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FUEL CELL POWER

The transition from combustion to clean electrochemical energy conversion

HEADLINE NEWS

Hydrogen is increasingly being utilised to store Intermittent energy from renewable sources and to make it available when required. Riversimple's Rasa car is seen here being refuelled.

Riversimple uses locally produced hydrogen to power their Rasa car. They are starting with hydrogen stations which are convenient for users, near to people's homes, work or at supermarkets .

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RIVERSIMPLE BUILDING LOCAL HYDROGEN FUELLING STATIONS

There are currently seventeen active hydrogen refuelling stations in the UK with a further five in the immediate pipeline. Behind these projects are a mixture of universities, manufacturers and fuel providers. Most new projects are being built along motorways and trunk roads with the aim of linking towns and cities together,

These refuelling stations are supporting intercity driving and, by default, longer journeys. As if to prove the point, Toyota drove one of its Mirais the length of the country refuelling at four different locations. There is undoubtedly a need for these types of journeys, but with the average car journey lasting only 22 minutes (Dept for Transport 2017) the majority of journeys are not catered for in this model. While any additional hydrogen refuelling station is whole-heartedly welcomed, Riversimple believe that the key to eliminating the environmental impact of personal transport is closer to home, providing for the 94% of all journeys that are under 25 miles.

One of the benefits of a hydrogen electric vehicle such as the Rasa is that it can be refuelled in the same way as a conventional petrol or diesel car, with a simple pump on a forecourt. Hydrogen refuelling stations can be located in familiar locations such as supermarket car parks and local service stations.

A hydrogen refuelling station on the other hand, can be placed on an existing forecourt and, like a petrol station, support thousands of cars. Per car served they are considerably cheaper, which in turn makes the hydrogen infrastructure more economical. With a 300 mile range you only need a reason to come into town once a week or so.

We have installed the 17th hydrogen refuelling station in the UK in the centre of Abergavenny in Wales.

This model of smaller units based in local communities offers a solution to the problem of whether fuel cell cars or hydrogen refuelling stations are introduced first. The motorway pumps will hardly ever see a car (there are currently only 93 hydrogen cars on the roads in the UK), whereas the Riversimple pump will have a captive fleet of 20 vehicles all refuelling approximately once a week. Let's see these new filling stations being supported by the Government and build up a nationwide network of vehicles and filling stations hand in hand.

At the moment the hydrogen for our cars is reformed from natural gas produced as a by-product for a large number of industrial processes. It is more efficient to generate hydrogen than electricity from natural gas 70% rather than 49% according to Government statistics (Dukes 2018). We are also making the most of any hydrogen we use: you can go 200 miles on a kilo of hydrogen in a Rasa, as opposed to 66 miles in a Toyota Mirai. We are looking forward to plentiful green sources of hydrogen, including electrolysis from green electricity, photo catalysis, as well as waste from methane-eating bacteria.

RASA HYDROGEN FUEL CELL CAR

Air pollution concerns have brought the need for clean cars to the fore. Now that combustion-engine vehicles have a 'Sell By' date of 2040, there is much greater focus on practical and viable alternatives and the question of scale is surfacing. What are the 34 million cars in the UK alone going to be replaced with? Riversimple's Rasa is the car furthest on the road towards sustainability. It has the lowest CO_2 well-to-wheel and the lowest particulates and NO_x from tyres and the electrical braking. There are no harmful emissions from the exhaust – just pure water. It is the longest lasting car, with maximum recovery of value at the end of life. At the equivalent of 250mpg, it is probably the most fuel–efficient vehicle yet designed for everyday road-going use.

Riversimple engineers are now fine-tuning the software and modifying some of the hardware for the new Beta cars. The new carbon fibre chassis includes front and rear subframes and is 20 kgs lighter. It's the synthesis of all these technologies that delivers the groundbreaking efficiency and range, many times better than inserting fuel cells into conventional, heavy, vehicles.

Riversimple remain the only car-maker to adopt a circular economy, and are sticking firmly to their fundamental aim of making the car accessible to the general motoring public. Whilst battery electric cars will have a part to play, large-scale adoption is likely to be stymied because around 50% of UK customers do not have easy access to overnight charging. Each publicly accessible battery charger only supports a handful of cars.

There is growing interest around the world in the local hydrogen economy and fuel cell powered road vehicles. The Rasa was displayed at a meeting in Swindon, UK, of the 'Hydrogen Hub', which has over 30 organisations working to deploy hydrogen and fuel cell technology. The Rasa was also displayed in Brussels at the annual meeting of the Fuel Cells and Hydrogen Joint Undertaking (FCHJU). Riversimple is focused on applying great engineering and design to the deployment of hydrogen fuel cell vehicles. This is indisputably good news for the environment and it also makes sound business sense.

RIVERSIMPLE ACCELERATES IN DUBAI

The Dubai Future Foundation, headed by Dubai's Crown Prince, invited Riversimple to take part in the 4th Dubai Future Accelerators (DFA) programme. Riversimple were sponsored by a powerful government department, the Road and Transport Authority. The DFA is designed to enable businesses to develop technologies and proposals quickly.

Riversimple delegates met with around 80 different interested parties, exploring opportunities with R&D establishments, data specialists, niche vehicle builders, financiers, transport companies, energy suppliers and distributors, and a host of national and federal government officials. Delegates from the Welsh Government were also there to support the Company. The result is an agreement with the Road and Transport Authority to progress the Riversimple agenda and ultimately it is hoped to build a dedicated Dubai -friendly prototype.
www.riversimple.com

Claire Perry of Cardiff University is seen here in a Rasa marking the first 'Green GB Week'. This is led by the UK Government, with the aim of engaging the British public in the importance of tackling climate change and ensuring clean growth.

WORLD'S FIRST ENERGY SELF SUFFICIENT HOUSING COMPLEX

The world's first energy self-sufficient housing complex is located in Vårgårda, Sweden where a block of 30 flats now runs entirely on solar energy and stored hydrogen in a Danish-Swedish partnership between Better Energy and Nilsson Energy.

This solar-hydrogen project is a breakthrough in clean energy and sustainable building. When the complex is completed and fully operational, a total of 172 flats in six housing blocks will be capable of operating completely free from external energy sources. Residents will be 100% independent and disconnected from electrical power grids, outside heating sources and fluctuating electricity prices. The rooftop solar PV panels alone will produce enough energy to meet their power needs year-round.

The challenge of renewable energy is that energy production and consumer demand do not always match. A long-term storage solution is needed to provide electricity and heat when the sun shines less.

Hydrogen gas has the largest energy content of any fuel, which means that a small amount of hydrogen can store a large amount of energy. Hydrogen is also chemically stable and can store energy for long periods of time. In a solar-hydrogen system, energy from the sun can be harnessed and stored for later use, producing only oxygen and pure water as waste products.

Nicolai Faaborg Andresen of Better Energy said: "Our solution involves the limitless energy of the sun and the simplest, lightest, most abundant element on Earth, hydrogen. These resources and technologies are right in front of us and we are combining them in a new, clean and extremely efficient manner."

Solar panels on the Vårgårda housing block soak up sunlight and convert it into electrical energy ready for immediate use. Surplus energy passes through an inverter and is collected in a battery that is used to power an electrolyser.

The electrolyser produces hydrogen gas by splitting water molecules into the base elements of hydrogen and oxygen. The hydrogen is compressed to 300 bar and stored in a pressure tank. When energy is needed, the hydrogen can be converted cleanly and efficiently back into electricity by way of a hydrogen fuel cell. The only emissions from the system are oxygen and pure water.

This solar-hydrogen solution offers many advantages not only for urban smart cities and housing but also for remote communities and locations. Summer's overproduction is stored as hydrogen for use in the winter months - year-round, 24-hour access to the power of the sun. Benefits of solar-hydrogen solutions include:

- Zero carbon energy, zero unwanted emissions or by products
- Long-term storage and flexible response to demand
- High reliability of power, even under variable and extreme weather conditions
- Reliable power generation for remote locations, critical healthcare institutions and industries
- Low maintenance and operating costs
- Quiet operation, low noise pollution

The system is based upon the development work of Hans-Olof Nilsson, who obtains all his electricity and heat from solar PV and solar thermal panels.

RENEWABLE ENERGY FOR TRANSPORT ALL YEAR ROUND

A hydrogen highway is being built across Europe, with one of the forerunners being the municipality of Mariestad in Sweden. In order to meet the demand for emission-free energy all year round, Nilsson Energy has built the RE8760 (Renewable Energy for all 8760 hours of the year) which is to be powered by solar energy. The RE8760 system will enable Mariestad to supply locally produced hydrogen for the European highway E20. In addition to the RE8760 system, Nilsson Energy is commissioned to build the solar park that will feed the system with fossil-free energy. This will be the first solar powered hydrogen refuelling station in the World.

The first container-based RE8760 has been delivered to the hydrogen filling station in Mariestad. This will be powered by the solar park adjacent to it and hydrogen for transportation will be produced by electrolysis from water.

Latest information will be given at Energy Storage Innovations Europe
On 10th—11th Apr 2019 at Estrel Convention Center, Berlin, Germany hosted by IDTechEx.
www.offgridenergyindependence.com www.betterenergy.com
www.nilssonenergy.com

FUELCELL ENERGY CUTTING EMISSIONS

EFFICIENT SEQUESTRATION OF CARBON DIOXIDE

FuelCell Energy applauds the extension of the US carbon sequestration credit which will give a credit of up to $50 per ton for CO2 that is sequestered and up to $35 a ton for CO2 that is re-utilized. Businesses would have 12 years to take advantage of the credits and no limit would exist on the amount of CO2 that can be sequestered or re-used. The original bill, passed in 2009, was enacted at $10 per metric ton and capped at 75 million metric tons. The new legislation also extends the tax credit to industrial utilization of captured CO2, which should significantly accelerate adoption of carbon capture. Finance incentives, such as this carbon tax credit, are instrumental in establishing a value for captured carbon and will encourage additional investment in carbon capture technology by the energy producers in the United States.

Concentrating carbon dioxide is a normal side reaction for FuelCell Energy's electrochemical generation process. Power plant exhaust is directed to the fuel cell, replacing air that is normally used in combination with natural gas during the fuel cell power generation process. As the fuel cell generates power, the carbon dioxide becomes more concentrated, allowing it to be more easily and affordably captured and stored. Utilizing fuel cells, 90% of the CO2 emissions can be captured, as well as destroying 70% of nitrogen oxides from a plant's emission stream.

Carbonate fuel cells have the ability to concentrate carbon dioxide in dilute flue gas streams while making power, making this approach to carbon capture more economical than existing scrubber conventional capture technology. The potential breakthrough comes from an increase in electrical output using the fuel cells, which generate power, compared to a nearly equivalent decrease in electricity using conventional technology. FuelCell Energy is developing the technology for capture of CO2 from coal based power generation, in a development and demonstration project supported by the US Department of Energy. The company is also pursuing the use of carbonate fuels cells for carbon capture from natural gas power systems and in parallel is progressing a pilot plant for capture from natural gas fuelled systems in a joint development program with ExxonMobil.

More support is also planned for renewable energy. The Connecticut Department of Energy and Environmental Protection (DEEP) is currently evaluating proposals submitted in conjunction with a bi-partisan bill to expand Connecticut's renewable portfolio standard target to 40% by 2030. Fuel cells, a Class I clean energy generator in Connecticut, use chemistry to convert a fuel source into electricity and heat in a highly efficient process that emits virtually no pollutants, as the fuel is not burned. The combination of near-zero pollutants, modest land-use needs, and quiet operating nature of these stationary fuel cell power plants facilitates installation in urban locations where the power is used. With higher electrical efficiency, SureSource™ power plants drive better economics and environmental stewardship, supporting both social responsibility goals and public policy objectives.

INTEGRATING EFFICIENT INNOVATIVE TECHNOLOGIES

Fuel Cell Energy has been awarded $3.1 million by the U.S. Department of Energy (DoE) for its proposal to advance the commercialization of ultra-high efficiency Solid Oxide Fuel Cell (SOFC) systems. This is part of the Innovative Natural-gas Technologies for Efficiency Gain in Reliable and Affordable Thermochemical Electricity Generation (INTEGRATE) program.

The INTEGRATE program has the objective of developing natural gas fuelled distributed generation systems with ultra-high efficiency (>70%). The project will further develop FuelCell Energy's advanced solid oxide cell technology, specifically focused on advanced stack designs capable of operating at elevated pressure. High pressure operation allows the configuration of very high efficiency power generation systems, and also enhances the efficiency of solid oxide based electrolysis and energy storage systems. The performance enhancements enabled by the project will allow higher efficiency utilization of domestic fuels, as well as high efficiency electrolysis and energy storage for integration of intermittent renewable power sources in the grid.

NRG YIELD BUYING WASTE WATER FACILITY

FuelCell Energy has agreed to sell the company that owns the 2.8 megawatt fuel cell power plant project located at the Tulare Waste Water Treatment Facility in California to NRG Yield, Inc. This project has been developed and constructed by FuelCell Energy and will be placed into commercial operations following the sale.

The project company, under the new ownership of NRG Yield, will deliver the clean power and heat to the City of Tulare under a multi-year power purchase agreement. FuelCell Energy will operate and maintain the power plant under a twenty-year service agreement with the project company.
"NRG Yield is continuously looking to grow its portfolio of power generation assets that provide customers with cleaner, sustainable, and more resilient ways to meet their energy needs," said Christopher Sotos, President and Chief Executive Officer of NRG Yield. "The Tulare Waste Water Treatment Facility is just such an opportunity, providing an excellent clean energy and heat solution for our customers."

The Company received ISO certification for its Environmental Management System, reinforcing FuelCell Energy's core values of continual improvement and commitment to environmental stewardship. Tony Rauseo, Chief Operating Officer, said "This certification exemplifies our commitment to environmental performance in a socially responsible manner. This is engrained in our corporate culture and business management, as well as in the design, manufacturing, installation and servicing of our SureSource™ fuel cell power plants."

FuelCell Energy's operation is so clean and quiet that systems are installed adjacent to or inside buildings. They provide both electricity and heat with minimal harmful emissions. This fuel cell is situated at Hartford Hospital, USA.

ADVANCES WITH SOLID OXIDE FUEL CELLS (SOFC)

CERES WORKING WITH WEICHAI POWER

Ceres Power has announced a strategic collaboration with China's Weichai Power, one of the leading automobile and equipment manufacturing companies whose business covers complete vehicles, powertrains, intelligent logistics, parts and components. This long term strategic relationship provides Ceres Power with access to the Chinese market, the world's fastest growing market for fuel cells. Initial plans are for Ceres Power and Weichai to jointly develop and launch an SOFC fuel cell range extender system for China's fast growing electric powered bus market. Weichai has a wide network of customers in China with sales volumes of circa 30,000 buses per year.

The agreement potentially provides significant staged revenues to Ceres Power through engineering services and technology transfer, licence and royalty payments and a longer term share in the profits from a proposed manufacturing Joint Venture. The agreement includes a potential initial £17million equity investment by Weichai in Ceres Power and a potential further equity investment of £23million, both subject to approval by provincial governmental authorities of the People's Republic of China and by Ceres' shareholders. Weichai is a Chinese state-owned enterprise listed on the Main Board of both the Hong Kong Stock Exchange and Shenzhen Stock Exchange with a market cap of over USD$10 billion.

Phil Caldwell, CEO of Ceres Power, said "We are delighted to be working with Weichai in a partnership that provides access to the Chinese market for our SteelCell® technology and also scale-up capital for growth in the UK. Weichai has a successful track record of partnerships with international companies and shares our ambitious growth plans. Working with Weichai provides demand for a variety of applications, driving significant volume and cost reductions for the SteelCell® and helping to establish the technology as an industry standard."

Tan Xuguang, Chairman and CEO of Weichai said "China has set very ambitious targets to significantly reduce air pollution and our bus transportation system is key to this. We believe there is considerable scope to develop a compelling range of new power system products for the Chinese market and in Ceres Power, we are confident that we have found the right partner in the field of solid oxide fuel cells, with globally leading technology to bring our vision to fruition. The SteelCell® is highly robust, responsive, efficient and fuel flexible and why we feel so excited about our collaboration. We look forward to progressing our partnership towards commercial launch and to working closely with Ceres Power as a strategic investor".

The parties will work together to develop a 30kW SteelCell® SOFC fuel cell range extender system for demonstration in an Electric City Bus application for the Chinese market in early 2019, utilizing Compressed Natural Gas ("CNG") fuel which is widely available in China. The low-emission public transport market in China represents a major commercial opportunity. This is being driven by the Chinese Government, who are stimulating this sector through subsidies and Zero-Emission Zones, designed to reduce air pollution, carbon emissions, and road noise, while increasing public health and reducing operating costs. In addition to increasing the operational range of electric buses, the Ceres Power range extender has the advantage of being able to run on widely available fuels such as CNG and does not rely on the roll out of hydrogen infrastructure. This is a significant market opportunity for Weichai.

CERES PARTNERSHIP WITH NISSAN

Ceres Power has entered into a new partnership with Nissan to further develop fuel cell technology for EV applications. Ceres Power and The Welding Institute ("TWI") have been awarded a total of £8m UK government funding through the Advanced Propulsion Centre for this project. The new partnership builds on the successful joint development with Nissan over the past 2 years and sees Ceres Power accelerating commercialisation of its SteelCell® fuel cell technology in automotive markets. After a successful two-year Innovate UK funded development programme (EVRE - Electric Vehicle Range Extender), this project is the next step towards increased technology and manufacturing readiness for mass production of Ceres Power's SteelCell® for automotive applications.

This project will involve the design, build, test and demonstration of a compact, robust, UK-produced SOFC stack, deployed within a Nissan designed fuel cell module suitable for operation with a variety of high efficiency fuel types, including biofuels. The UK Government's 'Road to Zero' strategy, which requires a significant reduction in CO2 emissions, is accelerating the shift to battery electric vehicles. Introducing fuel cell technology alongside batteries further enables increased drive range and has a significant role to play in the acceleration of the uptake of battery EVs.

This latest announcement demonstrates Ceres Power's ability to bring its technology toward commercialisation through existing partnerships. The SteelCell® continues to attract world-class OEMs that are looking to develop an alternative to combustion engine technologies. Ceres Power has six strategic partners, including Cummins, Honda & Nissan, two as yet unnamed partners and a recently confirmed strategic investment partner in Weichai Power, which is primarily for range extension technology in China's fast-growing battery-electric bus market.
www.cerespower.com

BLOOM ENERGY SERVER CHOSEN BY KOREA SOUTH EAST POWER

Bloom Energy recently announced the selection by Korea South-East Power Corporation ("KOEN") of its 8.35MkW Bloom Energy Server, an innovative and clean electricity generation system. This was in an open bid for the Bundang combined thermal power plant, in which Bloom Energy Japan jointly participated with SK Engineering & Construction.

The Bloom Energy Server is a breakthrough solid oxide fuel cell technology that generates clean electricity at over 60% efficiency during initial performance. Bloom Energy Servers have been installed in many locations that require an uninterrupted power supply such as data centers, manufacturing operations, communications, and facilities with high energy loads, including refrigeration and critical services in the United States.

In South Korea, all power companies with more than 500MW generation capacity are required to produce a certain percentage of electricity from renewable and new energy sources, including fuel cells, under the Renewable Portfolio Standard (RPS) system. KOEN is installing Bloom Energy Servers to meet their RPS target.

The Bundang Power Plant project will be the first installation of an industrial and commercial solid oxide fuel cell in South Korea. The system will be utilizing natural gas from the existing infrastructure. All the electricity will be sold to households and enterprises by KOEN.

www.bloomenergy.com

HYDROGEN AND FUEL CELLS GEARING UP FOR COMMERCIALISATION

The 14th UK International Conference on Hydrogen and Fuel Cells in Birmingham in March 2018 illustrated the technical advances which are enabling cost effective fuel cells to be integrated into the power, heat and transport sectors.

EXPANSION OF FUEL CELLS IN CHINA

Dr Zhiziang Liu of the Foshan Institute for Hydrogen Energy outlined progress with hydrogen fuel cell vehicles and their refuelling infrastructure in China. Electric vehicles have flourished under the stimulation of government subsidy. Fuel cell cars get ¥200,000 (US $30,000), while buses and heavy duty trucks get ¥500,000, (US $75,000). The large cities are seeking alternative transport and several manufacturers are providing fuel cell vehicles.

SAIC Motor has been developing fuel cell trucks since 2008 with fuel cells provided by Sunrise Power. The SAIC Maxi was launched in 2017 with a 45 kW fuel cell and 14.5 kWh battery. Fuelling time is 5 minutes, giving range of 500 kms. The cost is ¥1,300,000 (US$195,000)

A hundred hydrogen fuelling stations generating 200 megawatts (MW) for 10,000 fuel cell vehicles will be in situ by 2020, building up to a thousand stations generating 100 gigawatts (GW) for 2 million vehicles by 2030. The demonstration of fuel cell trams and ships is also planned for 2020.

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Feichi is delivering 300 fuel cell buses this year to Foshan and Yunfu City. The 30 kW fuel cells are produced by Synergy-Ballard JV. Yane Laperche-Riteau said that in 2017 Ballard shipped over 600 heavy duty fuel cell modules to China. They have now started a joint venture with Guangdong Synergy in Yunfu. This is starting with 6,000 stacks per year, sufficient for 2,000 to 3,000 fuel cell vehicles. The increase in volume production is enabling costs to be reduced.

ROLE OF HYDROGEN IN THE ENERGY TRANSITION

Jorgo Chatzimarkakis, Secretary General of Hydrogen Europe, said that they represent the European fuel cell and hydrogen sector, working with the European Commission and the Hydrogen Council. He outlined the seven roles for hydrogen in the transition to zero emission energy: hydrogen enables seasonal storage of renewable energy; enables distribution of energy across sectors and regions; increases system resilience; decarbonises transportation; decarbonises industry energy use; helps decarbonise building heat and power; and serves as a feedstock using captured carbon.

Luke Tan of Johnson Matthey showed how they are making developments to meet the growing requirements of the different market sectors for hydrogen and fuel cells. Stationary applications include industrial, commercial, residential and back-up power. The transportation sector covers materials handling, heavy duty vehicles and extending the range of electric vehicles and is aiming for a million automotive vehicles by 2025.

Jon Hunt, Manager of Alternative Fuels at Toyota, said that they are building a megawatt scale 100% renewable power and hydrogen generation plant at Long Beach, California. This will generate 2.5MW electricity and 1.2 tonnes hydrogen per day, enough to power 2,350 average homes and 1,500 vehicles. He said that Japan H2 Mobility was set up earlier this year to progress the strategic deployment of hydrogen stations and improve facilities for fuel cell vehicle users.

TRANSPORT - COMMERCIAL AND PUBLIC

Andrew MacKenzie of Commercial Group showed how they have reduced their carbon dioxide emissions from transport by 80% since 2006. They are the UK's largest private fleet operator of hydrogen vehicles. ITM Power provides the hydrogen from onsite wind or solar energy, as well as from offsite sources of renewable electricity transferred by Good Energy.

David Yorke of Tower Transit explained that their fuel cell buses have been in regular service in London for many years. As well as the Wright Bus, they operate fuel cell buses from Van Hool. They are planning to scale up operations with fuel cell buses to be a world leading operator in this field.

Ben Todd of Arcola Energy said that they are developing the whole power train for a 3.5 tonne van with a 200 mile range and 1000 kg payload. They are optimising the drive train, the fuel cell, battery and traction motor, as well as the hydrogen storage. Arcola is also working with Alexander Dennis on the detailed design of a double-decker bus.

TOYOTA MIRAI - A DRIVER'S OPINION

Jonny Goldstone Managing Director of Green Tomato Cars said that they were the first eco-friendly cab service. They have been driving the fuel cell Mirai from Toyota since 2015 and are now preparing for a widespread launch.

A driver said "The Mirai still feels like new and is a joy to drive, being easy to manoeuvre and providing smooth and reliable performance whatever the weather or road conditions. It's also been very quick to refuel, taking less than four minutes, and I typically get 300 miles from a full tank."

FUEL CELL OR BATTERY VEHICLES?

Dr David Wenger of Wenger Engineering GmbH said that the greatest challenges facing mankind are the efficient and effective use of fossil fuels and resources. His company is developing the technologies to solve these problems, including thermodynamics, chemical engineering and computational fluid dynamics. These enable their customers to save energy, reduce vehicle weight and volume and at the end of the day, also save significant amounts of money. Based upon their 15 years of experience, Wenger compared battery electric vehicles with fuel cell vehicles. He is impressed by Tesla's electric car but believes there is also a role for hydrogen fuel cell vehicles.

Jeremy Bowman, Engineering Director of Hypermotive Limited, compared the energy and cost of batteries and fuel cells for transport applications. A very large battery is needed to provide higher levels of power. It is recommended that batteries are utilised to meet power requirements up to 30kWh and fuel cells are utilised to power larger vehicles. Fuel cell cost must be reduced with a cheaper catalyst and increased volume production. Carbon alloys are being developed to replace expensive platinum catalysts and manufacturers are now supplying a range of automotive hydrogen compatible components.

LATEST PERSPECTIVES ON HYDROGEN MOBILITY

Ben Madden of Element Energy showed how hydrogen fuel cell vehicles are beginning to meet requirements for zero emission transport in cities. First markets for cars will be in regions where hydrogen refuelling stations are available, where emissions must be cut and where mileage is higher than that covered by a battery electric vehicle.

In Paris fuel cell taxis are allowed to work on double shifts. In Hamburg sharing fuel cell cars is underway. Some cities ensure free parking for zero emission cars and their police cars and emergency fleets are subject to emissions rules.

There is also rapid prototype development of heavy duty trucks and trams, as well as the Siemens Ballard train illustrated. European cities are preparing to change over to zero emission buses. The market is for thousands of zero emission buses per year across Europe, starting in 2020. It is projected that as production increases, hydrogen powered buses could compete with other zero emission options without subsidy.

MANUFACTURING HIGH VOLUMES

Fergal Harrison-Beatty of the London-based Manufacturing Innovation Institute (HSSMI), outlined their work with fuel cells based on printed circuit boards (PCB) as range extenders for electric vehicles. PCB-based fuel cell technologies can harness existing economies of scale. The global PCB manufacturing industry is expected to reach £53.7bn this year. By encouraging the horizontal transfer of technological expertise, standardised high volume manufacturing techniques, previously out of reach of the fuel cell industries, have been unlocked. Advances in digital engineering are also exploited. The design, prototype manufacture and testing phases can be conducted over very short timescales, akin to standard PCB processes, as can the integrated power electronics specification and design.

The inherent modularity of the design means that stacks can be created of almost any size, and configurations can be changed to vary power, voltage and current delivery at late stages in the project. This avoids potential retooling costs when requirements change. The Flexiplanar FuelCell Manufacturing collaborative R&D project was undertaken by an HSSMI project managed consortium. The integration of the manufacturing processes into existing PCB manufacturing allows rapid up-scaling, reduction of life cycle cost and flexibility and cost competitiveness to serve multiple markets, such as automotive and consumer products.

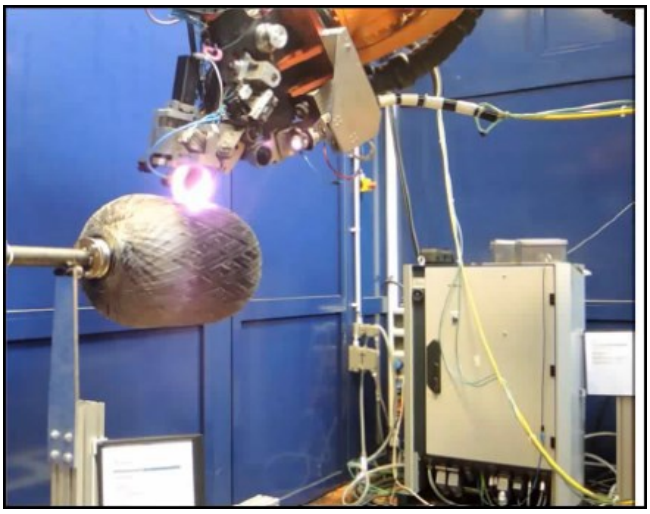
UK Clean Air Zones due in 2019 will force fleet operators, and in particular van operators who run diesel vehicles in city centres, to adopt alternative fuel power trains. The Workplace Charging Scheme is also encouraging businesses to install charge points by offering £300 per installation, across up to 20 sites. Existing fleets can be retrofitted with hydrogen fuel cell technology. The success of the Symbio FCell van under the Hydrogen Mobility Europe programme demonstrates this, achieving ranges as great as 228 miles with a full payload, compared to the quoted 100-150 mile ranges from current pure electric vans. The current PCB-based fuel cell is already demonstrating cost reductions and greater ease of manufacturing than existing PEM fuel cells. By improving these inherent advantages through further R&D, and with no foreseeable raw material supply issues, the technology is forecast to go from strength to strength.

Desi Bacheva outlined the work of UK-based HiETA Technologies which are specialists in thermal management of fuel cell systems using metal additive manufacturing. This enables joining of materials, usually by layers, to create products from 3D model data. The benefits of additive manufacturing are rapid product development, thermal efficiency, high value low volume parts and up to 40% reduction in product volume. HiETA is developing an innovative phase-change heat exchanger for an automotive fuel cell system.

HYDROGEN AND FUEL CELL SUPPLY CHAINS

Dr Nick van Dijk outlined the work of the UK-based electrochemical materials company, PV3 Technologies. They are developing and testing materials for specialist electrochemical applications including proprietary catalysts for fuel cells and electrolysers and electrochemical hydrogen compression. They are now making available novel catalysts and coatings for bi-polar plates. Continuous innovation has enabled them to obtain long-term partners. They are moving technologies from the laboratories to commercial deployment with three key technologies: increasing performance; improving long term durability; and lowering cost/increasing sales.

Dr Mark Lidgett, Engineering Manager of Haydale, said that they are making advances with composite pressure vessels. They incorporate graphene in enhanced polymers for additive manufacturing and in advanced resins for carbon fibres. They have for-mulated proprietary graph-eme-based inks and coatings. Recent innovations are rotationally moulded liners and robotic filament winding.



Haydale's head office is in the UK, with companies around the world. They have recently worked with Arcola Energy and the Commercial Group in providing a zero emission drive train for commercial vehicles.

Chris Rowland, Structural Engineer at Pancom, explained that they have an online monitor for pressure vessels, which ensures safe hydrogen refuelling. They are working with R Tech Materials, TWI and Arcola Energy in a project funded by Innovate UK.

Vincenzo Orcisi, Project Engineer at Pure Energy Centre, outlined the real benefits of artificial intelligence (AI) for hydrogen systems. Hydrogen production is facilitated when micro renewable systems are connected to an AI hydrogen electrolyser. Their novel control sys-tem also reduces the stress on fuel cell stacks caused by rapid load changes. Africa's first hydrogen wind energy system employs AI. It is used for research activities at the University of Al Akhawayn in Morocco. AI is also utilised in the production of hydrogen from solar en-ergy and biofuels.

Dr Chris Dudfield of Intelligent Energy said that they are focussed on the development and commercialisation of their PEM fuel cell for a range of markets including automotive, stationary power and Unmanned Aerial Vehicles (UAVs). Their headquarters are in the UK, with additional operations in the US, Japan, India and China. They are participants in the EU funded DIGIMAN programme which is delivering automated manufacturing maturity for fuel cell stacks and components. They are establishing an integrated European supply chain for key fuel cell components. By 2020 they will deploy next generation automated assembly processes capable of scaling up to a production of 50,000 stacks per year.

BUILDING THE HYDROGEN INFRASTRUCTURE

Bill Ireland of Logan Energy showed how the hydrogen infrastructure could be built up to match the growing volume of wind and solar energy. The Levenmouth Community energy project in Scotland has 910 kW renewable electricity generation from a 750kW wind turbine and 160 kW solar panels. This powers buildings and the two hydrogen refuelling stations. They also have an EU funded project to convert sea water to transport fuel for use in Tenerife.

Mark Neller of Arup, who is the director of the UK Government Hy4Heat programme, explained that this is a £24m project funded by the Department for Business, Energy and Industrial Strategy (BEIS). They will establish whether it is technically possible, safe and convenient to replace methane with hydrogen to power domestic, commercial and industrial appliances. This will enable the government to decide whether to go ahead with using hydrogen for heating residential buildings in the next three or four years.

Guy Verkoeyen said that Hydrogenics are providing both alkaline and PEM electrolysers around the world. The energy regulatory framework is not suited for this type of application. There is important scope for cost reduction as they move from small-scale production to large-scale manufacturing. They are aiming to build up to 100MW with capital expenditure of €580/kW, power price €36/MWh and grid costs of €7/MWh. The falling cost of renewable power is improving the case for hydrogen. There is huge decarbonisation potential via renewable H2 in the EU industry, with CO2 free iron and chemical production. There is also massive potential for decarbonisation in the power, gas and transport industries. What is needed is: green hydrogen certification; premium value for end product/ application; access to renewable electricity at low cost; and grid connection to deliver balancing services.

Michael Burford of KIWA Hydrogen Consultancy, Leeds UK, said that they are helping to demonstrate that hydrogen could be rolled out using the existing gas infrastructure.

Appliances and infrastructure could be upgraded to hydrogen with minimum disruption and cost. This would appear today as technically and economically feasible and the safety case is underway. They provide technical expertise in a Government-funded programme led by Arup to provide hydrogen for heating.

KIWA facilitates the design and manufacture of appliances for 100% hydrogen. They offer testing and certification for: hydrogen vehicle components; hydrogen storage tanks; fuel cells; electrolysers; steam methane reformers; and solid fuel hydrogen storage. The next steps are to convert grid hydrogen to automotive fuel cell purity requirements. They are beginning to examine the feasibility of converting a small village to 100% hydrogen gas.

Andrea Puccini of Erredue, Italy, said that they have a range of high purity hydrogen generators around the world. Excess renewable energy produced by sources with a high variation output, such as wind turbines, is used for hydrogen generation through water electrolysis. The hydrogen can be stored in a hydrogen refuelling station.

Hydrogen is also stored on a smaller scale, for instance to power quieter road vehicles. Excess renewable energy stored as hydrogen can be added to carbon, perhaps captured from biofuels, and turned into methane, which is injected into the gas grid as synthetic natural gas. The mutual convertibility of electricity and gas enables a smoothing of the electrical supply.

Steve Griffiths of BlueGen and SolidPower said that their micro combined heat and power (CHP) system is a cost efficient pathway to zero carbon. Efficiency is 60% for electricity production and 85% in CHP mode. It is remote controlled and is an ideal partner to fluctuating renewable energy sources, biogas, wind and solar energy. Their hydrogen refuelling station will provide 100 – 200 kg hydrogen per day. Over 16 million hours of fuel cell operation have proven 99% reliability.

Eddie Broadley of SICE UK described the development of Collaborative Autonomous Power Systems (CAPS) for remote electronic equipment. A hydrogen fuel cell was installed in a trial in 2016. The system is modular so it can accommodate future advances and developments. They are developing the refuelling aspect using electrolysis or reformation to produce hydrogen from other materials.

LIQUID ORGANIC HYDROGEN CARRIER (LOHC)

Dr Cornelius von der Hedyt of Hydrogenious Technologies GmbH said that they were developing hydrogen technologies to meet new requirements. It is not enough to utilise hydrogen as it has been produced for industrial processes, it must be widely available for use as the future energy carrier. In European cities alone there could be a demand for over 2,000 tonnes of hydrogen per day to power zero emission buses. They are also preparing hydrogen fuelling stations for cars and trains.

In their dehydrogenation process the Liquid Organic Hydrogen Carrier (LOHC) creates a liquid fuel which will enable them to utilise the existing fuel infrastructure and then make fuel available for electricity, heat and transport. Large volumes of hydrogen from renewable sources will be used in an efficient process, which will be easy to handle, safe and low priced.

Hydrogenious also had a partnership with a company in China and the first LOHC system will be operational there early next year.

NATURAL GAS, BIOFUELS OR HYDROGEN

Chris Evans, Director of Engineering at Ceres Power, explained that fuel cells are the most efficient way to generate power from fuel, whether it is natural gas, syngas, gas from coal, biofuels or hydrogen. Their Steelcell™ is affordable, made from conventional steel with thin ceramic coatings. It is scalable with conventional high volume manufacturing equipment from solar PV. They are providing electricity and heat for the home, industry, transport and the cloud. Their home system field trial generates 80% of home electricity and sufficient electricity for an electric vehicle. They are meeting targets for the ten trial systems which have been operating in UK homes since 2016. For offices and shops they will provide 5kW to10 kW systems. Ceres Power are working with five partners, including Honda and Nissan in the build-up to commercial scale. They are also working with Cummins on a US DoE funded project for data centres.

On-board fuel cells using biofuels from waste sources enable long range and short refuelling. They have zero emissions of NOx or SOx. The UK's additional demand for electric vehicles is projected at 8-16 GW. There will be no need for a hydrogen infrastructure. The SteelCell™ is grid independent, powered by bio-ethanol from waste sources.

Christian Engelke of Viessman showed the advantages of their fuel cell boiler for individual homes. The electrical output of their natural gas powered Vitovalor 300-P is 750W, with thermal output 1kW. The fuel cell module has 37% electrical efficiency and with heating 90%. The system reduces up to 40% CO_2 and has zero NOx emissions. It can be monitored remotely by smart phone or PC and it is guaranteed for ten years. The system is pre-assembled at the factory. Fuel cell systems are now affordable with the price of the Vi-tolator falling, reductions in energy use and government subsidies.

INVESTMENT AND PUBLIC SECTOR FUNDING

Dr Kerry-Ann Adamson of 4th Energy Wave said that renewable hydrogen is set to outperform gasoline on a cost basis. Parity with fossil fuels is expected to be reached in parts of Europe, but in Norway and the USA action is needed to increase the pace of the transition to green hydrogen. Based on the model of carbon trading, a system of green hydrogen certificates (GH_2) should be introduced taking into account the level of carbon saving between green and brown hydrogen. Certification of green hydrogen is already underway in the EU's Certify Hydrogen Project and this would enable long term stable hydrogen pricing. A potential market place is 'Blockchain' which is still in the early stages of development but could be efficiently utilized where prices can fluctuate. Carbon prices across industry are likely to get stronger.

Giles Pinnington, Patent Attorney, and Rebecca Lovell outlined their work around the world. Intellectual property rights are intangible assets with real value. Although many patents were filed last year in the UK, UK firms lagged far behind foreign counterparts. An exception is Intelligent Energy, which has many patents which will enable them to lead the international markets with their fuel cells. The long period of exclusivity, up to 20 years, enables companies to recoup their investment. Patents enable joint partnerships around the world in developing markets. For instance, Ceres Power has partnerships with several other companies wanting their fuel cells in Japan and the USA.

Alex Mauser of the Enterprise Europe Network said that they provide access to partnerships and funding. They are the world's largest support network for SMEs with 3000 local experts working in international markets. Innovate UK has several branches around the country. Horizon 2020 also supports innovative SMEs as well as larger companies around Europe.

Harsh Pershad of Innovate UK outlined their support for R & D. They have funds for materials development and to expedite manufacturing. They work with the Knowledge Transfer Network and the Energy Systems Catapult.

Marc Elliott of Investec envisages a growing requirement for investors in renewable energy in view of environmental pressures and government actions. Hydrogen can cross energy boundaries more easily than many technologies. It can be utilized for electricity and heat generation, as well as for transport. The Alternative Investment Market (AIM) is best suited for growth companies, with opportunities for both large and small companies.

Helen Fairclough said that EU Energy Focus is the UK contact point for the EU's Hydrogen 2020 program. UK companies are eligible to bid for EU funding until 2020. If funding is not agreed by that date the UK Government may underwrite UK partners. Current demonstration projects include fuel cells for mid-size passenger ships or inland freight. Research includes compressed storage systems for transport and thermo-chemical hydrogen production from concentrated sunlight.

MIDLANDS HYDROGEN AND FUEL CELL NETWORK

Speakers from the Midlands Hydrogen and Fuel Cell Network illustrated the global movement towards fuel cells powered by either hydrogen, biofuels or natural gas.

Prof Kevin Kendall of Adelan said that the small Chinese city of Foshan has the world's biggest programme with hydrogen fuel cell buses. Government subsidies for fuel cell cars, buses and trucks had encouraged new companies to set up and invest. A hundred hydrogen refuelling stations are planned for 2020 and a thousand by 2030.

The bus manufacturers in Yunfu signed an agreement with Ballard and now 300 PEM fuel cell buses are being manufactured. They proudly demonstrated one of the buses to Prof Kendall. The energy consumption per km is considerably lower than that for a petrol engine vehicle. The average hydrogen consumption per bus is 7kg per 100 km.

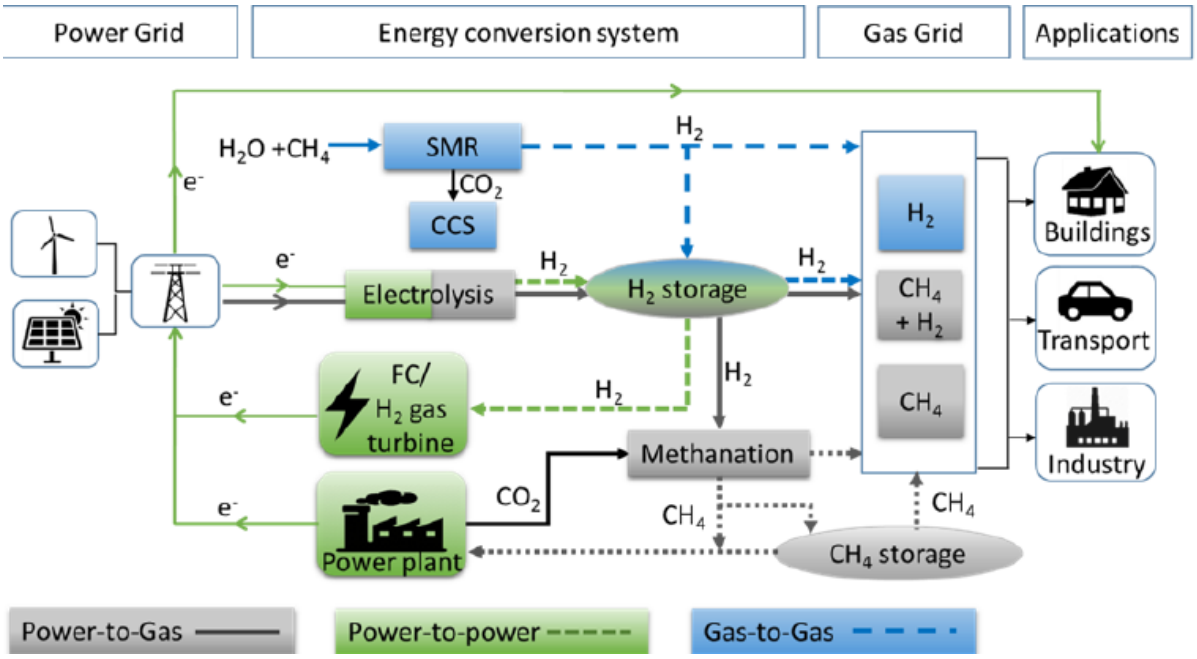
Prof Kendall also gave the latest information about Adelan's micro-tubular solid oxide fuel cell (SOFC) which is being developed for the Chinese market. This is lightweight, starts rapidly and is powered by propane.

Clare Jackson of the UK's Hydrogen Hub explained that this is an industry-led group of hydrogen and fuel cell developers, which will assist the change to secure, cost effective, clean energy for power, heat and transportation.

Dr Marc Stanton of CPSL (Clean Power Solutions Ltd) said that they are working with solar, wind and biomass sources to provide efficient, cost effective energy. They have a hydrogen trial site in Cheshire, UK, where they utilise surplus renewable energy from a 20kW wind turbine and a 48kW solar power system for a 5kW electrolyser. The stored hydrogen is used to fuel commercial vehicles. They have also developed a hybrid refuse collection vehicle powered by diesel and hydrogen. This enables waste industries to utilise the municipal waste collected and to produce their own fuel, thereby decreasing carbon emissions for inner cities and reducing the need to transport waste to landfill. The energy can also be used to provide combined heat and power (CHP) which qualifies for the UK Government's CHP generation payments.

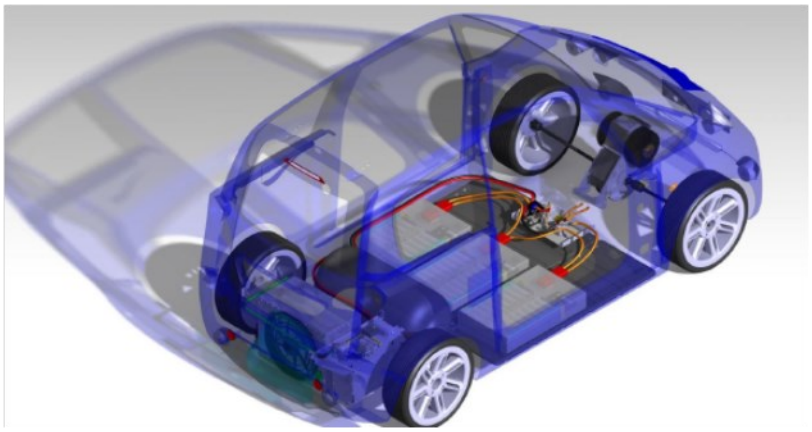
David Terry of the University of Birmingham Centre for Hydrogen and Fuel Cells Research outlined the work they are undertaking to facilitate the change to cleaner fuel production. Their work includes: the production of hydrogen from biomass; hydrocarbon reforming with methane and propane; high temperature electrolysis; using hydrogen as a storage medium for renewable energies; and micro-tubular SOFC developments. They work on biofuels and hydrocarbons as these can be efficiently utilised by solid oxide fuel cells.

At the Birmingham Research Centre they are planning to connect the power and gas grids. Steam methane reforming (SMR) converts water (H2O) and methane (CH4) to hydrogen (H2) and carbon dioxide (CO2). The carbon can be captured and stored (CCS). Hydrogen is also obtained by electrolysis using wind or solar power. It can be stored for use in buildings, transport or industry or returned to the grid to meet peak electricity demands.



Prof John Jostins of Coventry University and Managing Director of Microcab Industries has developed a fuel cell powered vehicle with the German electric vehicle company, Mahle Efficient Electric Transport. This has a 40V system with 40 to 60kW power. Heating is controlled from a touch screen in the centre, with each side having its own control as well.

A new Air Liquide hydrogen station is opening this year and other vehicles are also going to Brussels as part of the EU's project for Small 4-Wheel fuel cell passenger vehicle Applications in Regional and Municipal transport (SWARM).



The vehicles will contribute to the 'Circular Economy' as they are built from waste materials. The power train incorporates an 80kW Ballard fuel cell and three 24V traction batteries.

The fuel cell stack has a cell voltage monitoring system. The new vehicle control unit has active intelligent power management. Microcab's open platform concept allows numerous variations on lean weight design and supports technical progress. Coventry University also has a development with FEV, a new Institute in Aachen which includes hydrogen and fuel cells in its programme.

Full Presentations at the Conference are freely available at
www.climate-change-solutions.co.uk

The next International UK Hydrogen and Fuel Cell Conference will be on 19th March 2019.
jacqui.staunton@climate-change-solutions.co.uk

HYDROGEN AND FUEL CELLS POWERING THE FUTURE

Forty international speakers will be giving presentations at the next international conference. As cities around the world change to intermittent renewable energy, hydrogen is providing storage for year round emission free energy. Hydrogen fuel cells have no harmful emissions, only potable water. The full list of speakers is available at climate-change-solutions.co.uk.

Enterprise Europe Network will complement the programme, enabling participants to meet strategic partners, potential customers and suppliers.

For the first time in this series of conferences, exhibitors will include International Continuous and Automotive Vehicles (ICAV). Their workshop will focus upon AI and Optimisation in this massively expanding sector.

INTELLIGENT ENERGY FUEL CELLS FOR AIRBUS AND METAVISTA

Airbus was awarded the German Aviation Innovation Award at the International Aerospace Exhibition in Berlin for a concept design that is powered by Intelligent Energy fuel cell stacks. The HP2U is a concept demonstrator which has been designed as a potential means to re-place the auxiliary power unit (APU) in the tail of an aircraft. It uses six of Intelligent Energy's air cooled fuel cell stacks. The aim is for the fuel cell to power an electric power plant which in turn powers a rotating shaft to drive an air conditioning system or a generator. The new H2PU system could replace the kerosene-fuelled APU. Fuel cells only emit a small amount of water vapour, meaning they are zero emission at point of use.

FUEL CELLS DOUBLE EFFICIENCY

The team of developers at Airbus Systems Engineering have stated that running a motor on electric power from fuel cells is more efficient than a kerosene-based drive. The novel turbine has an efficiency of roughly 50 per cent compared to 20 per cent or so achieved with the conventional APU. The fuel cell system could eventually be integrated into any Airbus aircraft without design changes and the interfaces of the concept system are compatible with those of the present APUs. Dr Christopher Dudfield, Chief Technology Officer at Intelligent Energy, said: "We congratulate Airbus on their recent award win and look forward to seeing how the product develops in the future. Our Air Cooled fuel cell stacks produce DC power in a simple, cost-effective, robust and lightweight package. They are modular and can be scaled to meet precise customer power requirements."

METAVISTA'S RECORD BREAKING FLIGHT

South Korean liquid hydrogen specialist MetaVista has demonstrated a record breaking 10 hour and 50 minute multi-copter test flight using an Intelligent Energy lightweight 650W Fuel Cell Power Module. It is believed to be the longest flight time of its kind. MetaVista used 390g of liquid hydrogen in a specially designed 6L cylinder. This has proved that liquid hydrogen enables three times longer flight time than compressed hydrogen.

Intelligent Energy has launched a £100,000 Charitable Trust Fund to benefit local community groups and organisations in the area of Loughborough. The launch of the Trust was attended by The Lord-Lieutenant of Leicestershire, Mr Mike Kapur OBE, and a number of key local figures from various organisations. The Trust has been established to support local causes in need of financial assistance which aid, amongst others, community groups, young people, sport and lifelong learning. www.intelligent-energy.com

FUEL CELL ENGINEERS PRODUCE ENERGY FOR HEALTHY CITIES

UK HEALTH ALLIANCE ON CLIMATE CHANGE

A report by the UK Health Alliance on Climate Change, which represents fifteen organisations in this field, is calling for action to deal with both air pollution and climate change in order to realise the public health benefits that this will bring. They give six steps that the Government and health sector must take to improve air quality and tackle climate change:

1) Increased collaboration to promote a joined up approach to tackling air pollution and climate change.
2) Phase out coal power stations by 2025.
3) Expand clean air zones.
4) Better monitor air pollution in areas where vulnerable populations are concentrated.
5) Retain or improve EU air quality standards.

Health professionals are powerful messengers when advocating for interventions outside of the clinical setting which protects the health of their patients. A bias in favour of investment in road building and motorised transport has led to a 'windscreen perspective' which views transport issues only from the driver's perspective. It is also often found that vehicles emit more pollutants than expected. The NHS employs more than 1.5 million people and by engaging with local energy, transport and infrastructure decisions they can ensure that policies which benefit both public health and the environment are implemented. A 2016 report by the Sustainable Development Unit assessed that measures to reduce emissions could save the NHS £400million by 2020 and provide health benefits to patients.

Fuel Cell Power comments that the UK Government only supports engineers who have the backing of an established company, but these do not want competitors in their markets.

The implementation of all types of fuel cells will contribute to the six Steps required:

1) The transition from combustion to electrochemical energy conversion with fuel cells will tackle both air pollution and climate change.
2) Coal can be replaced globally by waste from household, industrial, agricultural or forestry sources. The electrochemical process is two or three times more efficient than combustion. It is so clean and quiet that electricity and heat can be generated on site as combined heat and power (CHP) with up to 90% efficiency.
3) Fuel cells have very low or zero emissions of air pollutants so they will facilitate the introduction of clean air zones.
4) Fuel cells can be introduced first in areas where vulnerable people are concentrated, at schools and hospitals.
5) The use of fuel cells will expedite the highest air quality standards.
6) The work of innovative engineers who have developed fuel cells powered by renewable energy should be expedited.

ROAD TO ZERO

The UK Government envisages in this report that existing fuel suppliers and manufacturers will lead the change to clean energy technologies. However, major changes are more likely to emerge from engineers who are not supported by the establishment. *Road To Zero* states that vehicles are becoming more complex with shorter lifecycles, but developers of advanced fuel cell systems are halving the number of component parts. Very high volume manufacture of batteries and power trains by existing suppliers is proposed, but with computer aided design (CAD) it is likely that smaller volumes will be produced locally. Innovative engineers will also ensure that vehicles and components can be refurbished or recycled on a local basis.

CYGNUS ATRATUS BROADENS ITS REACH

REMANUFACTURING ELECTRIC VEHICLES

The Cygnus Atratus Group develops both hydrogen and ethanol fuel cells. The company is partnering others in a feasibility study to remanufacture London Black Taxis as ethanol fuel cell powered vehicles. In the mean time, negotiations are underway to provide ethanol fuel cells for Liverpool Black Taxis and other vehicles with a local convertor of transport to electric drive.

In South West France, Cygnus Atratus is working with an engineering firm, an ethanol producer, and Pangaea SAS, which together form one of our Collaborative Manufacturing Enterprise (CME) partners. Pangea is supporting the rebuilding of one of the first hydrogen fuel cell powered London Taxis, built and operated in 1999 by Zetek PLC. The taxi, a Metrocab, operated in London as a demonstrator for over a year prior to the demise caused by the tragedy of 9/11 in the USA when investors abandoned the company.

The vehicle is having its original, but still working alkaline fuel cells, replaced with ethanol fuel cells manufactured locally in France under licence to Pangea SAS.

Pangea SAS is also collaborating with a company rebuilding electric versions of the ubiquitous Citroen 2CV and Mahari cars, so beloved by the French public. The use of ethanol fuel cells brings real advantages to electric vehicle convertors, making their remanufacture a speedy entrance into the transport market. Our fuel cells enable very low emission operation with comparable range and refuelling time to that of an i.c .engine vehicle. The low weight of our vehicles reduces the emission of particulate matter from vehicle tyres which is increased when heavy batteries are put into existing vehicles.

WASTE TO ENERGY CLEANING LAND AND OCEANS

Cygnus Atratus is collaborating in the first true waste to energy system on a Perigordine demonstration farm using its hydrogen fuelled alkaline fuel cells converting animal and municipal solid waste to electric energy, water and heat.

Our partnerships with Collaborative Manufacturing Enterprises are widening, including the launching of a waste to energy maritime systems company. The new company will be working with ship brokers and owners to meet new regulations to improve emissions at sea and particularly to proactively clean our oceans.

Cygnus Atratus and our academic partners are making steady advances and our strategy of encouraging practical partners to work with us in our CMEs is seeing quick progress in bringing our technologies to markets.

NEWS

The Newport Beach hydrogen station, operated by Shell, is the 35th retail hydrogen station in California. It is located in Orange County. The hydrogen station first opened in 2012 and was recently upgraded to accommodate retail sales.

TOYOTA RAMPING UP SALES

Toyota Motor Corp said it plans to set up a facility to mass manufacture hydrogen fuel cell stacks, a key component of fuel cell vehicles, as it seeks to ramp up production of hydrogen-powered cars and expand their usage as a zero-emission alternative to gasoline vehicles.

The new unit will come up on the grounds of its Honsha plant in Toyota City near the automaker's global headquarters, the company said in a statement. It is also constructing a dedicated line at the nearby Shimoyama plant to produce tanks for storing high-pressure hydrogen gas inside vehicles.

Toyota declined to give details about their latest investment in this technology, but said mass production of components will begin around 2020, enabling the company to meet its target for global annual fuel cell vehicle sales of more than 30,000 units, including passenger cars and buses.

Toyota already sells the Mirai sedan, the world's first mass-market fuel cell electric vehicle (FCEV), in Japan, in the United States and also some European countries.

The model starts at about 7.2 million yen ($65,807.51) in the Japan market.

Due to its high cost and complexity of building its components, the Mirai is produced in small lots. Only around 5,300 units have been sold since its 2014 launch, a fraction of regular production models.

Mass manufacturing of the two components - hydrogen fuel cell stacks and hydrogen tanks - will enable Toyota to lower the price of FCEVs, and expand its fuel cell technology.

Honda Motor Co and Hyundai Motor Co also manufacture fuel cell vehicles, while other automakers are also developing the technology. However, many automakers, including Nissan Motor Co and Tesla Inc, are focussing on all-battery electric cars as a solution to reduce vehicle emissions.

Toyota, which developed the Prius, the world's first gasoline hybrid vehicle, sees hydrogen FCEVs as a zero-emission alternative, which requires less time to refuel compared with the time it takes recharge electric vehicle batteries.
($1 = 109.4100 yen)

Reuters

BALLARD FUEL CELLS FOR GROWING WORLD MARKETS FOR ELECTRIC BUSES

NEW FLYER ELECTRIC BUSES TO DELIVER ZERO-EMISSION TRANSIT THROUGHOUT UNITED STATES

New Flyer electric buses powered by Ballard fuel cells have completed rigorous testing at the Altoona Bus Research and Testing Center in Pennsylvania under a program established by the Federal Transit Administration (FTA). Testing included evaluations of safety, structural integrity and durability, reliability, performance, maintainability, noise, fuel economy and braking.

New Flyer's 40-foot and 60-foot buses are commercially available for sale utilizing FTA funding. Both models will also be eligible for California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). HVIP is part of California Climate Investments, a statewide program that puts billions of cap-and-trade dollars to work reducing greenhouse gas emissions, strengthening the economy and improving public health and the environment — particularly in disadvantaged communities.

The current $300,000 voucher incentive covers 40-foot transit buses and Class 8 trucks powered exclusively by hydrogen fuel cells. Both funding opportunities enable transit agencies to support the transition to zero-emission operations.

New Flyer's fuel cell electric buses offer a complement of important advantages to battery-electric alternatives, including: extended range in excess of 260 miles; rapid refuelling with hydrogen in less than 10-minutes; 95% material recycling; and full route flexibility. It is projected that 40% of new heavy duty transit buses in the U.S. will be electric by 2022 and Ballard provides zero-emission, high performance fuel cell modules to power electric buses within this rapidly-growing transit segment.

Chris Stoddart, President of New Flyer noted, "New Flyer, along with many major automotive manufacturers, strongly believes that hydrogen and fuel cell technology remains a viable complementary electric propulsion option for clean cities with extended range operations. We celebrate this important milestone in deploying zero-emission bus propulsion technology on a proven, safe, and reliable bus platform."

As cities and new regulations push transit agencies to accelerate the transition of bus fleets to zero emission vehicles, electric buses powered by Ballard's FCveloCity®-HD module – will offer a one-to-one replacement for diesel and compressed natural gas (CNG) buses, with no compromise in terms of service and no road-side recharging infrastructure.

BALLARD APPOINTS TWO BOARD MEMBERS FROM WEICHAI POWER

As part of their strategic alliance with Weichai Power, Ballard has appointed two highly experienced members from Weichai to their Board of Directors, Mr. Kevin Jiang and Mr. Sherman Sun. Kevin Jiang noted, "As representatives of Weichai, this position on Ballard's Board of Directors provides an opportunity to collaborate at the strategic level, underpinned by our extensive knowledge of the China market." Sherman Sun added, "We will be able to leverage and coordinate Weichai's resources and strong relationships within the vehicle manufacturing value chain for positive advantage in executing Ballard's growth strategy."

ORDER FOR FUEL CELL FOR UK HYDROFLEX TRAIN

Ballard has received a purchase order from Porterbrook Leasing Company Limited, a leading participant in the rail leasing market, for a fuel cell module and related support to power a HydroFLEX train in the U.K. Earlier this year U.K. Rail Minister, Jo Johnson MP, challenged the rail industry to develop decarbonisation plans, with the objective of removing diesel-only trains from the network by 2040. HydroFLEX is an innovative response to this challenge from Porterbrook and the University of Birmingham's 'Birmingham Centre for Railway Research and Education (BCRRE), bringing together industry and academia in partnership to deliver the U.K.'s first clean energy passenger train.

Porterbrook will provide a Class 319 electric train for conversion and Ballard will supply their fuel cell power module and provide system controls development, mechanical integration of sub-systems and other components. The HydroFLEX will be the U.K.'s first fully sized hydrogen demonstrator train. It will showcase how hydrogen can be used to power a train that retains the ability to operate across existing electric routes, on either third rail or 25kV overhead power. Testing and demonstration runs are planned for the summer of 2019 at RailLive, which will take place at Long Marston in Warwickshire.

Jesper Themsen, President and CEO of Ballard Power Systems Europe A/S said: "We are pleased to work with Porterbrook and BCRRE on the HydroFLEX rail program. As evidenced by this activity in the U.K., along with our work on fuel cell rail programs in Germany and China, momentum is rapidly building behind the development and deployment of Heavy Duty Motive fuel cell solutions for both inter-city trains as well as intra-city trams."

DEVELOPMENTS IN EUROPE'S FUEL CELL BUS MARKET

The fleet of 10 zero-emission Fuel Cell Electric Buses in Aberdeen, Scotland surpassed the one-million mile (1.6 million kilometer) operating milestone in January 2019. The buses went into operation in 2014, co-financed through two projects funded by the European Fuel Cells Joint Undertaking (FCH JU). Each bus is powered by a Ballard 150 kilowatt kW module. The fleet carries an average of 36,700 passengers per month, operating 7 days per week and has experienced more than 1,600 refuellings to date, with each refuelling taking just 5-to-7 minutes. Buses in the fleet travel as far as 250 miles (400 km) per day.

Councilor Philip Bell, Aberdeen City Council's hydrogen spokesperson said, "The million mile figure demonstrates the positive impact the hydrogen bus fleet has had in Aberdeen. Our city has a proud reputation as a global energy hub stretching back decades and this project shows Aberdeen is committed to continuing to push boundaries and developing technology that paves the way for a real shift in traditional thinking. The Council's own teams have worked hand in hand with the private sector to roll out the fleet and create the supporting infrastructure and this fantastic milestone is a great credit to all involved."

The first fuel cell buses in Denmark are planned for 2019. Three Van Hool zero-emission electric buses, powered by Ballard 85kW fuel cell modules, are to be deployed in Aalborg under the 3Emotion funding program. .They will operate for an initial 3-year period under the funding program and are expected to continue in normal service through subsequent years.

The City of Aalborg has also signed a contract for an electrolysis system and hydrogen refuelling station with GreenHydrogen, a Danish company, with the aim of producing hydrogen only during periods of surplus renewable electricity so that the impact is largely CO_2-neutral. Van Hool will deliver the same fuel cell electric bus model in Germany under the *Joint Initiative for hydrogen Vehicles across Europe* ("JIVE") funding programs. Van Hool has ordered 40 Ballard 85kW fuel cell modules for 30 buses it plans to deploy with the Regionalverkehr Köln GmbH transit agency in Cologne and 10 buses it plans to deploy with WSW mobil GmbH transit agency in Wuppertal.

Jesper Themsen of Ballard Power noted, "With European cities announcing plans to limit or even eliminate diesel buses and other internal combustion vehicles by specific target dates, we are now seeing a clear increase in the momentum toward deployment of zero-emission fuel cell electric buses."

BACK UP FUEL CELL SYSTEMS

Ballard has signed agreements to supply hydrogen back-up power systems to two Danish Companies, Eniig and Fibia A/S. Both customers began installing Ballard fuel cell backup power systems in their networks several years ago and together they currently have a total of over 125 Ballard systems in service. These enable individual network nodes to seamlessly maintain operation in the event of a grid power failure, Nick Højvang Andersen, Eniig Installation Specialist said, "With 11 years of experience using fuel cell systems for backup power, we are confident that these are a robust and reliable solution with a long lifetime in the field. We plan to convert all our battery backup power systems to fuel cell technology over the coming few years, as a result of the greater reliability, lower operating cost and stronger return on investment that fuel cells deliver." www.ballardpower.com

HYDROFLEX THE UK'S FIRST HYDROGEN TRAIN

Porterbrook Leasing has entered a partnership with the University of Birmingham to demonstrate the UK's first operational hydrogen train this summer. Porterbrook is a leading participant in the rail leasing market with a rolling stock fleet of around 6,000 vehicles which includes over 4,000 passenger vehicles. They are working with the University of Birmingham's Birmingham Centre for Railway Research and Education ('BCRRE') to create HydroFlex - the UK's first hydrogen powered train. This will allow both organisations to demonstrate how this fuel-of-the-future might be deployed across the UK's rail network.

Development work has recently commenced and HydroFlex will undertake testing and demonstration runs in summer 2019. The HydroFlex will retain the ability to operate across existing electric routes (on either 3rd rail or 25kV overhead power) and with the addition of a hydrogen fuel-cell it will also be capable of operating in self-powered mode, without the need for diesel engines. www.porterbrook.co.uk

EVENTS

19th March 2019
15th International Conference on Hydrogen and Fuel Cells.
Hydrogen and Fuel Cells - Powering the Future
The Conference, Exhibition and Partnering Event will be held in Birmingham, UK
www.climate-change-solutions.co.uk

1st—5th April 2019
Group Exhibit Hydrogen + Fuel Cells
Hannover Fair, Germany. Includes Europe's largest hydrogen, fuel cells and battery exhibition. www.h2fc-fair.com

2nd - 5th July 2019
Fuel Cells, Electrolysers and H2 Processing
Lucerne, Switzerland. www.efcf.com

Fuel Cell Power's Blog covers all types of fuel cells and their applications in distributed power generation, portable power, CHP and transport. For millennia, energy has been obtained by burning fuels, which is changing the chemistry of the atmosphere and the oceans. Cleanly, quietly and efficiently the electrochemical conversion of fuels is now becoming a practical alternative to combustion. Fuel cells utilize fossil fuels or energy from waste efficiently. They can equally be powered by hydrogen which can be generated from intermittent renewable energy sources. Articles and features in Fuel Cell Power will help individuals, businesses and communities to plan for energy efficiency, price stability and cuts in harmful emissions.

www.fuelcellpower.org.uk

Fuel Cell Power provides information on the practical application of fuel cells.
It is produced by the family and friends of the late Dr F T Bacon OBE, FRS,
who dedicated his life to the development of fuel cell technology.
Information can be obtained from: Jean Aldous, Editor, Fuel Cell Power,
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