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UKH$_2$Mobility launched to push the rollout of hydrogen powered travel in the UK

The UKH$_2$Mobility project – launched in mid-January – is a ground-breaking project to ensure that the UK is well placed to handle the commercial rollout of hydrogen fuel cell vehicles in the next three years. The initiative brings together three government departments and 13 industrial partners from the utility, gas, infrastructure, and global car manufacturing sectors.

UKH$_2$Mobility will evaluate the potential for hydrogen as a fuel for Ultra Low Carbon Vehicles in the UK, before developing an action plan for an anticipated rollout of hydrogen fuel cell vehicles to consumers by 2014–2015 as part of a balanced portfolio of drivetrains.

'The UK is proving itself to be a key early market for ultra-low emission vehicles, with growing numbers of electric and plug-in hybrids appearing on our roads,' Business Minister Mark Prisk said at the UKH$_2$Mobility launch event at the Royal Society in London. 'The government is supporting this market by investing £400 million (US$620 million) to support the development, demonstration and deployment of low and ultra-low emission vehicles.'

The UKH$_2$Mobility partnership aims to develop a definitive rollout action plan, by analyzing the specific case for the introduction of hydrogen fuel cell vehicles; reviewing investments required to commercialize the technology, including refueling infrastructure; and identifying what is required to make the UK a global hydrogen fuel cell player, thereby paving the way for economic opportunities.

The 13 industry participants are Air Liquide Hydrogen Energy, Air Products, Daimler, Hyundai Motor Company, Intelligent Energy, ITM Power, Johnson Matthey, Nissan Motor Manufacturing (UK) Ltd, Scottish and Southern Energy, Tata Motors European Technical Centre, The BOC Group, Toyota Motor Corporation, and Vauxhall Motors (part of General Motors).

Also participating are the Department for Business, Innovation and Skills, the Department for Transport, and the Department of Energy and Climate Change, in addition to the European Fuel Cells & Hydrogen Joint Undertaking. All of the partners have signed a memorandum of understanding to agree to share their knowledge and expertise.

UKH$_2$Mobility will deliver its evaluation of the potential of hydrogen as a transport fuel by the end of 2012. If the results are positive, an action plan will be developed to work through the steps needed to get the UK ready to be one of the first markets for the global commercial rollout of hydrogen fuel cell vehicles.

'The UK has a number of world-class companies that are developing exciting technologies in both the hydrogen energy and automotive value chains, and it is therefore vitally important that we identify what is required to make these cars a realistic proposition for UK consumers,' says Mark Prisk. 'UKH$_2$Mobility will bring together industry expertise to establish the UK as a serious global player in the manufacture and use of hydrogen fuel cell electric vehicles and the supporting infrastructure.'

Air Liquide Hydrogen Energy: www.airliquide-hydrogen-energy.com

Air Products, Hydrogen Energy: http://ow.ly/8EcYF

Daimler: http://ow.ly/8EcZK

Hyundai Motor Co: http://worldwide.hyundai.com

Intelligent Energy: www.intelligent-energy.com

ITM Power: www.itm-power.com

Johnson Matthey Fuel Cells: www.jmfuelcells.com

Nissan Motor Manufacturing (UK) Ltd: www.nissan.co.uk

Scottish and Southern Energy: www.sse.co.uk

Tata Motors, European Technical Centre: http://ow.ly/8Ed1V

The BOC Group: http://ow.ly/8Ed3Q

Toyota Motor Corporation: http://ow.ly/8Ed5d

Vauxhall Motors: www.vauxhall.co.uk

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The future of fuel: The future of hydrogen

By Dr Simon Bourne – Chief Technology Officer, ITM Power Plc, UK

ITM Power has developed a flexible hydrogen generation and refuelling platform which offers a sustainable supply of hydrogen for transport vehicles. Together with the company's Hydrogen On Site Trials (HOST) programme, ITM Power is showing the way to a cleaner and more independent future.

Hydrogen carries a well deserved reputation for being *the* clean fuel, and offering a route away from the continuous polluting cycle associated with mainstream fuels such as petrol and diesel. There is, however, a challenge for both commercial and private users of fuel to gain an understanding of hydrogen, the readiness of the associated technology, and the economics. This is a challenge that ITM Power has sought to address head on.

The HFuel system

The hydrogen refuelling platform developed by ITM Power is called HFuel®. It is modular, based around water electrolysis, and successfully integrates all of the equipment necessary to turn electricity and tap water into 350 bar (5000 psi) hydrogen and dispense it rapidly into vehicles. As an integrated package, it contains input water purification, AC/DC power conversion, hydrogen generation using PEM electrolysis, compression, storage and dispensing, together with an overarching control system and backup power provision. The systems are packaged in standard ISO shipping containers for ease of transport.

The hydrogen is generated in electrolyser stacks, which operate at 15 bar (218 psi), and is accumulated in a buffer store. An electrically driven compressor draws from the buffer store and progressively fills higher-pressure storage vessels to 250, 350 and 410 bar (3600, 5000 and 5950 psi). These pressures have been determined by analysis and optimisation of the cascade refuelling process, which uses the differential pressure to deliver hydrogen into the vehicle as quickly as possible. The use of hydrogen, unlike batteries, enables energy to be transferred into a vehicle in minutes rather than hours.

Crucially, the electrolyser technology is able to start and stop rapidly, and as such can accept an undulating input power profile – typical of renewable energy generation.

The 'triple zero' fuel

Hydrogen is well known for being clean at the point of use – when it is burned, it does not release any carbon or greenhouse gases. However, it is also important to consider the supply chain when assessing its green credentials. The vast majority of hydrogen is derived from natural gas via steam reformation, and then transported by tanker to where it is needed by sea and road.

But hydrogen generated by electrolysis is very different! In addition to being clean at the point of use, its generation is clean, as the input electricity can be sourced from a renewable resource such as wind or solar. Furthermore, there is no carbon footprint associated with the logistics of moving the hydrogen, as it can easily be generated onsite.

Engaging with the industry

ITM Power has devised and is operating a scheme called HOST (Hydrogen On Site Trials), which allows commercial companies to use hydrogen refuelling together with Ford Transit vans with internal combustion engines converted to run on hydrogen, and judge for themselves the value proposition to their businesses.

The HOST programme has 21 partners spread across seven industrial sectors – a deliberate move to gain exposure to as many different usage profiles as possible – which makes it the largest hydrogen refuelling trial in the UK. Participating companies utilise an HFuel system (capable of generating 15 kg of hydrogen per day) and two hydrogen/petrol bi-fuel Ford Transit vans, to be used as part of an existing return-to-base fleet for one week for free. At the end of each partner's trial, a comprehensive report is generated, summarising the operation of the system and highlighting key metrics which enable a commercial assessment of the system to be made. HOST was launched in March 2011 at London Stansted Airport, and 13 of the 21 trials have been successfully completed to date.

Performance in the field

The HOST trials have generated a rich data set. Key among the observations is 100% availability – no one has ever tried to refuel their vehicle and found that HFuel was not able to respond. Using data from the trial which took place with logistics operator DHL, 45 kg of hydrogen was generated over the five days, at an average efficiency of 56 kWh/kg. This translates to an average efficiency of 65%, with peaks of 69.5% for the whole system. Considering the cost of the input

ITM Power's HFuel® system for refuelling hydrogen-powered vehicles is based around a modular platform (packaged in a standard freight container), and can be expanded at any time to allow a staged rollout of hydrogen fuelling infrastructure.

Electrolyser systems such as HFuel have a significant role to play in enabling more renewable energy to be accepted by the electricity grid, since excess electricity can be converted to hydrogen at high efficiency, effectively storing energy for later use.

electricity, hydrogen achieves price parity with petrol per mile when electricity can be sourced for 6.5p/kWh – a tariff which is easily accessible to the commercial user.

This brief analysis includes the use of hydrogen in an internal combustion engine – the stepping stone to fuel cell vehicles.

Roughly speaking, 1 kg of hydrogen contains the same energy content as a gallon (US) of petrol. Therefore an internal combustion engine vehicle which achieves 35 miles per gallon (8 liters per 100 km) of petrol would be expected to complete 35 miles per kg of hydrogen. However, a fuel cell vehicle would achieve close to double that range for the same quantity of hydrogen, owing to the more efficient electrochemical conversion process. The Honda FCX Clarity car, for example, claims over 61 miles per kg of hydrogen.

The rollout of hydrogen infrastructure

There is no question that Germany is leading the way in Europe. The German H_2 Mobility programme will see the investment of €2.6 billion (US$3.4 billion) towards the deployment of hydrogen refuelling infrastructure across the country. A key date in this scheme is 2015; a date shared by most automotive OEM manufacturers, and coinciding with production quantities of hydrogen powered fuel cell cars hitting the streets. The Clean Energy Partnership – the organisation with the responsibility for installing the hydrogen refuelling stations – is seeking 'green hydrogen' to be dispensed by 50% of the infrastructure put down in Germany. Hydrogen derived by electrolysis is *the* way to satisfy this.

The UK government is following this lead. On 18 January Business Minister Mark Prisk officially announced the launch of UKH_2Mobility. This programme brings together three government departments and 13 industrial participants from the utility, gas, infrastructure, and global car manufacturing sectors.

The group will evaluate the potential for hydrogen as a fuel for Ultra Low Carbon Vehicles in the UK before developing an action plan for an anticipated rollout to consumers in 2014–2015.

This is an important commitment, signalling that the UK recognises hydrogen as the future of fuel, and intends to ensure that the UK is well positioned for the rollout of hydrogen fuel cell vehicles.

ITM Power is one of the 13 industry signatories of the memorandum of understanding that establishes UKH_2Mobility.

An integrated solution

A hydrogen system incorporates multiple components and subsystems. Crucial to their effective and efficient operation is careful integration. Taking on this job and achieving product compliance is not for the faint hearted!

As traction for hydrogen fuel builds, there is a need to offer flexibility in order to tailor the infrastructure to specific applications and usage profiles. This is something that ITM Power has taken to heart. The HFuel platform is fully modular, offering the user the flexibility to specify generation capacity and storage capacity separately. A wide range of schemes have been analysed, ranging from 5 kg/day to 100 kg/day of hydrogen generation, and up to 260 kg (circa 8.8 MWh) of energy storage capacity.

The renewable integration challenge

There has always been a mismatch between supply and demand of energy. Previously,

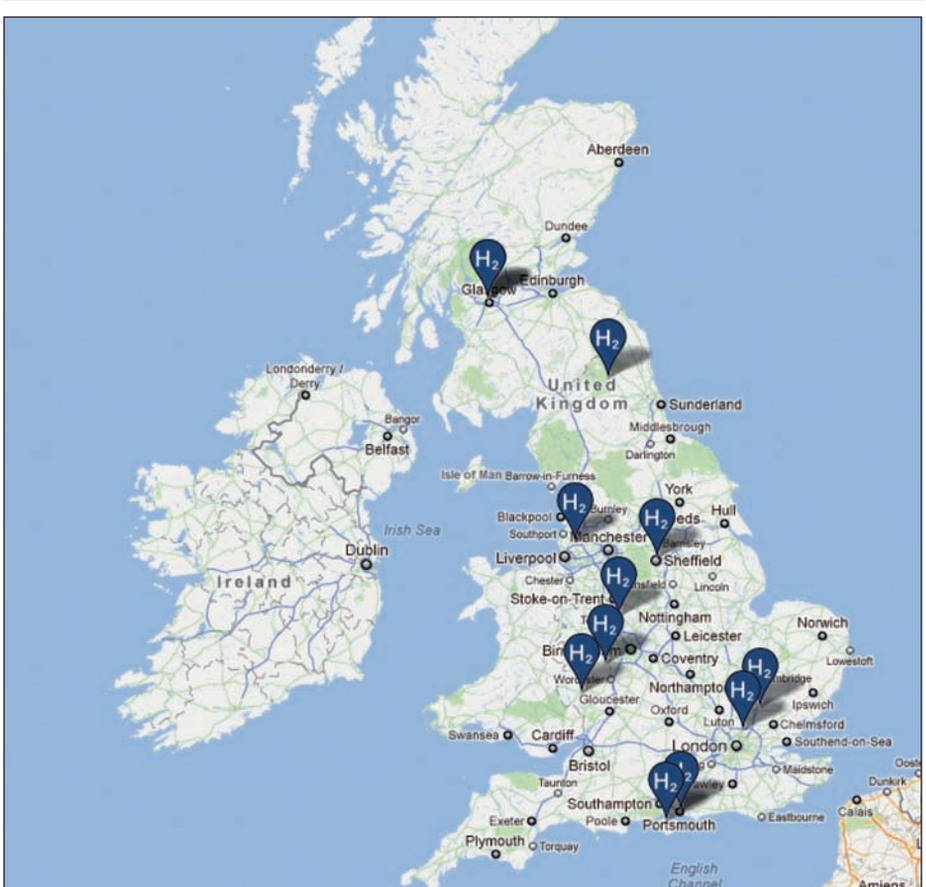
The optimised cascade refuelling process inside the HFuel system uses the differential pressure to deliver hydrogen into the vehicle as quickly as possible.

we have possessed the ability to modify the supply by turning different type of generation plant on and off. As we integrate more and more intermittent renewable energy into the energy mix, the generation becomes increasingly governed by the strength of the wind and sun. This means that the mismatch between supply and demand needs to be brokered on the demand side.

Even at today's low level (<10% capacity) of renewable energy generation in the UK, we frequently experience curtailment events. In

ITM Power's HOST programme comprises the operation of two hydrogen internal combustion engine Ford Transit vans, with hydrogen supplied by an HFuel high-pressure refuelling unit.

The HOST programme has 21 partners spread across seven industrial sectors, in order to gain exposure to as many different usage profiles as possible.



The HOST programme is the largest hydrogen refuelling trial in the UK, from the Isle of Wight on the south coast to several Scottish partners.

these scenarios, there is reluctance for the grid operators to accept wind power at times of low electricity demand. This usually results in a penalty – essentially a payment to the wind farm operator not to generate. This equates to negative electricity prices, and under-utilisation of renewable generation assets.

Electrolysis has a significant role to play in enabling more renewable energy to be accepted by the electricity grid. At times of excess supply, the electricity can be converted to hydrogen at a high efficiency. The hydrogen can be exported from the energy sector to the transport sector, seeding an infrastructure of clean fuel. At times of high electricity demand, the electrolysis systems can be turned off. This control can be exercised by the grid operators or utility companies remotely.

Without a step change in energy storage availability – such as that offered by demand side managed electrolysis – there is little chance of reaching the ambitious renewable targets for the UK and Scotland.

All of ITM Power's electrolyser systems are capable of following an intermittent input power profile.

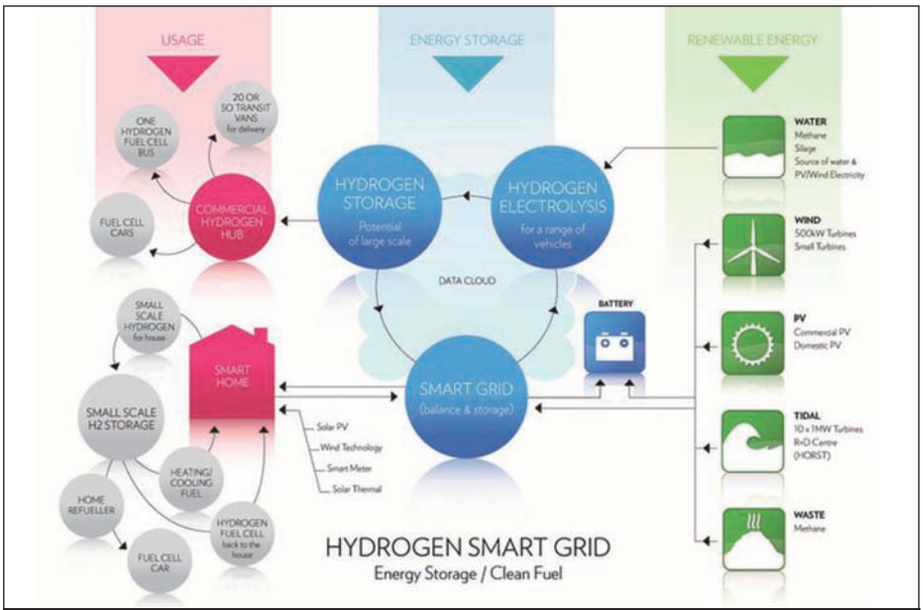
EcoIsland

EcoIsland is a project bringing together within a single island energy system a critical mass of smart energy technologies, to demonstrate how a future energy system can be configured – a prototype for a larger system for the mainland. With renewable generation including wind, solar, tidal and geothermal, the Isle of Wight will need to match supply and demand using battery energy storage, hydrogen energy storage, and demand side management. These technologies will be coordinated centrally by smart grid technologies supplied by IBM, Cable&Wireless Worldwide, Scottish & Southern Energy (SSE), and Toshiba.

ITM Power is the hydrogen fuel partner for the EcoIsland initiative, and will supply hydrogen refuelling equipment controlled by smart grid technology to optimise both renewable energy storage and the provision of fuel to both fuel cell vehicles and hydrogen internal combustion engine (HICE) commercial vehicles. The intention is that the Isle of Wight will also be a showcase for advanced, low-emission hydrogen vehicles being launched from 2013.

The economic case

While there can be no argument over the environmental benefits of 'green hydrogen', nor the independence of a locally produced fuel, the economics are of equal importance.

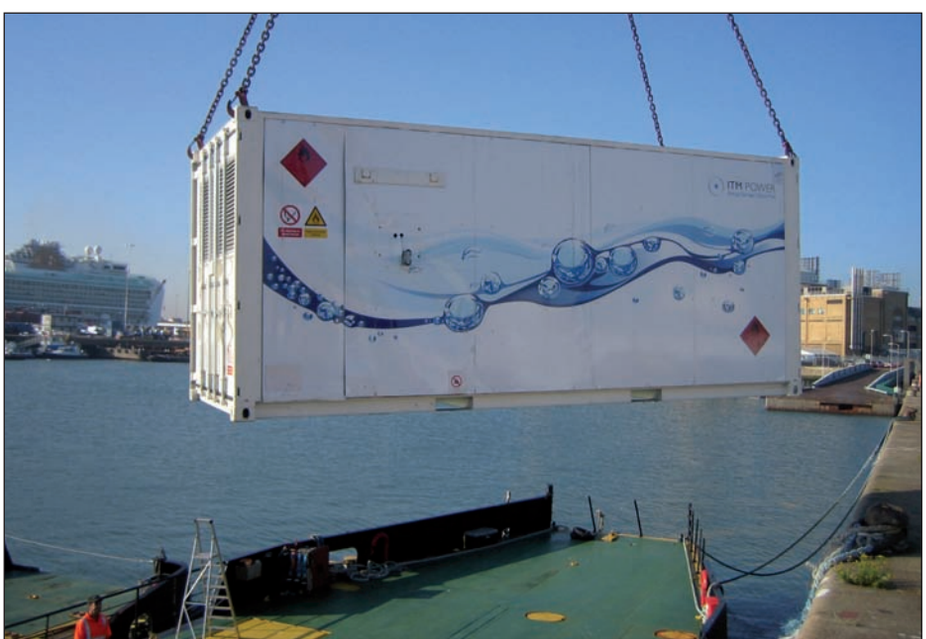


The EcoIsland project aims to bring together within a single island energy system – i.e. the Isle of Wight – a critical mass of smart energy technologies.

Hydrogen cost (£/kg)						
	4p/kWh		6p/kWh		8p/kWh	
Electricity	2.40		3.60		4.80	
Capital grant	0%	50%	0%	50%	0%	50%
5 years	8.31	5.35	9.51	6.55	10.71	7.75
10 years	5.35	3.88	6.55	5.08	7.75	6.28
20 years	3.88	3.14	5.08	4.34	6.28	5.54

Table 1. Using an HFuel system, hydrogen costs can already beat future European targets.

Hydrogen costs are best expressed in £kg, and reflect both capital cost amortisation and electricity cost (see **Table 1**). Based on a 100 kg/day HFuel system, hydrogen cost ranges from £3.88/kg (based on 4p/kWh and a 20-year capital expenditure amortisation) to £10.71/kg (based on 8p/kWh and a 5-year amortisation). This compares to €9.90/kg (£8.49/kg), which is the European target (according to a McKinsey/NEW-IG report[1]) for 2015, and coinciding with the planned major rollout of fuel cell vehicles across Europe.



ITM Power is the hydrogen fuel partner for the Isle of Wight's EcoIsland initiative. Its HFuel will serve both renewable energy storage and hydrogen refuelling of fuel cell and HICE vehicles.

Owing to the ability of HFuel to turn on and off rapidly and to be demand side managed as a smart load, electricity prices of 4p/kWh – and potentially as low as 0p/kWh, or even negative – can be accessed in some parts of Europe utilising a high percentage of intermittent renewable power.

A 100 kg/day HFuel generation system with a 5-year amortisation and 4p/kWh electricity price produces hydrogen at a cost of £8.31/kg, which is lower than the European target for 2015. After the 5-year amortisation period, the hydrogen cost from the same system is £2.40/kg, which is lower than the European target for 2025.

This analysis assumes 100% uptime. The hydrogen storage unit – which is usually tailored to user-specific requirements – is excluded, to permit comparison with other forms of hydrogen delivery. The maintenance scheme is developed to match the installation site and usage profile.

As Graham Cooley, CEO of ITM Power, comments: 'What could be more compelling than an economic fuel made from renewable power that has zero emissions?'

About ITM Power

ITM Power designs and manufactures hydrogen energy systems for energy storage and clean fuel production. The company has grown from its original platform of novel polymeric electrolytes (for water electrolysis and hydrogen fuel cells) to that of a technology provider. It now has both a strong base of intellectual property and engineering expertise for providing complete hydrogen solutions and CE-marked products for sale. ITM Power is traded on the London Stock Exchange AIM market.

Reference

1. *A portfolio of power-trains for Europe: a fact-based analysis. The role of Battery Electric Vehicles, Plug-in Hybrids and Fuel Cell Electric Vehicles.* NEW-IG Secretariat, Brussels, Belgium, November 2010. Available online at: www.zeroemissionvehicles.eu [*and summarised in a feature in FCB, January 2011*].

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