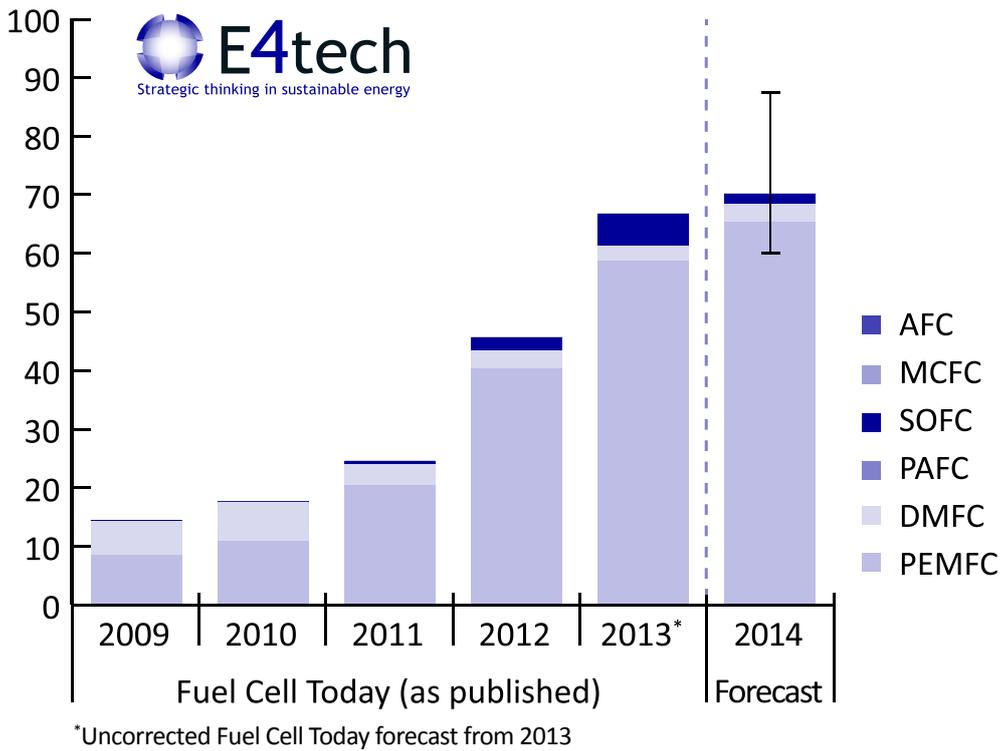
Insurance

Another sign of the "mainstreaming" of fuel cell technologies, and the creativity of some insurers in pursuit of advanced energy markets, is the issuance of 'performance insurance'. A policy was developed for Bloom Energy by a team of underwriters including XL Group's Complex Accounts unit, Munich Re's Green Tech Solutions team and consulting firm New Energy Risk. The policy will support several Bloom installations over 15 years, insuring customers against losses should Bloom be unable to meet its warranty obligations.

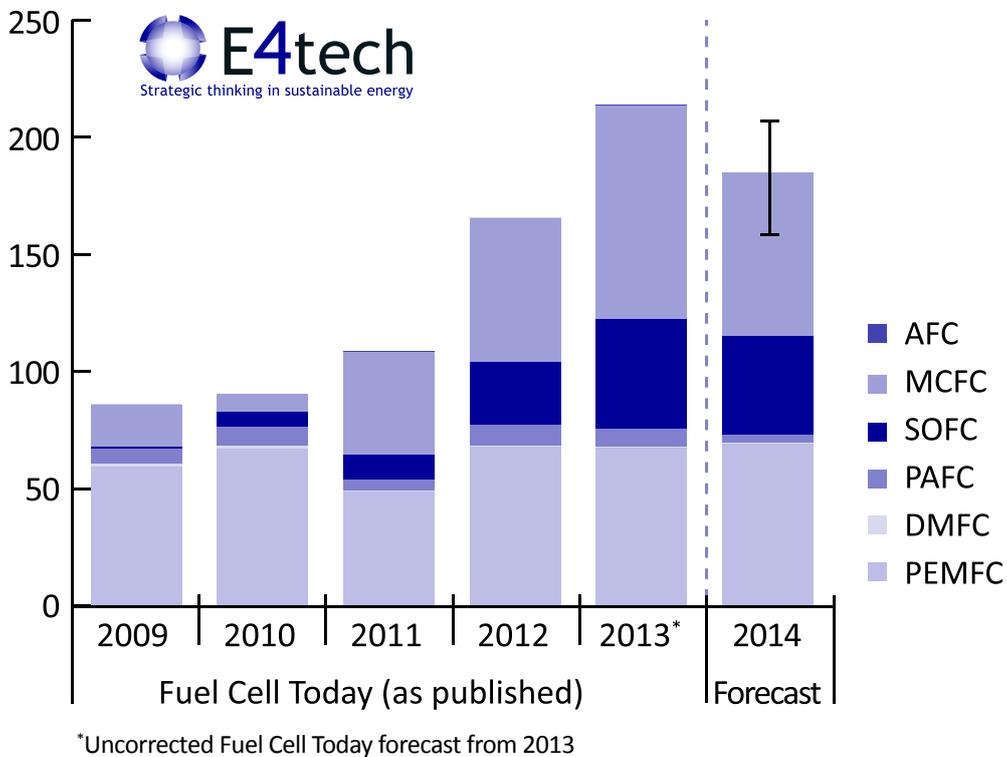
The insurance provision had real financial impact, allowing Bloom to raise US\$99 million in project financing via an investment-grade bond.

Shipments by fuel cell type

Shipments by fuel cell type 2009 - 2014 (1,000 units)



Megawatts by fuel cell type 2009 - 2014



Footnote to charts: Data from 2009-2013 are as published by FCT, including their forecasts for 2013; 2014 is our forecast for the full year. We include an error bar for 2014, based on the quality of our data sources and our views on the uncertainty in the forecasts.

PEMFC was the predominant electrolyte chemistry shipped by number of units in 2014, continuing the trend evident from 2009 onwards. The majority of these of these shipments were in the stationary sector: the residential micro-CHP systems shipped under the Ene-Farm programme, and backup power units. Almost all transport applications use PEM, and numbers could go up sharply in 2015 if FCEVs roll out as suggested.

DMFC unit shipments are next after PEMFC and alongside SOFC, in the portable and backup and off-grid applications. Systems using both electrolytes are estimated to have shipped well over 1,000 units. For **SOFC** chemistry the units are primarily for the residential micro-CHP segment in Japan and Europe. It is worth noting that actual 2013 shipments of SOFC units were lower than shown in the FCT estimates by about 3,000 units, as JX Nippon Oil did not ship as many SOFC units as forecast in the Japanese Ene-Farm programme.

MCFC and **PAFC** are typically used in large stationary systems for prime power or CHP, often at the multi megawatt scale. Because of the large unit sizes we have estimated that fewer than 50 units shipped in 2014 for each of these chemistries, hence these do not show up in the unit shipments. We know of no **AFC** (Alkaline Fuel Cell) shipments in 2014, although this should change in 2015, albeit in small numbers.

Capacity numbers by fuel cell type:

PEMFC has consistently shipped in both large unit numbers, as noted above, and in substantial MW. The MW shipped in PEMFC has been relatively stable over the years, although as unit numbers have increased the average power output per unit has fallen. This trend is partly explained by the increasing number of smaller residential micro-CHP units; those shipped as part of the Ene-Farm programme are less than 1 kW, usually about 700–750 W. Larger PEMFC units tend to be used in transport applications, especially buses, but also in the backup and material handling segments.



The dominant fuel cell type shipped in 2014, following on from 2013, is **MCFC**. The large size of these stationary power system for prime power applications, from 300 kW through to several MW scale per unit, mean that a relatively small number aggregate to substantial total MW. As noted above these units have been delivered to end-users in South Korea and the USA, and less so to Europe in the past two years. Looking forward plans in South Korea for further fuel cell parks as well as the expansion of POSCO and FCE production plants all point to MCFC being the dominant fuel cell type (in terms of MW) into 2015 and perhaps beyond.

The **SOFC** numbers are mainly driven by shipments of the larger kW capacities of Bloom Energy's prime power applications. The residential micro-CHP units have only a marginal effect on the MW shipped. 2014 MW shipments are likely to be lower than 2013, with fewer Bloom Energy servers thought to have shipped than the previous year, though it is possible that final numbers may be increased if more information becomes publicly available. It is worth noting that 2013 was itself an improvement on the prior three years. Announcements by Bloom in 2014 for partnering, funding and service agreements point to a recovery for 2015 and beyond. Also of note are announcements by General Electric of a manufacturing plant for SOFC in New York State in the US and a partnership between Redox Power Systems, offering an SOFC using slightly different materials, and Microsoft.

Based on the more recent units of 400 kW each, several MW of **PAFC** capacity for prime power and large CHP applications were shipped in recent years by UTC power. Shipments in 2014 have fallen off; ClearEdge suffered from the funding issues resulting in its eventual purchase by the Korean Doosan Corporation, and Doosan Fuel Cell America emerged. Their plans are to re-build shipments from 2015 onwards, so 2014 may be

the low point for this fuel cell type. Another player in this technology is Fuji Electric, producing 100 kW units typically deployed in Japan.

Although several thousand **DMFC** will have been shipped by end 2014, the cumulative capacity is comparatively small, due to typical unit sizes between 50 and 100 W.



Transport... holding its breath for 2015

Looking only at the data on units shipped, transport has had something of a quiet year in 2014. But there is tremendous activity beyond the numbers, including the first commercial lease, by Hyundai, of a fuel cell vehicle in the United States, to add to its deliveries in Europe and Korea.

The focus of much of the industry, and the public, has been on cars. The year 2015 has for years been an important date in fuel cells, with the announced availability of fuel cell cars in showrooms – in a few places worldwide. Hyundai has already started manufacturing, selling and leasing its ix35, delivering its first mass-produced vehicles to Europe in 2013 and its first vehicle to a California customer in June 2014. Toyota and Honda have shown the shells for their 2015 vehicles, and Toyota has put its considerable marketing muscle behind the rollout. Toyota's president Toyoda, a trained auto racer, drove one of the new FCEVs as a pace car in a recent road rally in Japan. There is a possibility Toyota will begin offering vehicles in Japan in December 2014.

It would be both astonishing and worrying if these makers did not follow through and make vehicles available next year, although Toyota is clearly more enthusiastic than Honda.

Other companies are at varying stages along the path: GM continues to work on cost reduction and performance improvement, but has made no recent public announcement on release dates. It

does have a partnership with Honda, however. Daimler pulled back last year from a previously-suggested 2014-15 release, citing a new expanded partnership with not only its long-time associate Ford, but also Renault-Nissan, and the time it would take to get everyone to the same level of development. Daimler's new date is 2017, for a vehicle that will be much more cost-effective (they say) than those in 2015. Neither Ford nor Nissan has committed to 2017 yet.

VW, a long-time fuel cell cynic, is working with Ballard of Canada in an engineering services programme that could see much of Ballard's very substantial knowhow delivered to VW's engineering teams. Interestingly, VW also announced a partnership in 2014 with Shanghai's SAIC, historically a partner of the GM fuel cell programme. The German automotive sector's representation is completed by BMW. In January the company announced a memorandum of understanding with Toyota on advanced drivetrains, and the media have suggested that a fuel cell variant of BMW's electric i3 may be in the offing.

Not all automotive OEMs have the deep pockets to invest in fuel cells. GM claims it has spent US\$2.5 billion on the technology to date. So if the sector does emerge successfully, it may mirror the conventional vehicle sector: some companies will produce their own fuel cells, which they may share with others; and yet more will buy fuel cells from proven Tier 1 suppliers. Some fuel cell companies



Plug Power's small order

Perhaps the most significant aspect of the announcement in October that Plug Power will supply Golden State Foods with 39 material handling vehicles was the small size of the order. Golden State is a California-based manufacturer and distributor of foods for the fast food industry. The Plug Power lift trucks will help deliver hamburger and other goods to more than 460 McDonald's in the Midwestern US. The vast majority of fuel cell forklift sales have been much larger, usually well over 100 units. The larger numbers, and two- and three-shift operations, have been needed to support the cost of the units and infrastructure. If Plug can profitably serve smaller fleets, it will open a significant new market segment.

Early fuel cell forklift installations were pieced together. One of several lift truck companies

would supply the vehicle, Plug would supply the packaged fuel cell system; a merchant gas company would supply infrastructure and hydrogen. Early in 2014, Plug Power announced it would provide packaged hydrogen infrastructure and service along with its lift trucks. It is called GenKey. Plug's Andy Marsh told a federal advisory committee that the package yields significant savings on the infrastructure side.

Controlling all aspects of installation, hydrogen supply and maintenance reduces deal-killing risk and complexity for customers, while Plug retains the profit not only from the sale of systems, but also maintenance and hydrogen sales. This makes for what Marsh called a "recurring and increasing revenue stream" that improves the business model.

believe they could be credible in that role: Ballard, whose 5-year automotive lock-out agreement with Daimler and AFCC expired early in 2014 is one; others include Nuvera, Intelligent Energy, who state that a European premium manufacturer has integrated one of their systems into a vehicle, and perhaps Hydrogenics, where GM retains a small stake. It is unlikely that these companies would themselves achieve qualified Tier 1 status, but they could licence and transfer technology to the typical suppliers in the space.

Also in the frame for vehicle applications more broadly are smaller companies like Proton Motor in Germany and SymbioFCell of France. And Shen-Li and Sunrise Power in China have long

been involved in providing stacks and systems for Chinese transportation projects.

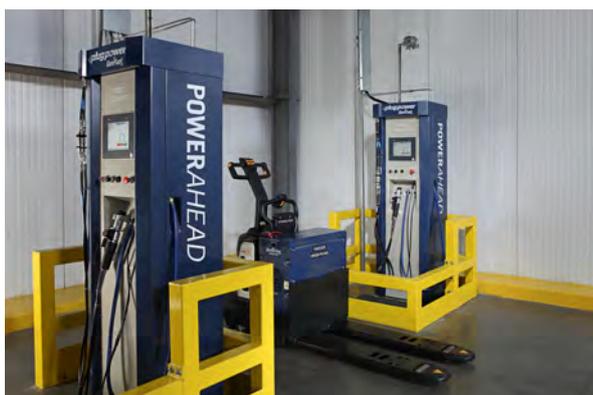
The transport sector is very diverse, however, and applications less sexy than cars are being developed around the world, from the well-known materials handling trucks through utility vehicles, buses and vans to go-karts.

While bus demonstrations moved ahead in Europe, notably the Aberdeen project in Scotland and CHIC project in Europe, BC Transit in Canada announced that the Whistler fuel cell bus project – the largest in the world to date with 20 buses in full revenue service – had run its course. Both Ballard and Hydrogenics offer fuel cell power systems for buses, as does US Hybrid, which bought the PEM system designed by UTC for heavy vehicles including buses, though Ballard later bought the underlying patents.

On the more sexy side, perhaps, are companies like GreenGT, quietly working on all-out race cars.

The importance of cooperation

For fuel cell cars to really succeed, several things need to simultaneously be put in place. Vehicles



need to be available, affordable, and supported by their suppliers. Infrastructure needs to be available too; enough for people to feel they can refuel when they need to. In California, Hyundai offers free fuel and servicing with its leased ix35 FCEV, to ensure that customers do not feel they're taking an unnecessary risk.

And policy, regulations, codes and standards all need to align. The way this has been approached is through partnerships and coalitions. In Japan the industry has had close ties with government for many years, in part through the Fuel Cell Commercialization Conference of Japan (FCCJ). In Germany the first H2Mobility initiative performed this role, bringing together the required stakeholders in the form of government, automotive OEMs, infrastructure providers and other technology suppliers. UKH2Mobility followed, as did similar initiatives in Switzerland and France. In the US, the California Fuel Cell Partnership has been instrumental for years, and was supplemented in 2013 by H2USA, which is involving the federal government in ways not seen for many years. All of these initiatives are in different stages of development, but fuel cell vehicles are promised by many of them over the coming one or two years.

California – the fuel cell state?

In California, new legislation in 2014 (AB8) provides a commitment of up to US\$20 million per year to fund hydrogen refuelling stations (HRS) until at least 100 public stations exist. Support is generous: up to 85% of station costs and up to US\$100,000 per year for three years for operating expenses. This is an extension to the Alternative and Renewable Fuel and Vehicle Technology Program, which provides about US\$100 million a year for all such technologies. In October 2014, nine public stations were open in California, with 49 in the pipeline, plus an additional two bus fuelling stations, supported by a US\$90 million financing commitment by the State to date.

The California legislature requires the California Air Resources Board (CARB) to report annually

on vehicle numbers and infrastructure needs. In June 2014 CARB's first report found 125 FCEVs registered with the Department of Motor Vehicles. "Auto manufacturer projections indicate that California's FCEV fleet will grow to 6,650 by the end of 2017 and 18,500 by the end of 2020, with in-state fuelling capacity at 9,400 kilograms per day by the end of 2015. The coverage and capacity provided by these stations will be nearly sufficient through 2018 to support the FCEV fleet within that timeframe," reports CARB, but... "Additional coverage and capacity needs in 2020 will require up to 49 additional stations." CARB concluded that "CEC should maintain the course – the maximum US\$20 million allocation and any other potential funding sources identified by ARB and CEC should be utilized in the next CEC funding program for hydrogen fuel stations..."⁵.

The estimate of 18,500 vehicles by 2020 is a far cry from the 2011 estimate of 53,000 by 2015-2017, a reflection of the increasingly conservative market penetration estimates from the auto industry. But even those levels represent a US\$925 million market just for the vehicles (at US\$50,000 per car), which underscores just how huge the auto market will be, and how important an industry and supply chain driver it is.

Hydrogen refuelling station infrastructure

In the US outside California no truly public hydrogen stations are in operation, though a few are usable by appointment. Work is under way to assess station needs and locations but the process is slow, with no sense of urgency on the part of either governments or the auto industry.

Sufficient HRS infrastructure is essential for the successful commercialisation of FCEVs, but it has long been caught up in the 'chicken and egg' discussion ("which comes first?") between FCEV suppliers, and HRS providers and fuel retailers. Recognising that FCEVs roll-out and HRS infrastructure must proceed together, efforts are being made to establish nascent HRS

⁵ CEC: California Energy Commission; ARB: Air Resources Board (California)



infrastructures to provide FCEV drivers with suitable geographical coverage as well as the convenience and speed of conventional ICE vehicle refuelling.

To date many HRS have been installed specifically for private use in demonstration projects. Now, however, growing a public HRS infrastructure has taken on more urgency with the first steps to the roll-out of FCEVs. As noted above, California easily leads the way in the USA. Japan also has an extensive HRS network, with 54 stations planned for the end of 2014 and 100 by the end of 2015, strongly supported by government.

In Europe, the various national H2Mobility programmes, representing coalitions of players from along the hydrogen and FCEV value chain, have drawn up plans for establishing HRS networks in the immediate future. Germany is most advanced, with an estimated 25 HRS in place and a plan for 50 HRS by the end of 2015; the state of Baden-Württemberg being one of the latest to announce HRS locations in October 2014. Similarly, the UK Government recently announced funds of £5.5 million, matched by private funds of £3.5 million, to create a network of up to 15 HRS by 2015. This will be achieved both through upgrading existing HRS and installing new stations. Incremental progress is being made elsewhere in Europe; for example Air Liquide announced in mid-2014 that it will supply four HRS to Denmark to expand the existing Danish HRS network.

HRS have hitherto been produced more or less as one-off projects. To have any chance of keeping up with the number of installations anticipated, manufacturers will have to move to

more standardised, modular designs capable of being produced in series production. Of particular significance in 2014, therefore, was the official opening of Linde's small series production HRS plant in Vienna, announced as the world's first. The plant will deliver HRS worldwide, including Japan; at the same time, Linde announced an agreement with the Iwatanti Corporation for the delivery of 28 HRS.

The role of 'green hydrogen' in H2Mobility is being increasingly emphasised. Whilst the public may be prepared to accept hydrogen reformed from natural gas initially, work by the UKH2Mobility initiative shows that 'green hydrogen' is expected to become available. 'Power-to-gas' schemes, currently mainly in demonstration mode, can use renewably-sourced power to operate electrolyzers and could play an important role in supplying hydrogen to HRS networks. Many HRS are already based on local production of hydrogen using electrolyzers, and 50% of HRS in the UK are anticipated to get their hydrogen this way. An example of this is the HRS located at Honda in Swindon in the UK which was launched as a 'green hydrogen' HRS at the end of October 2014. Hydrogen comes from a Hydrogenics electrolyser powered by a nearby solar farm. Of course, California already requires that 33% of hydrogen made available at publicly funded stations is derived from renewable sources.

The availability of a nascent HRS network, with clear plans for future growth, will of course influence the roll-out decisions of the automotive OEMs. It is not surprising that countries with such networks, plans and activities to establish HRS infrastructure are being selected to receive the coming FCEV models over the next few years.



Portable Power

The application of fuel cells for portable uses, generally for off-grid and on-the-move requirements of one or two to hundreds of watts, has been a successful sector for manufacturers, with annual sales for some running in the 10,000s range. Portable fuel cell applications tend to fall into three areas: fuel cells for charging consumer electronics, most notably mobile phones; for auxiliary power units in leisure applications, such as camper vans and now caravans; and for military use for soldier power and other small power uses such as certain unmanned aerial vehicles (UAV). Fuel cells are also used at very small power levels for educational uses and toys; we do not track these applications.

Battery chargers for consumer electronics, especially smartphones with their typical heavy usage, have long been seen as a promising market opportunity. However, the competition from stand-alone battery-based chargers, wall sockets and even supercapacitors is intense, the technology is challenging to miniaturise cheaply, and the industry hard to break into. Many companies, including the world's largest consumer electronics corporations, have reduced or abandoned previously major development efforts. Nevertheless, a small number of companies is either already selling units, or claims sales are imminent. MyFC and Horizon have had sales of very small units (around 5W) for several

The military application of fuel cells has long been a source of interest and funding from leading armed forces across the world. The US military has played a leading role in the adoption of fuel cells for soldier power. Protonex's 100 to 1,000 W PEM and SOFC based chargers provide flexible power at less weight than conventional battery systems. Ultra Electronics-AMI's SOFC-based ROAMIO defender series (245 and 300 W) offer similar advantages. UltraCell also provides high power micro-fuel cells in this area, the XX55 and the larger 150 W Blade models. In other applications Neah Power has announced a partnering agreement with Silent Falcon UAS Technologies to integrate its fuel cell technology into the Silent Falcon UAV. Ultracell will incorporate a less well-known fuel cell – the solid acid fuel cell or SAFC, into a soldier power system.

years. Others, such as Intelligent Energy, are about to start competing in this space. Intelligent Energy's Upp 5 W charger, using their proprietary air-cooled fuel cell and a metal hydride store of hydrogen was unveiled at the end of 2013. This year the company announced that it was partnering with Brookstone, the US retailer, and with Sure, part of the Batelco Group, to distribute the Upp. Intelligent Energy announced that 50,000 units were to be produced and shipped



before year-end, though we have not included these in our calculations, as these estimates are frequently optimistic.

MyFC's PowerTrek charger is a fuel cell-battery hybrid rated at 5 or 6.5 W (depending on the model) and using a chemical hydride store, which has been on test with selected customers of the mobile telecom company 3 in Sweden for smart phone and tablet charging. Meanwhile US business Neah Power Systems announced that its multi-energy source charger, the BuzzBarSuite, will soon be available for electronic device charging. Variants of the product will include a fuel cell along with solar and battery technologies. Aquafairy of Japan continues to develop its own charger, and BIC, which acquired Canadian company Angstrom Power and its charger technology at the end of 2011, remains quiet about any launch. Unfortunately Lilliputian, which had several times announced imminent availability of its butane-fuelled micro-SOFC product Nectar, proved that the sector remains hard to enter when it closed its doors earlier this year.

More positively in the leisure market, Horizon and SFC Energy are selling units into the larger (100+ W) battery charger markets. This year Horizon

announced the manufacture of its Aquigen 180 system, a 180 W charger for the camper van and caravan markets, in Australia. This complements the 150 W HydroMax system, developed for the yachting and other leisure markets by Dutch-based Dynad, which uses a Horizon fuel cell plus malic acid and a salt solution as a fuel source. Fuel Cell Systems, the newly formed sister business of the UK business UPS, has said that its sales of fuel cell systems, using an SFC Energy DMFC stack, in this segment continue to rise.

German-based SFC Energy moved into the oil and gas sector through the purchase of Simark Controls, now a subsidiary, and has spent much of 2014 consolidating that purchase. This brings SFC Energy access to a more general off-grid segment of hundreds of watts of power. Ultra Electronics-AMI is seeking to use its SOFC ROAMIO defender technology in gas pipeline monitoring applications, remote railroad and other transportation systems. Swiss business CEKAtec, famous in some circles for its fuel-cell powered espresso machines designed for Swiss trains, has announced that its IHPos-E fuel cell system is ready for market, targeted at the leisure and emergency segments.



The outlook for 2015

The purpose of this Industry Review is just that, to review. But we would be remiss if we did not take the opportunity to comment on what may happen in the coming year, though without attempting to provide quantitative forecasts.

The year 2014 was one of consolidation – voluntary or involuntary – for much of the nascent industry. 2015 is likely to be similar in terms of individual company development, but otherwise has the potential to be a watershed year. Despite the old adage that “fuel cells are five years away – and always will be,” the line drawn in the sand by the automotive manufacturers some years ago has not changed. In 2015 fuel cell cars will be available. They will be in smaller quantities than initially anticipated, and from fewer manufacturers initially, but available.

Most important may be some unexpected aspects of this launch: similar to the positive effect that fuel cell buses have on riders and drivers in cities they enter, the availability of fuel cell cars could have an important positive psychological impact on the general public. Or

companies that have not yet chosen to enter the supply chain, due to a lack of visibility on when it might become profitable, may be more prepared to take a risk. Hydrogen refuelling infrastructure will start to be tested in earnest. And journalists and others will finally be able to compare commercial FCEVs with their direct competition, primarily BEVs, with a knock-on impact on policy-makers and financiers.

It will be interesting to follow the impact of announcements in the transport sector on developments in stationary power. Certainly Toyota’s aggressive visibility campaign in the US has made a palpable, if still small, difference in opinion-leader attitudes toward fuel cells generally. Analysts and journalists have become much more sophisticated since the peak of the hype cycle around 2001, when any mention of fuel cell success drove shares in the whole sector higher, regardless of their relevance to the specific chemistry or application. However, the view from 2014 suggests that shares in fuel cell companies still can move in lockstep based on individual announcements.





Although our aggregated data show a flat year overall, as some companies slow down, a small number of companies will ship much greater numbers of units in 2014. We expect more successes in 2015, though likely balanced again by declining sales or outright failures at other companies, and so overall shipments may still not take on the hockey-stick acceleration that financiers crave. Small systems such as chargers are likely to ship in greater numbers and are likely to end up dominating our unit shipment charts. Their increasing ubiquity may also start to increase consumer confidence in fuel cells as a whole.

In Europe, energy provision is in turmoil. Many large utilities have had to write off generating assets, including comparatively new gas-fired plant, and many are losing money. The implementation of renewables in different countries and the move from nuclear power has ripped traditional business models apart, giving alternatives some opportunity. The UK is operating at historically low capacity margins, giving rise to fears of imposed demand management, just to keep the lights on. The impact of this turmoil on the fuel cell industry is quite unclear. Uncertainty may bring opportunity,

but it also brings increased risk, which may not help the relatively recent moves of Japanese residential fuel cell suppliers into Europe.

The general shape of the industry is unlikely to change dramatically, however. The bias towards PEM and SOFC appears entrenched, and while the other chemistries are likely to persevere, they will probably not dominate. Although MCFC can retain an important portion of the prime power and cogeneration markets, it will never be the single solution.

New twists on the technology will continue to emerge, and new companies too. Some of these may be implementing known technologies in different regions, for example through technology transfer from Europe and North America to countries like China. Some will have potentially new solutions to offer, through alternative materials or architectures. But these new companies will not be able to shortcut the need for extensive technology proving in the lab, in demonstrations and in the field before they can sell something a consumer will be comfortable buying. This suggests that many of the companies that are likely to succeed, when the industry finally matures, are already there.

Data Tables

Shipments by application						
1,000 Units	Fuel Cell Today (as published)					Forecast
	2009	2010	2011	2012	2013*	2014
Portable	5.7	6.8	6.9	18.9	13.0	21.8
Stationary	6.7	8.3	16.1	24.1	51.8	45.6
Transport	2.0	2.6	1.6	2.7	2.0	2.9
Total	14.4	17.7	24.6	45.7	66.8	70.2

Shipments by region						
1,000 Units	Fuel Cell Today (as published)					Forecast
	2009	2010	2011	2012	2013*	2014
Europe	4.4	4.8	3.9	9.7	6.0	6.1
North America	3.2	3.3	3.3	6.8	8.7	17.1
Asia	6.7	9.5	17	28	51.1	45.2
ROW	0.1	0.1	0.4	1.2	1.0	1.8
Total	14.4	17.7	24.6	45.7	66.8	70.2

Shipments by fuel cell type						
1,000 Units	Fuel Cell Today (as published)					Forecast
	2009	2010	2011	2012	2013*	2014
PEMFC	8.5	10.9	20.4	40.4	58.7	65.3
DMFC	5.8	6.7	3.6	3.0	2.6	3.1
PAFC	0.0	0.0	0.0	0.0	0.0	0.0
SOFC	0.1	0.1	0.6	2.3	5.5	1.8
MCFC	0.0	0.0	0.0	0.0	0.0	0.0
AFC	0.0	0.0	0.0	0.0	0.0	0.0
Total	14.4	17.7	24.6	45.7	66.8	70.2

*Uncorrected Fuel Cell Today forecast from 2013

Megawatts by application						
Megawatts	Fuel Cell Today (as published)					Forecast 2014
	2009	2010	2011	2012	2013*	
Portable	1.5	0.4	0.4	0.5	0.3	0.5
Stationary	35.4	35.0	81.4	124.9	186.9	147.3
Transport	49.6	55.8	27.6	41.3	28.1	28.2
Total	86.5	91.2	109.4	166.7	215.3	176.0

Megawatts by region						
Megawatts	Fuel Cell Today (as published)					Forecast 2014
	2009	2010	2011	2012	2013*	
Europe	2.9	5.8	9.4	17.3	17.3	10.4
North America	37.6	42.5	59.6	61.5	74.7	52.3
Asia	45.3	42.5	39.6	86.1	122.9	112.4
ROW	0.7	0.4	0.8	1.8	0.4	1.0
Total	86.5	91.2	109.4	166.7	215.3	176.0

Megawatts by fuel cell type						
Megawatts	Fuel Cell Today (as published)					Forecast 2014
	2009	2010	2011	2012	2013*	
PEMFC	60.0	67.7	49.2	68.3	68.0	69.7
DMFC	1.1	1.1	0.4	0.3	0.2	0.2
PAFC	6.3	7.9	4.6	9.2	7.9	3.8
SOFC	1.1	6.7	10.6	26.9	47.0	32.3
MCFC	18.0	7.7	44.5	62.0	91.9	70.0
AFC	0.0	0.1	0.1	0.0	0.3	0.0
Total	86.5	91.2	109.4	166.7	215.3	176.0

*Uncorrected Fuel Cell Today forecast from 2013

Notes

- 2009-2013 figures are as published in the Fuel Cell Today Industry Review 2013. Note that the figures for 2013 were a forecast to full year, which we have not changed retrospectively, though our analysis suggests they are slightly high.
- Our 2014 figures are a forecast for the full year. Data for 2014 have been collected directly from fuel cell manufacturers where they were able to share it; through interviews with industry experts; careful review of publicly available sources such as company statements, press releases, reports of public companies and demonstration and roll-out programmes.
- Unit numbers are rounded to the nearest 100 units. An entry of zero indicates that fewer than 50 systems were shipped in that year.
- Megawatt numbers are rounded to the nearest 0.1 MW. An entry of zero indicates that less than 100 kW was shipped in that year.
- Portable fuel cells refer to fuel cells designed to be moved. They include fuel cell auxiliary power units (APU), and consumer electronics (e.g. phone chargers). Toys and educational kits are not reported.
- Stationary fuel cells refer to fuel cell units designed to provide power at a fixed location. They include small and large stationary prime power, backup and uninterruptable power supplies, combined heat and power (CHP) and combined cooling and power.
- Transport fuel cells refer to fuel cell units that provide propulsive power or range extender function to vehicles, including UAV, cars, buses and material handling vehicles.
- Our geographical regions are broken down into Asia, Europe, North America and the Rest of the World (RoW), including Russia.
- Shipments by fuel cell type refer to the electrolyte. Six main electrolyte types are included here. High temperature PEMFC and conventional PEMFC are shown together as PEMFC. Other types of fuel cells currently in an early stage, such as microbial fuel cells and solid acid fuel cells, are not included in the numbers shown.

About E4tech and the authors

Since 1997, E4tech has been helping clients to understand and solve problems at the interface between energy technology, regulations and policy, and business opportunities. We have maintained our focus on innovative approaches to sustainable energy. We have in-depth expertise and long experience in sectors including biofuels, heat, power and chemicals; in low carbon vehicles; energy systems and storage; and in sustainability and resource analysis. Fuel cells and hydrogen are particular areas of strength, and we have carried out projects for early stage companies, SMEs, large corporates, financiers and governments worldwide. These projects range from market and competitor analysis through business strategy, technical and commercial due diligence, and support for policy development.

Prof David Hart is a Director of E4tech, responsible for the Fuel Cell and Hydrogen Practices. He has been working in the fuel cell sector for 20 years, consulting and carrying out research on fuel cell and hydrogen issues for a wide range of organisations worldwide, including national governments, major industrial companies, financial organisations and NGOs. He is also a Visiting Professor at Imperial College London's Centre for Environmental Policy, chairs the Steering Committee of the Grove Fuel Cell Symposium, and has been an invited speaker at conferences on six continents.

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Robert Rose is executive director of the Breakthrough Technologies Institute, an independent nonprofit advocate for technologies that carry environmental benefits to society; BTI's fuel cell activities date back to 1991. Rose has served in senior communications and policy positions in the US government, and as an advisor to state and regional governments, nonprofit organisations, and the private sector. Rose founded the US Fuel Cell Council, the trade association of the fuel cell industry, in 1998 and was Executive Director for 10 years. He writes and lectures widely about fuel cells and hydrogen energy and has received numerous industry awards.

Jonathan Lewis is an independent consultant with over twenty years' experience in the business development arena, ranging from strategy and policy development through business plans to commercialisation activities in the technology space. He has worked in the fuel cell and hydrogen area for more than 10 years, initially with Rolls-Royce Fuel Cell Systems Ltd, and more recently in an independent capacity working for the private and public sectors. He has extensive experience in Europe, serving on the Board of the FCH JU and the NEW-IG, and more recently working with the FCH JU in a variety of roles.

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PG IMAGE

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- Dr Mike Hugh
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- FuelCell Energy, Inc.
- Hexis AG
- SFC Energy AG
- Toyota Motor Corporation
- Intelligent Energy Ltd.
- Plug Power Inc.
- H2Logic A/S
- Hydrogenics Corp.
- Intelligent Energy Ltd.
- Horizon Fuel Cell Technologies
- Panasonic Corporation
- Hyundai Motor Company

Note on currencies:

The following exchange rates can be used as guidance to convert currencies mentioned in this report. These are the average mid-point exchange rates from 31st October 2013 to 31st October 2014.

US\$1 = €0.7417	€1 = US\$1.3492	1£ = US\$1.6565	1¥ = US\$0.0097
US\$1 = £0.6039	€1 = £0.8146	1£ = €1.2282	1¥ = €0.0072
US\$1 = ¥103.16	€1 = ¥139.12	1£ = ¥170.85	1¥ = £0.0059

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