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www.fuelcellpower.wordpress.com

FUEL CELL POWER

The transition from combustion to clean electrochemical energy conversion

HEADLINE NEWS

Ballard Power is providing hydrogen fuel cells for Solaris Bus and Coach In Europe. Solaris is deploying buses in Italy, Germany and the Netherlands. In the UK Wrightbus is utilising Ballard fuel cells in their zero emission hydrogen fuel cell buses. These buses are all supported by the EU Joint Initiative for Hydrogen Vehicles (JIVE).

Other manufacturers are utilising biomethane or ethanol produced from organic waste to provide clean energy for transport, buildings and industry.

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BALLARD LEADING THE CHANGE TO HYDROGEN FUEL CELL BUSES

BALLARD POWERS SOLARIS BUSES IN EUROPE

Ballard Power Systems has had a purchase order from Solaris Bus & Coach S.A. a leading European bus and trolleybus manufacturer and Ballard partner, for 25 of the Company's new 70 kilowatt heavy-duty FCmove™ fuel cell modules. These modules will power Solaris Urbino 12 hydrogen buses planned for deployment in Cologne and Wuppertal in Germany. This will be supported by the Joint Initiative for Hydrogen Vehicles Across Europe (JIVE 2) funding program.

The Solaris Urbino 12 hydrogen fuel cell electric bus is capable of travelling 350 kilometres on a single hydrogen refuelling. The bus incorporates an axle with two electric motors and is equipped with a climate control system utilizing heat generated by the fuel cell.

Rob Campbell of Ballard said: "These German cities have previously ordered 45 fuel cell buses powered by Ballard. The combined fleet will be the largest fuel cell bus fleet yet in Europe, highlighting the benefits of simple refuelling, long range and zero emission operation. Ballard powered fuel cell buses in service now exceed 70 buses in Europe."

Ballard launched its next-generation FCmove™ product in 2019. Solaris selected it for the Urbino 12 fuel cell bus and secured its first project for 12 buses in Bolzano, Italy.

Ballard has also announced a purchase order from Solaris for 20 of their new 70 kilowatt heavy-duty FCmove™ fuel cell modules. These will power 20 Solaris *Urbino 12 hydrogen* buses planned for deployment in South Holland under the JIVE 2 funding program. The buses will be operated by Connexxion, which provides transport services for South Holland province.

Rob Campbell noted "With the deployment of these 20 buses next year by Solaris, Ballard will be powering a total of 40 buses in The Netherlands. This order is another strong indicator of the growing demand for zero-emission public transportation solutions in Europe and, indeed, globally.

Solaris 'Urbino 12 hydrogen' Fuel Cell Electric Bus

As Europe contemplates a 'Green Recovery' from COVID-19, and as recent studies have linked PM2.5 air pollution with COVID-19 mortality rates, we see the opportunity for accelerated adoption of zero-emission fuel cell electric buses."

BALLARD AND WRIGHTBUS IN EUROPE

Ballard and Wrightbus are founding members of the *H2Bus Consortium*, announced in June 2019 and focused on deployment of at least 1,000 zero-emission fuel cell electric buses and related infrastructure in European cities at commercially competitive rates. Wrightbus owner, Jo Bamford, also owns Ryse Hydrogen, which is working towards the creation of a green hydrogen ecosystem for the production, distribution and dispensing of clean hydrogen fuel.

Randy MacEwen of Ballard noted, "These buses from Wrightbus will meet a number of important requirements – including extended range and rapid refuelling – in addition to being highly beneficial from an environmental perspective. The U.K. Department for Transport has announced a 5 year plan which represents a significant leading edge of the anticipated rapid growth in zero-emission fuel cell-powered buses as we move forward in Europe."

Ballard currently has orders in-hand from bus OEMs – including Wrightbus – for a total of 127 fuel cell modules to power fuel cell buses in at least 7 cities in the U.K., Germany, Italy and the Netherlands. These are all under the Joint Initiative For Hydrogen Vehicles Across Europe (JIVE) program funded by the European Fuel Cells and Hydrogen Joint Undertaking.

EUROPEAN CLEAN VEHICLE DIRECTIVE

In the broader European context, the European Commission has introduced "A European Green Deal", striving to become the first climate-neutral continent with no net emissions of greenhouse gases, by 2050. In addition, the European Commission's Clean Vehicle Directive is expected to be an important driver behind the adoption of zero-emission buses across the entire continent. The Directive sets minimum targets for zero-emission buses, varying for each EU member, stipulating percentages of clean buses to be purchased by 2025 and 2030. In addition, 50% of the minimum Clean Vehicle Directive target for each country must be fulfilled by procuring zero-emission buses, including fuel cell electric buses, defined as a vehicle emitting less than 1g CO_2/kWh or less than 1g CO_2/km.

WRIGHTBUS ORDERS MORE BALLARD FUEL CELLS FOR UK BUSES

Ballard has received follow-on purchase orders for 15 of its 85-kilowatt heavy-duty FCveloCity® fuel cell modules from Wrightbus a leading bus OEM and Ballard partner headquartered in Northern Ireland. These will be used to power fuel cell electric buses planned for deployment in the U.K. Wrightbus was recently re-capitalized by Bamford Bus Company after having gone into administration last year.

Including the 15 modules announced today, Ballard currently has orders in-hand from Wrightbus for a total of 50 modules to power fuel cell buses in the U.K. Of those 20 are to power buses planned for deployment in London and 15 are for buses in Aberdeen.

Earlier this year the U.K. Government's Department for Transport announced a 5-year, £5 billion (US$6.4 billion) plan to enhance bus and bicycle infrastructure in the country, together with deployment of at least 4,000 zero-emission buses. Further details are expected in a *National Bus Strategy* to be published later in 2020. The case for using sustainably produced hydrogen in transportation to further the U.K.'s climate and air quality objectives is presented in a June 2020 report from *The Centre for Policy Studies*, titled "Driving Change: How Hydrogen Can Fuel a Transport Revolution".

Jo Bamford of Wrightbus said, "Cities around the world are seeing massive reductions in air pollution as many vehicles have been kept off the road during the pandemic. However if we just go back to how public transport has traditionally been run, levels of pollution will quickly rise again. We have an opportunity, working with Ballard's leading-edge technology, to build hydrogen powered buses that will make a huge difference to air quality. Therefore, our organization is strongly encouraging the Department for Transport to provide funding support for the deployment of 3,000 fuel cell electric buses, as part of the U.K.'s *National Bus Strategy*."

HYDROGEN FUEL CELL BUSES IN USA AND CANADA

Following rigorous testing by the United States Federal Transit Administration, New Flyer's buses powered by Ballard fuel cells are now commercially available. Chris Stoddart of New Flyer noted that along with many major automotive manufacturers, they strongly believe that hydrogen fuel cell technology is a viable complementary electric propulsion option for clean cities with extended range operations.

Ballard Powered 'New Flyer' for zero emission transit in the United States and Canada

MEMBRANE ELECTRODE ASSEMBLIES (MEAs) FOR CHINA

In 2017 Ballard and Guangdong Nation Synergy Hydrogen Power Technology Co. Ltd. (Synergy) set up Synergy-Ballard JVCo in the city of Yunfu in China. The Company has a long-term agreement for MEA supply and stack assembly.

Ballard has received a purchase order for $7.7 million of MEAs for use in manufacturing FCvelocity® fuel cell stacks from Synergy-Ballard JVCo.

Membrane Electrode Assemblies (MEAs) are a critical component of every cell in a fuel cell stack, enabling the chemical process that generates electricity from a combination of hydrogen and oxygen.

"Ballard's fuel cell technology is currently powering over 650 fuel cell electric buses and more than 2,200 fuel cell trucks in China, representing key market share." said Alfred Wong, Ballard Managing Director - Asia Pacific.

"We expect to see high adoption of fuel cell electric vehicles in China as the national and provincial governments increasingly prioritize the decarbonization of mobility with zero-emission solutions. Where vehicle use cases require extended range and rapid refuelling, we believe Ballard fuel cell technology will offer a compelling value proposition, including high reliability and durability along with competitive total-cost-of-ownership."

www.ballard.com

JCB LEADS THE WAY WITH FIRST HYDROGEN FUELLED EXCAVATOR

JCB has developed the construction industry's first ever hydrogen powered excavator as it continues to lead the sector on zero and low carbon technologies.

The 20-tonne 220X excavator powered by a hydrogen fuel cell has been undergoing rigorous testing at JCB's quarry proving grounds for more than 12 months. The development means JCB is the first construction equipment company in the world to unveil a working prototype of an excavator powered by hydrogen.

In the coming months, JCB will continue to develop and refine this technology with advanced testing of their prototype machine and they will continue to be at the forefront of technologies designed to build a zero carbon future. Lord Bamford's son Jo Bamford set up Ryse Hydrogen and then bought Northern Ireland bus giant Wrightbus. He has won contracts to supply the world's first hydrogen double-decker buses to cities such as London and Aberdeen.

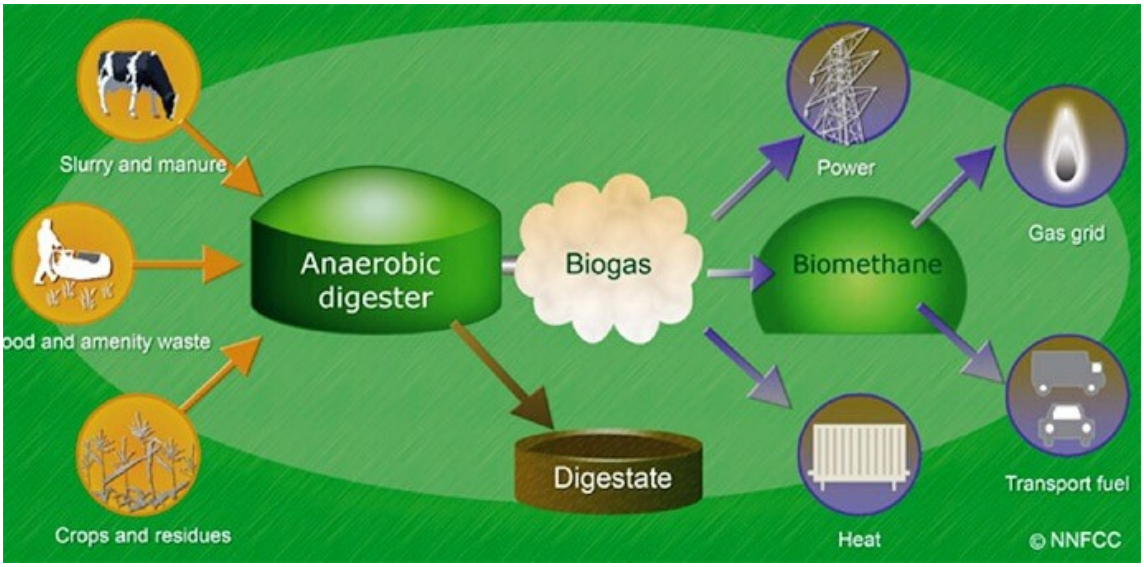
Jo said: "I truly believe hydrogen is the UK's best opportunity to build a world-leading industry which creates UK jobs, cuts emissions and is the envy of the globe." Buta Atwal, Chief Executive of Wrightbus added "As bus transportation seeks to decarbonise Wrightbus has the potential to lead the way given its track record in manufacturing state-of-the-art zero emission hydrogen buses as well as electric and hybrid models."

Power for JCB's prototype excavator is generated by reacting hydrogen with oxygen in a fuel cell to create the energy needed to run electric motors. The only emission from the exhaust is water.

The video link to JCB's Hydrogen Fuel Cell X series excavator - a zero emission industry first is: https://youtu.be/q1-__SYskjc

RENEWABLE ENERGY FROM ORGANIC WASTE

As North Sea gas supplies decline, electricity and heat are increasingly being obtained from the combustion of energy crops and organic waste. According to the UK's renewable energy consumer website, ***The Switch,*** biomass is second only to onshore and offshore wind energy when looking at the renewable energy mix. It is estimated that over a million British homes are now supplied with green gas.



Compost is produced by air-breathing (aerobic) bacteria and microorganisms. Anaerobic digesters process biomass from vegetable residues and crops, food and other organic waste and agricultural slurry and manure. They produce biogas which is being utilised in combined heat and power units in offices and homes. The residue is the digestate, a nutrient rich material that can be repurposed into fertiliser. Waste often comes from local industrial projects, construction or food preparation. Carpentry waste is either compostable or can be used in an anaerobic digestion facility.
https://theswitch.co.uk/energy/guides

In a report by the Anaerobic Digestion and Bioresources Association entitled ***Biomethane: the pathway to 2030***, it is explained that biomethane could meet 30% of the saving needed to meet the UK's 5th carbon budget for 2030. Biomethane is chemically identical to natural gas (CH_4) but it is obtained from organic waste which would otherwise be burnt or sent to landfill.

The report proposes that there should be support for local circular economy projects that use anaerobic digestion to transform local waste into onsite heat and power. Anaerobic digestion could remove the UK's dependence on other nations for our energy needs as we generate energy onsite from local waste or locally grown produce. It also helps farmers to contribute to food security, recovering vital ingredients from organic waste and reducing dependence on mined nutrients from abroad which have limited supply. This circular process enables nutrients and organic matter to be recycled back to our soil some of which is in poor health after years of intensive farming.

Digestate is a nutrient rich liquid and can displace artificial fertilisers which have a high energy demand to produce. 'Circular cities' will recycle all unavoidable inedible food waste from their residents and businesses. This waste can then provide heat and power in buildings and fuel buses and other essential transport. The residues can be utilised to fertilise city farms and urban community gardens.

ANAEROBIC DIGESTERS OPERATING

Over 670 anaerobic digestion plants are currently operational in the UK, generating nearly 12 terawatt hours (TWh).

The biomethane will displace 22% of current fossil gas demand for domestic heat, 70% of the UK's bus and heavy goods vehicle energy demand, or 21% of total electricity demand, supplying a base load to meet demands for peak periods.

This could be five times greater if all available feedstocks were utilised but a large amount of waste feedstocks is not being collected and diverted to anaerobic digestion for processing. The main challenge is that the services that anaerobic digestion delivers, for the climate, the environment and the circular economy are not properly reflected in market prices, which do not incorporate societal benefits.

PRESENT CARBON SAVING

		$MtCO_2eq$	EQUIVALENT TREES PLANTED
Displaced fossil gas (heat & transport)		0.42	6,944,000
Displaced fossil-based electricity		1.70	28,109,000
Displaced artificial fertiliser		0.46	7,606,000
Prevented methane emissions from…	…farm waste	0.22	3,637,000
	…food waste	0.69	11,409,000
	…sewage	1.58	26,125,000
	TOTAL	5.07	83,767,000

ACHIEVING FULL POTENTIAL CARBON SAVINGS

Recommendations are made for the different policy areas: heat, transport, agriculture and waste management.

Energy tariffs and infrastructure funding will make biomethane available for combined heat and power in buildings and to power essential transport. An Agricultural Bill could recognise the benefits of anaerobic digestion to reduce emissions alongside generating renewable energy and generating renewable biofertiliser.

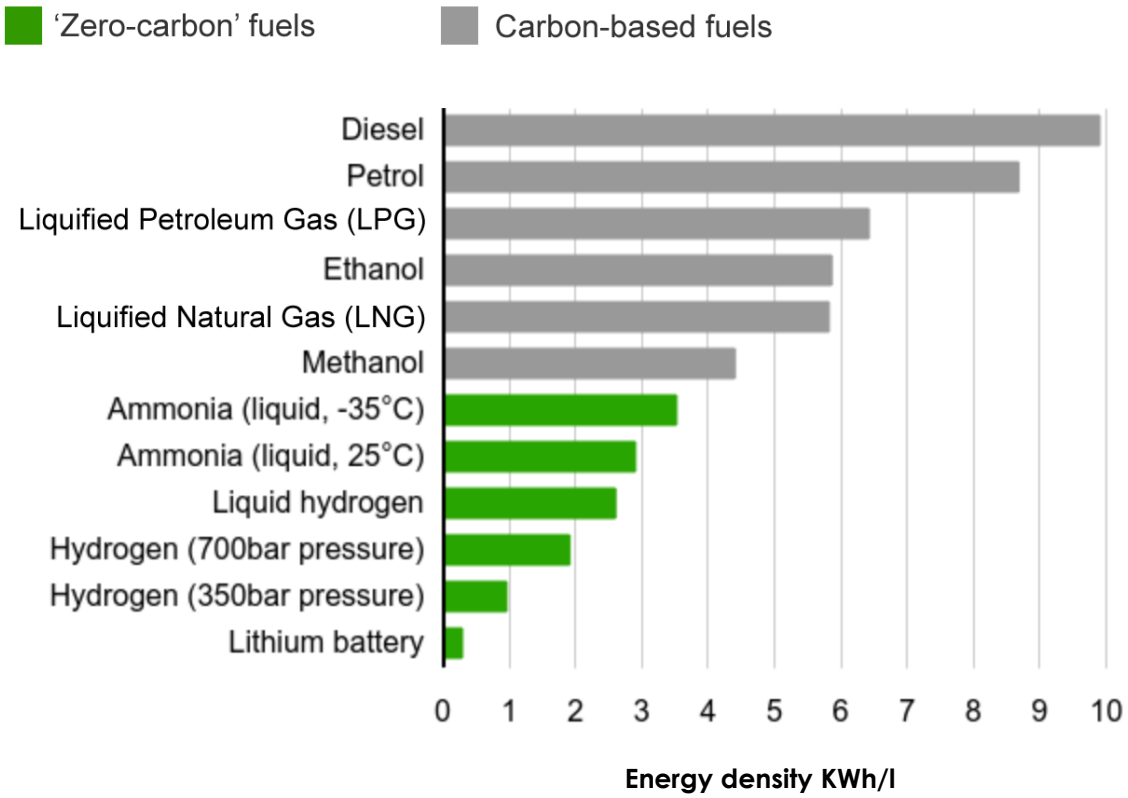
Waste management should encourage the treatment of all organic wastes through anaerobic digestion.

Government policies reduce the price of fossil fuel for those in low income households, but more targeted measures are needed. This should include a robust and ambitious carbon pricing system in the UK. The International Energy Agency is quoted as saying that a biogas plant is the hub in the future circular economy.

www.adbioresources.org

VOLUMETRIC ENERGY DENSITY

The volumetric energy density of a range of fuels is illustrated in the Royal Society's report entitled ***Green Ammonia Policy Briefing*** as shown below. Electrochemical conversion is two or three times more efficient than combustion so the energy available from an ethanol fuel cell is much greater than that obtained from the combustion of diesel, petrol or natural gas.



Ethanol is listed as a carbon based fuel but when it is obtained from organic waste it is not adding to the CO_2 in the air but is carbon neutral. Ethanol is a liquid fuel with lower energy density than diesel and petrol but it is similar to liquefied natural gas. However the internal combustion engine is heavy and inefficient, while electrochemical energy conversion with fuel cells is highly efficient. At present 10%of ethanol (E10) is being added to petrol or diesel to reduce their carbon dioxide emissions. Instead of supporting present inefficient forms of transport, which are major causes of air pollution and climate change, ethanol would be better used to power fuel cells in the transition to zero emission transport.

The present energy system is wasteful and inefficient, with separate infrastructures for electricity and gas. Wood burning emits large quantities of fine particles which are damaging to health, and there is also concern about cutting down trees and using land which could provide food or support biodiversity. The use of organic fuels will enable more electricity and heat to be produced locally and will help to balance the loads from intermittent wind and solar energy. Ethanol can replace the diesel or petrol used for standby power alongside renewable energy plants. It can be stored in the existing fuel containers for use when the wind or solar energy is not available.

ELECTROCHEMICAL ENERGY CONVERSION

Unlike combustion, which is a major cause of air pollution, the electrochemical process has no harmful emissions. Combustion, as well as producing carbon dioxide, joins the oxygen in the air with nitrogen to form polluting nitrous oxides. The electrochemical process only joins the oxygen with the hydrogen in the fuel to form H_2O, that is potable water. As there are no harmful emissions, fuel cells are providing heat and power (CHP) adjacent to or inside buildings, with efficiency up to 90%.

GASIFIED ANAEROBIC DIGESTER

The Gasified Anaerobic Digester (GAD™) produces ethanol and large quantities of fertiliser from organic waste. Ethanol can be used in fuel cells to provide zero emission heat and power in buildings. It can also provide fuel for essential transport, without major changes to the existing refuelling infrastructure. The GAD™ and the electrochemical process separate the carbon in the fuel and ambient air and store it as a carbonate. The carbonate is then recycled for use by agriculture or industry, so the whole process is carbon negative.

BY-PRODUCTS FERTILISER AND POTABLE WATER

As the organic waste is not burnt, there are large residues which can be used as fertiliser. Another essential by-product of electrochemical conversion is pure water. Conventional electricity production requires large quantities of water, but this is not needed for electrochemical conversion, which produces pure water as a by-product. Approximately 6 litres of potable water per kilowatt hour is produced, depending upon air moisture.

ENERGY FOR DEVELOPING COUNTRIES

There will be a major role for the electrochemical conversion of ethanol from organic waste in developing countries which do not have extensive infrastructures to transfer electricity and heat and are still investing in coal. They will not have to invest in carbon capture and storage infrastructure as the carbon from the fuel and ambient air are captured and stored as carbonate and then recycled.

SOLVING MASSIVE PROBLEMS WITH WASTE

At present crop residues are often burnt on the soil and this leaves some fertiliser, but can also cause extensive air pollution. Sewage waste causes pollution when it is dumped into rivers and chemical fertilisers are creating eutrophication, or dead areas, in the oceans. The GAD™ with the fuel cell enables developing countries to produce their own clean energy, fertiliser, potable water and recycled carbonate.

LOCAL MANUFACTURE OF CLEAN ENERGY

The alkaline fuel cell can be manufactured cost competitively with solar energy and more cheaply than wind, nuclear or conventional power production. The technology is available under licence, it can be manufactured locally and is 100% recyclable. The fuel cells can be powered either by renewable hydrogen or ethanol. The system can also be manufactured to produce an electrolyser to enable the onsite production of hydrogen from wind or solar power. www.fairair.london

FUELCELL ENERGY EFFICIENT PRODUCTION OF CLEAN ELECTRICITY, HEAT AND HYDROGEN

MULTI MEGAWATT FUEL CELL IN CONNECTICUT

FuelCell Energy has announced the first deployment of its multi-megawatt SureSource4000™ fuel cell in the City of Danbury, Connecticut. The plant is designed to extract more electrical power from each unit of fuel with an electrical efficiency of approximately 60%. Since it generates power near end users it does not incur the transmission losses typical of larger central generation plants. It also does not emit harmful emissions such as NOx, SOx and particulates that large combustion turbines emit.

The SureSource 4000™ power plant generates enough power for approximately 3,700 average sized homes on less than a quarter of an acre. Jason Few, President of FuelCell Energy, said: "Based on our modular design, we are able to locate our platforms right where the power is needed: in this case, in the middle of downtown Danbury, avoiding inefficient and unsightly transmission infrastructure. Our SureSource 4000™ platform is designed and configured to deliver 60% electrical efficiency while operating with a 95% capacity factor, versus an average capacity factor of 25-35% for solar and wind. Our energy platforms provide electricity, thermal energy, and hydrogen generation."

Tony Rizzo said that Rizzo Companies is working with FuelCell Energy on this project. FuelCell Energy provides the area with high quality engineering, manufacturing and construction jobs, while developing the clean, local power solutions that are so sorely needed.

CARBON NEUTRAL ENERGY FROM BIOGAS

Fuel Cell Energy's 2.3 MW fuel cell will provide carbon neutral energy from biogas to completely power Toyota's facilities at the Port of Long Beach, California. The plant will produce electricity, hydrogen and water from biogas to power local operations and fuel Toyota's zero-emission fuel cell trucks. It will result in improved air quality in the community and lower transport emissions, enabling the Port of Long Beach to achieve air quality compliance. The balance of the electricity will be supplied to the Southern California grid.

ANAEROBIC DIGESTER GAS UTILISED NOT FLARED

Fuelcell Energy has commenced site construction for its 1.4MW biofuels fuel cell project with the City of San Bernardino Municipal Water Department in California. Renewable power produced by the fuel cell will contribute to California's decarbonisation objectives and reduce emissions of particulates, NOx and SOx.

The SureSource power plant will operate on the City's anaerobic digester gas, which will be treated by the proprietary SureSource Treatment™ system, cleanly producing electricity and thermal energy to support the operation of the water reclamation plant. This system allows FuelCell Energy to clean up the biofuel and use it on site without injection into the common carrier gas pipeline. Gas treatment requirements are reduced compared to pipeline injection because the fuel cell system utilizes lowBtu biogas.

The SureSource fuel cell will use methane–rich biogas that would otherwise be flared, wasting energy and producing emissions. Instead the fuel cell will produce clean, renewable, carbon neutral power. Servicing a population of approximately 200,000 residents, the Municipal Water Department delivers more than 15.5 billion gallons of water per year and provides wastewater collection and treatment at the water reclamation plant. The project is expected to become commercially viable in December 2020.

Jason Few commented: "The continuous power profile of our platforms makes them an excellent tit with wastewater treatment plants. Specifically, our fuel cell can operate at peak efficiency utilizing the on-site anaerobic digester gas while providing important thermal heat that enhances the treatment process. Perhaps most importantly, our platform will enable the reduction in usage of another flare."

Miguel Guerrero, General Manager of the San Bernardino Municipal Water Department commented, "Especially important to our city is the reduction of the flaring of the wastewater treatment biogas, which is also a key element in the Department's compliance plans with the South Coast Air Quality Management District."

HIGH CAPACITY FUEL CELLS

Korea Southern Power Company (KOSPO) is getting excellent performance from their 20MW fuel cell park which has eight Suresource 3000™ fuel cells.

In South Korea high population density with limited land requires highly efficient, quiet and affordable power that can be located near centres where the power is used.

The fuel cells have a higher capacity factor than nuclear, geothermal, hydroelectric, wind or solar photovoltaic systems.

CAPACITY FACTOR

KOSPO 20 MW Fuel Cell Park	**97.0%**
Nuclear	93.5%
Geothermal	74.4%
Hydroelectric	39.1%
Wind	34.8%
Solar Photovoltaic	24.5%

Source: U.S. Energy Information Administration for the calendar year 2019

SURESOURCE DELIVER 10 MILLION MEGAWATT HOURS

SureSource™ fuel cell power platforms have delivered 10 million megawatt hours globally since the first commercial installation. SureSource™ plants are currently installed and operating on three continents, with many owned by leading utility companies and global commercial and industrial enterprises from around the world that recognize the benefit of clean, resilient, continuous power. FuelCell Energy is committed to environmentally responsible power solutions that address major energy opportunities around the world.

"Ten million megawatt hours is the culmination of five decades of innovation optimizing the SureSource™ power platform," said Jason Few. "Our fuel cell platform provides differentiated clean energy solutions to meet key utility, community, and commercial and industrial customer's energy needs. They meet the energy needs of critical facilities such as hospitals, schools, and microgrids.

Our platforms are multi-fuel including zero-carbon solutions through the use of onsite biofuels and hydrogen. We are advancing the transition to a large scale, distributed energy infrastructure, with platforms that produces virtually no pollution."

www.fuelcellenergy.com

PROTECTING THE EARTH

PIPE DREAMS

Carbon Tracker points out that the major new gas pipeline planned to cross Canada will be surplus to requirements under the terms they have made for the Paris Agreement. Canada has previously shown leadership on climate change issues, but its government support for new pipelines which are reliant on the failure of the Paris Agreement risks damaging its credibility. www.carbontracker.org

APPEAL AGAINST UNNECCESSARY GREENHOUSE GASES

ClientEarth, the international group of lawyers, has launched a High Court Appeal against the new 3.6GW gas plant planned for Yorkshire, UK. The Government supports this although their own Planning Inspectorate recommended that it be refused on climate change grounds. ClientEarth says that one of the fundamental objectives of the Government's planning policies is to avoid projects that risk locking in unnecessary greenhouse gas emissions for decades to come.
www.clientearth.org

TRANSPORT ALL CHANGE

After decades when carbon emissions from UK transport have remained the same, the UK Transport Secretary recommends all change.

Grant Shapps proposes in the Government consultation *De-carbonising Transport* that public transport and cycling should be the first choice. We will use our cars less and be able to rely on a convenient, cost-effective public transport network he says.
www.gov.uk

ITM POWER'S HYDROGEN FILLING STATIONS

ITM Power is continuing to support key workers during the COVID-19 pandemic. ITM electrolysers generate hydrogen fuel on-site, using renewable electricity and water with the fuel dispensed at the station where it is generated. This means a zero carbon footprint and no use of further transport infrastructure which is under pressure in the current situation. An additional benefit of hydrogen is its role in supporting the drive for cleaner air. This is particularly important for anyone suffering from the virus, for whom clean air is essential.

ITM's customers include the Metropolitan Police in London and Green Tomato Cars, who are helping to get key workers where they need to be. They are continuing to use the Company's hydrogen refuelling stations. Each three minute car refuel provides a range of up to 400 miles.

www.itm-power.com

INTELLIGENT ENERGY FUEL CELLS FOR MICROGRIDS IN MALAYSIA

Intelligent Energy and MBR Global are starting to use surplus solar energy to produce hydrogen from rainwater. This will be used to power zero emission fuel cells for communities without electricity in Asia. Intelligent Energy is supplying the zero emission fuel cells for deployment by MBR Global, which will be implementing a micro-grid to supply power to two remote villages in Malaysia.

MBR Global will be integrating a 1.2kW and a 2.4 kW fuel cell module into a renewable energy based microgrid to supply back-up power to the sites of individual homes which are off-grid.

MBR Global has a number of deployments already in place, including Asia's first hydrogen based off-grid community. Hydrogen generator manufacturer Enapter is supplying its cost-effective, modular electrolyser. Enapter recommended the use of Intelligent Energy fuel cells for the project as they were impressed by their performance. Intelligent Energy's fuel cells are certified and can be used across a range of industries and sectors, such as construction and for applications that need zero emission off grid power.

MBR Global will be integrating Intelligent Energy's fuel cells into its H-RESs system. This is a renewable energy storage platform which uses hydrogen that has been generated from rainwater to produce excess energy for use when required.

Lee Juby of Intelligent Energy said: "With many remote communities still living off-grid, it is important we look at sustainable ways to supply them with a reliable power source. Fuel cells are an ideal solution as they are zero emission, require minimal maintenance and operate quietly."

HUNDREDS OF HYDROGEN FUEL CELL SITES

Despite major advances in energy distribution there are still numerous rural areas within Asia requiring electrical connectivity. Living without electricity means that those living in these rural areas depend on natural daylight for many of their activities and kerosene for cooking and lighting at night. The project with H-RESs is a base line for a roll-out of several hundred sites.

Mark Shiels at MBR Global commented: "Unlike traditional microgrids the H-RESs is a system that does not use traditional batteries for daily energy storage or diesel generators for backup. HRESs is a 'hydrogen sponge' that stores unused photovoltaic energy and converts this to hydrogen for use later. As such H-RESs is 100% green, generates no CO_2 or noise and avoids the issues with battery substitution, replacement, servicing and fuel logistics which are normally associated with traditional microgrids."

He added: "Intelligent Energy's fuel cell modules are highly efficient, very compact and the design of their balance of plant makes this combined fuel cell/electrolyser approach unique in terms of reliability and scalability."

MBR Global has established interest in this 'battery-less, fuel-less' renewable energy storage solution and plans to deploy it in other microgrids in South East Asia.

www.intelligent-energy.com

HYDROGEN AND FUEL CELLS COMING OF AGE

The 16th UK International Conference on Hydrogen and Fuel Cells in Birmingham was postponed and there is a new provisional date of 9th November 2020. The papers for this important meeting are available at www.climate-change-solutions.co.uk

Yane Laperche Riteau of Ballard Power said that 18 countries, accounting for 70% of global GDP, have developed roadmaps for deploying hydrogen energy solutions. At a recent international meeting in Tokyo ministers and delegates pledged to introduce 10 million fuel cell vehicles and other hydrogen powered systems globally by 2030, as well as 10,000 hydrogen refuelling stations. Improvements in technology and products have led to a 60% reduction in the cost of fuel cell battery buses over the past decade.

The total cost of ownership of fuel cell electric vehicles (FCEVs) is currently the same as the total cost of battery electric vehicles for some applications and infrastructure costs are coming down. Further lifecycle cost reductions and economies of scale in manufacturing are expected to enable the total cost of ownership of a fuel cell bus to be equal to a diesel bus by 2027. Fuel cell technology is needed to achieve decarbonisation of the heavy duty transport sector.

Over 570 buses powered by Ballard fuel cells are already in operation and 2,000 trucks are delivering goods. Fuel cell stack life of 30,000 hours is being demonstrated. 12,000 forklifts are in operation and trains and ships are in development.

Chris Murray of Plug Power said that their aim is to change the way the world moves with hydrogen fuel cell vehicles for high growth markets around the world. They have already supplied over 30,000 hydrogen fuel cell powered fork lift trucks and are now aiming for the large market for road vehicles. Fuel cells have ten times higher energy density than batteries and have fast fuelling times. This enables longer range and the potential for shared vehicles.

Plug Power has developed robotic hydrogen fuelling technology for motive power applications. They also have an advanced fuel cell powered Unmanned Aerial Vehicle (UAV) which has flown for over 10 hours.

The power demand for road vehicles ranges from 30kW for light duty trucks and small buses up to 250kW for heavy duty vehicles.

Plug Power are working with Lightning Systems to provide a heavy duty fuel cell powered vehicle for transport between distribution centres.

John Jostins of Microcab said that in the UK fossil fuel car and van sales are to end in 2035. Can fuel cell electric vehicles (FCEVs) step up to meet this challenge? Apart from transport, there are large requirements for hydrogen in buildings and industry. In the UK there will be no more gas for domestic heat in new builds after 2025.

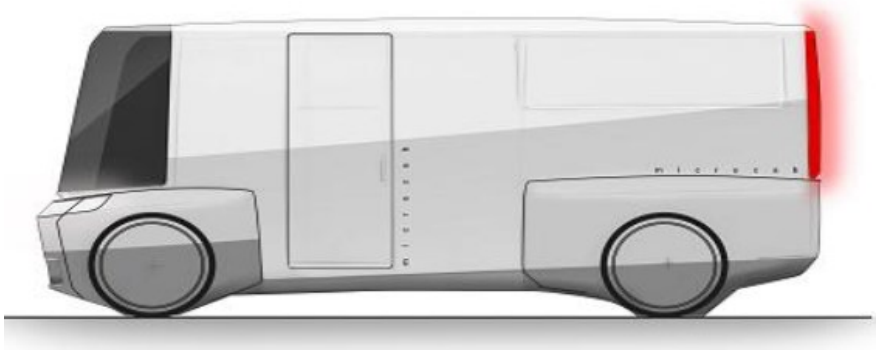
In the UK H21 is a suite of gas industry projects to support conversion of the UK gas networks to carry 100% hydrogen.

Hydrogen is often one of the few alternatives to diesel for larger vehicles such as buses and trucks as well as for trains and ships.

World's largest hydrogen production plant completed

Around the world there are a growing number of hydrogen infrastructure projects. The largest is in Fukushima, Japan which uses 20 megawatts of solar power to produce hydrogen by the electrolysis of water.

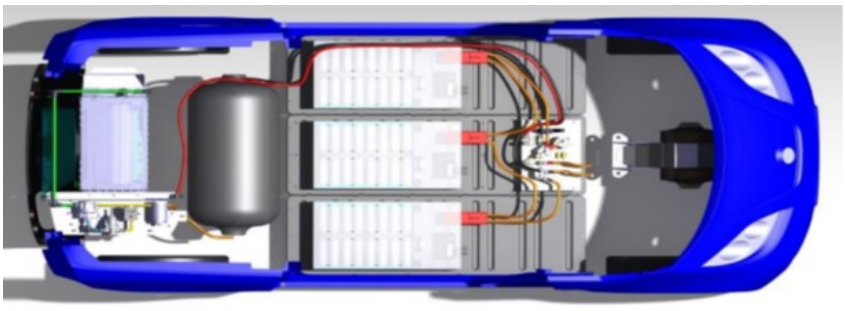
Under the EU's ECOBULK programme a new platform is being developed for larger deliveries or as a ten-seater passenger vehicle with a range of 300 miles. It is designed on circular economy principles, with a 20-year life cycle.



In the Netherlands wind power will be utilised in the NorthH2 project to produce 800,000 tonnes of hydrogen per year by 2040.

There are more than 8,000 operational fuel cell electric vehicles in California, supported by the California Fuel Cell Partnership.

The platform architecture for the Microcab dual fuel Vianova shows the 3.3kW PEM fuel cell and 4.6kWh lithium traction battery. The hydrogen refill time is 3 minutes.



Richard Kemp-Harper of Arcola outlined the rapid deployment of hydrogen fuel cell power trains for heavy duty vehicles.

They assess how much power and energy is needed for a given vehicle on a given route. What battery / fuel cell sizing options would be suitable to fit available space, budget and any supplier constraints. How to optimise efficiency and heat recovery as well as fuel cell and battery lifetime.

HYDROGEN VEHICLE PERFORMANCE
Better acceleration than diesel
Up to 40% more efficient than diesel on an energy basis
Refuelling in 5–10 minutes, depending on filling station capability
Efficiency 6–7kg H2 /100km hydrogen consumption expected, dependent on route profile
180–240 miles of zero emission range
Thermal integration with bus heating

BEV	BEV + FC&H	FCEV
7.5t	7.5t	7.5t
60 mile range	200 mile range	200 mile range
550kg battery	1000kg system	650kg system
4t payload	3.5t payload	3.9t payload

Ralph Clague of Jaguar Land Rover outlined the global action to reduce vehicle emissions. The EU's programme for net zero CO2 emissions from transport starts next year when manufacturers will be fined for each car sold which emits more CO_2/km than the legal limit. Seventeen countries have announced a ban on pure i.c.e. vehicles within the next 10 to 20 years and 34 cities have signed the 'fossil fuel free streets' declaration.

The $C0_2$ emissions of battery and fuel cell powered vehicles, including the manufacture and disposal of battery, fuel cell and H2 tank, are compared. The highest emissions are from battery electric vehicles powered by the grid and fuel cell vehicles powered by hydrogen obtained from natural gas. The lowest emissions are from solar powered battery electric vehicles and fuel cell vehicles powered by the wind.

Sylvie Childs of Hyundai UK, explained that they are taking action to deal with the problems of air pollution as well as climate change, which is causing droughts and flooding and harming wildlife. They support the Government's Road to Zero programme and the COP 26 in Glasgow.

They launched NEXO their hydrogen fuel cell car in 2013. Their second generation system is highly efficient, consuming only 1kg of hydrogen per 100 kms.

They estimate that fuel cell electric vehicles can be cost competitive with battery electric vehicles for larger vehicles or when the range required is 220 miles or over.

Baudouin de Lannoy and Denis Thomas of Hydrogenics-Cummins said that Cummins has a 100 year track record of delivering leading power solutions and is committed to bringing their customers the right technology at the right time. They are supplying PEM and alkaline electrolysers to provide clean energy from renewable sources for industry and transport. Fuel cell installations provide uninterruptible electricity whenever it is needed. Most of the hydrogen used today is not zero emission, as 96% comes from gas, oil or coal. Cummins is producing hydrogen from renewable energy by electrolysis and has no emissions.

This year sees the tipping point for hydrogen electrolysers as we move into the mainstream market with standardised products. Costs are reducing as products are more compact and efficient and are manufactured in larger numbers.

The aim of Hydrogenics-Cummins is to meet the IPCC goal of limiting the global temperature rise to 1.5C. They also support the EU Green Deal which is accelerating hydrogen markets in Europe. Renewable hydrogen has the potential to decarbonise a large range of applications around the world.

Power input 3MW
1,330kgpd

Power input 1.5MW
670kgpd

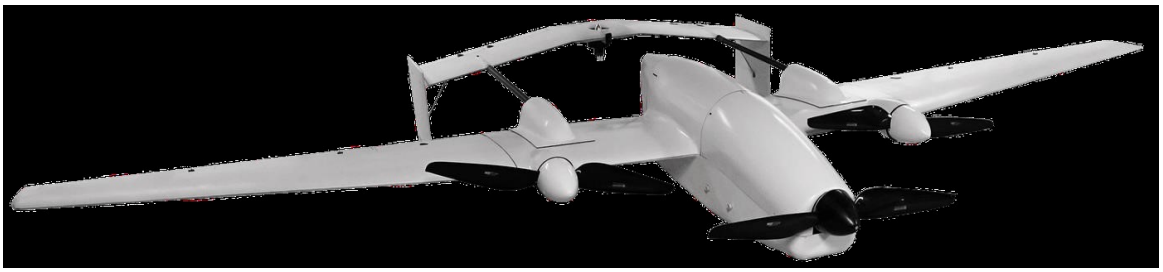
Electrolysers have been developed over the past 20 years and they are now available to meet customers' requirements.

The PEM HyLIZER is flexible and responds in seconds from standstill to demand and load changes.

Dr Lee Juby of Intelligent Energy said that their fully certified fuel cell modules come in a range of power outputs and can be applied to a number of applications. They are self-contained, easy to integrate, compact and power dense. The available energy from hydrogen fuel cells is compared with that from batteries with similar mass, giving illustrations of comparable flight times. The UAV market is expanding rapidly and the first fuel cell UAVs are commercially available. They are ideal for use at infrastructure and construction sites, for agriculture and for fast disaster response.

Several systems are under development, including a hydrogen fuel cell UAV for professional sports, filming, TV and broadcasting.
This will have a flight endurance of 60 minutes while carrying a 5kg payload.

Fuel cell technology is being developed for a range of aviation applications. In Germany, 'Silent Wings' will have vertical take-off and landing. It will carry up to 10 kg for up to 6 hours with a range of up to 700kms.



Paul Henderson of the UK Government outlined the key role of hydrogen in the UK to meet the target of net-zero carbon emissions by 2050.

The Government asked the Climate Change Committee (CCC) to review the role of hydrogen in their long term carbon emission reduction target. The CCC said that a large proportion of hydrogen comes from steam reforming natural gas and proposed that by 2050 carbon capture and storage (CCUS) should be used. There will also be hydrogen from biomass and from renewable electricity.

The Government will develop artificial intelligence and there will be major upgrades to the UK's infrastructure and changes to the way in which people, goods and services are moved. The Department for Business Energy and Industrial Strategy (BEIS) is allocating £33m for hydrogen production and storage, £25m under the Hy4Heat programme and £20m for industrial fuel switching. The Department for Transport is contributing £23m to hydrogen for transport. OFGEM and industry are providing £10m for hydrogen distribution and are also contributing to HyDeploy.

Under the Phase 2 Demonstration programme the Dolphyn project will produce hydrogen by electrolysis on floating offshore wind turbines. The HyNet project will produce hydrogen with carbon capture, use and storage (CCUS). The Gigastack project will produce hydrogen through gigawatt scale PEM electrolysers. Acorn and HYPER will develop advanced reformation processes.

The intermittent power generated by renewable energy sources (wind and solar) also needs reliable low carbon back up power from technologies such as nuclear and natural gas with CCUS and hydrogen. 'Green gases' will also be needed to heat homes, alongside heat pumps and heat networks.

Heidi Genoni of Arup outlined progress with the UK Government funded programme 'Hy4Heat'. The Department of Business Energy and Industrial Strategy (BEIS) is making funding available to expedite the change from using natural gas (methane) to using hydrogen in buildings. They are developing hydrogen-ready appliances which must meet, or improve upon existing emission, safety, and functional requirements. The British Standards Institute is providing guidance to several organisations involved. Appliances include: boilers, cookers and gas fires, as well as some innovative hydrogen appliances.

Hy4Heat participants are carrying out a market study into commercial sectors, covering all hydrogen appliances being developed for catering and production heating, space heating and combined heat and power. They are building on hydrogen safety aspects, covering leakage, accumulation, dispersion and ignition.

Helen Fairclough of EU Focus, the UK national contact point for Horizon 2020 Energy, said that UK organisations will continue to be eligible to participate in Horizon 2020 as partners and coordinators. Eligible organisations will receive EU funding for the lifetime of funded projects, including after 1 January 2021.

Funded projects include ZEFER (Zero Emission Fleet Vehicles for European Roll-out) which is deploying 180 FCEVs in Paris, Brussels and London. This is coordinated by Element Energy with Green Tomato, ITM, Cenex and the London Mayor's Office.

REFHYNE (Clean Refinery Hydrogen for Europe) will install and operate a 10MW electrolyser from ITM Power at a large refinery in Rhineland, Germany.

Horizon 2020 projects in the current year for the transport sector include demonstration of liquid hydrogen as a fuel for the waterborne sector and the development of hydrogen tanks for electric vehicle infrastructure. There is also cyclic testing of renewable hydrogen storage in a small salt cavern and underground storage of renewable hydrogen in depleted gas fields and geological stores.

Philip Brain of Kiwa UK showed how the development and introduction of hydrogen energy fitted together like the pieces of a jigsaw puzzle covering production and standards development, transmission, distribution and storage, skills, safety and application technology, policy support and market regulation.

The Institution of Gas Engineers and Managers (IGEM) have a reference standard for hydrogen and natural gas which can apply to buildings.

'Grey hydrogen' can be produced by steam methane reforming or autothermal reforming (ATR) or it can be obtained from industrial by-products. 'Green hydrogen' is produced by electrolysis using renewable energy. 'Blue hydrogen' comes from any of these sources and the carbon is captured and recycled (CCUS).

Storage of hydrogen can be locally based or connected with other regions. A national base with centralised geological storage would enable production to be disassociated from demand, thereby reducing costs. Programmes are underway to enable the transmission of hydrogen through the existing gas networks.

For transport fuel an extremely high quality hydrogen is required. Alternative low quality hydrogen for light and medium transport is being examined. For heavy duty transport, including shipping, ammonia is being explored as a hydrogen carrier. There are also scaled-up technologies being developed for static applications.

Lorna Millington Future Networks Manager of Cadent outlined the HyDeploy programme at Keele University Campus to provide hydrogen fuel for 100 residential houses, 8 multi-residential buildings, 17 office blocks and laboratories and 7 recreational and service facilities. This has wide interest and support throughout the industry from participants working in the energy field, not just the laboratories.

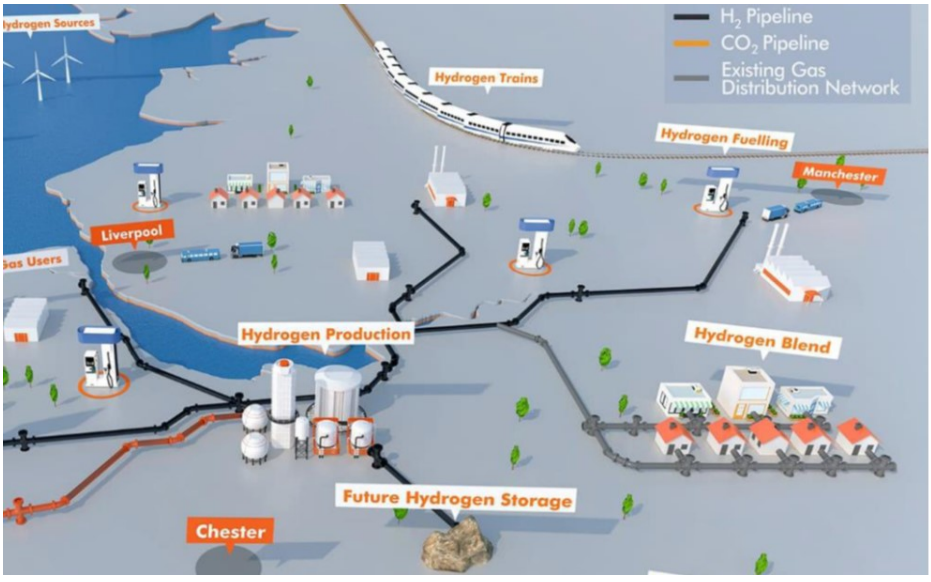
David Gill of Northern Gas Networks said they are putting the consumer at the heart of 'Net Zero'. The aim of the H21 programme is to demonstrate the suitability of the existing gas networks to transport 100% hydrogen. They are providing gas for 6.8 million people in the north of England which is transported over 37,000 kms.

Total energy demand in the UK is still around 20% electricity, 40% transport and 40% gas. There has been significant investment in renewable electricity generation and this is contributing to 'Net Zero'. They are also working with Cadent in the HiDeploy programme to increase the hydrogen blended into the gas supply.

Adam Baddeley of Progressive Energy outlined the work being undertaken to deliver the hydrogen economy. Meeting the 'Net Zero' target requires significant volumes of hydrogen with carbon capture and storage (CCS) delivered via 'industrial clusters'. HyNet will deliver up to 10MtCO2/annum to decarbonisation of NW industry, transport, heat and flexible power generation.

HyDeploy is successfully demonstrating blending at Keele University. HyNetHydrogen distribution and HyNetHydrogen Supply have been launched. HyNetIndustrial Fuel Switching is starting with live hydrogen trials at Unilever and Pilkington. HyNetCCUS (Carbon Capture Use and Storage) is underway.

Their programmes have been in development since 2016 with multiple interlinked elements underway. The first refinery obtained UK Government funding and will supply hydrogen at £43/MWh reducing to £37/MWh. Operation will start around 2025 with full scale reached by 2030.



Industrial clusters delivering hydrogen

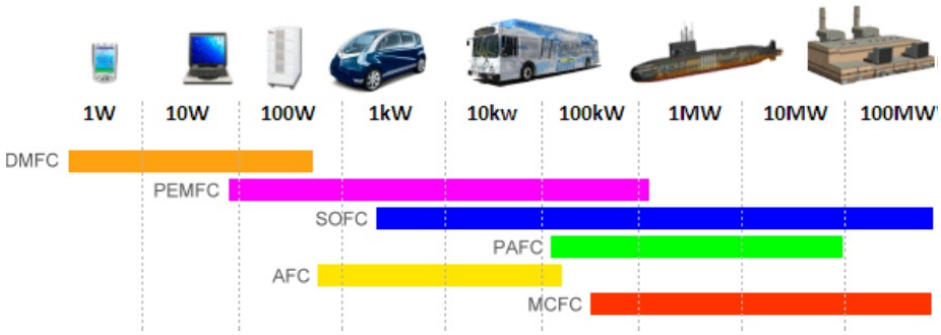
Prof Gavin Walker Director of the Centre for Doctoral Training (CDT) led a presentation by several universities on training the future leaders developing sustainable hydrogen. They are providing industry-led training so that after 4 years the PhD students will be ready for secondment to international research facilities. The team of scientists will cover all aspects from hydrogen generation, storage, distribution, combustion or fuel cells, systems and safety. The scientists based at the Universities of Nottingham, Loughborough, Birmingham and Ulster are funded by the UK Engineering and Physical Sciences Research Council.

Clare Jackson, Consultant at Ecuity explained the work of the Hydrogen Taskforce in securing the role of hydrogen in the future energy mix. The taskforce was launched in the UK Parliament in March 2020 in order to deliver a shared vision for hydrogen. Members include several of the UK's leading companies in the heart of the current and future energy system.

The taskforce has published its first report which makes the case for hydrogen as a critical part of the future energy mix. Their suggestions are that there should be cross-departmental hydrogen strategy. That the Government should allocate £1bn over the next spending review period to hydrogen production, storage and distribution. There should be financial support for blending hydrogen in the gas grid and for industrial use, power generation and transport. Hydrogen-ready boilers should be available by 2025 as a step towards 100% hydrogen heating. 100 hydrogen refuelling stations should be established by 2025 to support the roll-out of hydrogen transport. The taskforce will continue to make an Economic Impact Assessment on the case for hydrogen. They will engage with the media and inform the public on the benefits of hydrogen.

Sean Crespin, Fuel Cell Strategy Lead, Horiba explained how their products and services can be utilised in fuel cell development and manufacturing. The first industrial revolution was based on the steam engine, the second on electricity-based mass production, the third on computer/ internet based-knowledge and information. They now see the fourth industrial revolution based on hydrogen and fuel cells. Hydrogen and fuel cells have the potential to avoid greenhouse gas emissions and provide trillion dollar markets.

Horiba assists with materials development, electrolysers, fuel generation, storage, infrastructure and distribution.



Different fuel cells are suitable for all types of applications from watts to hundreds of megawatts.

Horiba's new fuel cell and battery equipment factory has been set up in Germany.

Mark Griffin of BOC said that in the UK there are 14 publicly available stations supplying 700bar hydrogen. Another nine stations are in various stages of completion, which will increase the range potential for hydrogen vehicles.

There is a cluster around London and BOC is now starting to expand countrywide with stations in Aberdeen, Sheffield and Swindon. BOC is part of a consortium involving Arcola Energy, Mersey Travel, Liverpool City Region and Aberdeen City Council which has been awarded funding to build a hydrogen refuelling station at BOC St Helen to fuel a fleet of 25 double-decker hydrogen buses. Hydrogen will be made available for cars, bikes, trucks, trains and local flights.

BOC are working with their partners to obtain renewable hydrogen from a variety of sources as listed below:

- Using wind, solar or water power
- Biological processes e.g. algae
- Biomass gasification: solid biomass e.g. wood, straw
- Biological reforming: liquid biomass e.g. glycerol
- Steam methane reforming: biogas e.g. landfill, sewage treatment, animal waste

Nick Tudor of DRisk outlined the ways in which the role of software is changing to ensure safety. As research and development lead to prototype and systems development, government, the private sector and investors demand that they meet ever more stringent regulations.

If DRisk's approach is adopted from the outset it will reduce the risk in both early development as well as in market access and regulatory approval.

Michaela Kendall of Adelan outlined a strategy for the international change to fuel cells. Adelan is the UK's longest established fuel cell company.

Prof Michaela Kendall is Chair of the Midlands Hydrogen and Fuel Cell Network (MHFCN) which brings together policy-makers, firms, consumers and civil society actors. Action is coordinated with other regional, national and international organisations.

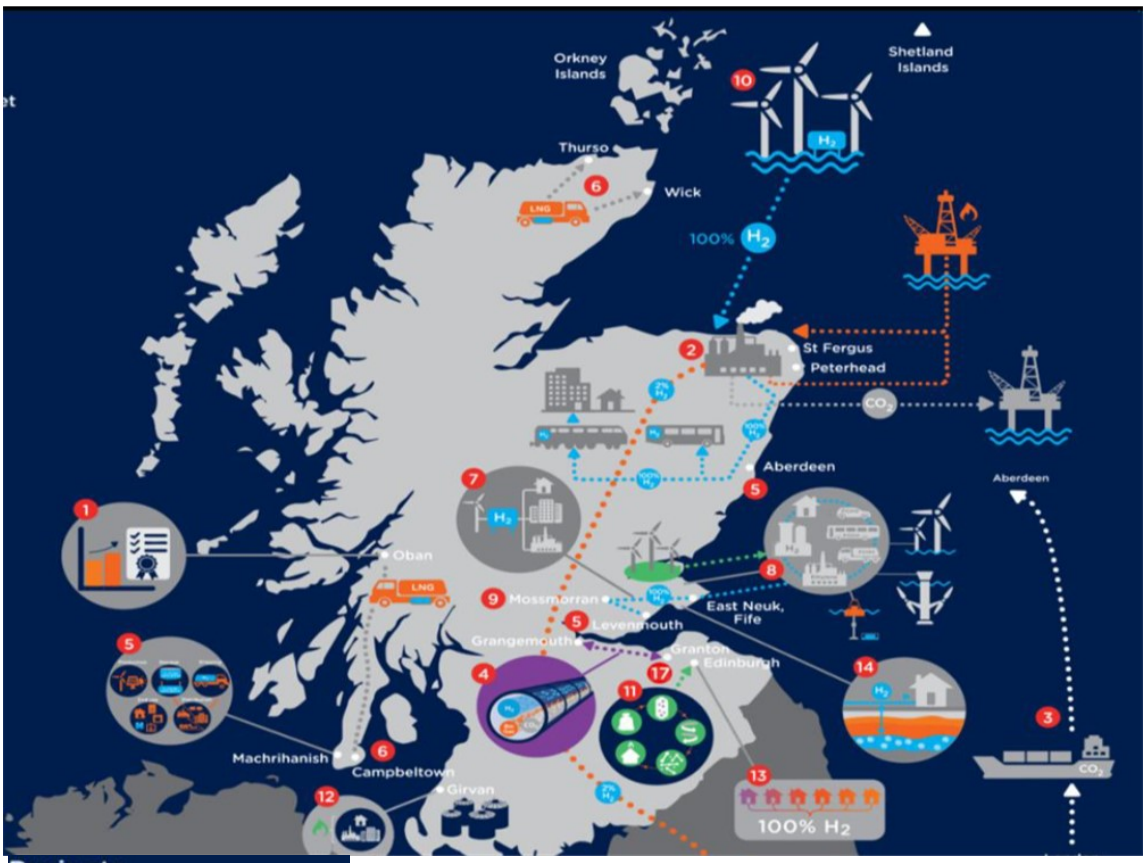
They are developing fuel cell stack assets to move towards commercialisation in key markets, and to develop new skills agenda at every level. They aim to invest in regional centres for fuel cell supply chains and commercialise UK R&D in low carbon energy.

They are making the business case for UK fuel cell technology manufacture with rapid prototyping, manufacture and deployment of UK fuel cell technologies. They are harnessing investments for fuel cell business scale-up and production.

China is leading the international change towards hydrogen fuel cells, with more than 3000 produced in 2019.

There are more fuel cell buses and trucks in the City of Foshan than in the whole of Europe.

Nigel Holmes of the Scottish Hydrogen and Fuel Cell Association (SHFCA) said that Scotland's target for net zero $C0_2$ emissions is 2045, so the hydrogen supply and infrastructure must be established by 2030.



Projects

1. Opening up the Gas Market
2. Aberdeen Vision
3. Project Cavendish
4. LTS Future project
5. H100 project
6. SIU project
7. Methiltoune project
8. East Neuk project
9. Mossmorran project
10. Dolphyn project
11. BioSNG City project
12. Green Billing for Industry
13. Hydrogen City Design
14. HyStorPor

Three quarters of Scotland's electricity was generated from renewables in 2018 and their aim is 100% by 2020. They are resolving the 'Energy Trilemma' of energy security, low cost and low carbon. Large amounts of natural gas come ashore in Scotland and this can be utilised with carbon capture, use and storage (CCUS).

The use of wind energy can be maximised with the use of electrolysis to produce hydrogen. Local hydrogen energy systems are being deployed in Methil, Fife and Levenmouth. In Orkney, 100% of the electricity is derived from renewables. Innovative hydrogen programmes in isolated territories are supported by the EU's BIG HIT funding in Eday, Shapinsay and Kirkwall. More hydrogen will be generated from wind and tidal energy in the Surf 'n' Turf project.

In Aberdeen, the fuel cell bus fleet has carried 1.6 million passengers. It is supported by EU, UK and Scotland funding. A hydrogen powered ferry has been developed with backing from the European Marine Energy Centre (EMEC) and others. Trials are underway of the 6 seater hydrogen fuel cell plane, Hyflyer, which has a range of 300 miles.

The members of the SHFCA are united in their work to introduce hydrogen fuel cells widely by 2030 and net zero carbon emissions by 2045.

Mark Lewis of Tees Valley Combined Authority said that the Tees Valley will be a global leader in clean energy, low carbon industry and hydrogen. They are linked to national and international markets through river and port access, strategic and rail connections and an international airport. They are recognised as a prime location for a UK hydrogen port.

Tees Valley will have the world's first zero carbon industrial hub by 2030. They will achieve a 'net zero' carbon industrial cluster by 2040, providing good jobs with long term prospects that local people can access. This sits at the heart of their framework for growth.

Zero emission power will be transmitted from combined cycle gas turbines with carbon capture and storage (CCS). Bioenergy and power from waste plants will provide negative carbon energy. They will make available decarbonised hydrogen as an industrial energy source. There will be spare capacity in hydrogen plant and distribution systems for use when there is no wind or solar energy.

Ben Madden of Element Energy said that information from the first deployments of fuel cell buses was assisting with scaling up the introduction of large numbers.

The EU Joint Initiative for Hydrogen Vehicles (JIVE) will demonstrate nearly 300 fuel cell buses in 20 European countries.

Minimal infrastructure will be required and the buses will have direct access to hydrogen derived from renewable energy.

The infrastructure for large numbers of cars and trucks is being introduced in the Hydrogen Mobility Europe (H2ME) programme. So far 180 cars have been ordered around Europe in the Zero Emission Fleet Vehicles for European Roll-out (ZEFER) project.

The buses will have a range up to 300 kms if required and refuelling in about 5 minutes. The fuel cells will have the ability to start in freezing conditions and there will be no need for auxiliary heaters in cold climates.

Nick Stapley of Logan Energy Group said that they are advancing hydrogen system engineering and technology integration with inhouse design and manufacture.

They are building up their hydrogen programme with global partners.

Hydrogen generation, purification, compression, storage and transportation will enable the production of clean, green and quiet energy.

A 300kWe MCFC combined heat and power unit is located at 20 Fenchurch Street in London.

Other key projects are a 100kW PEM fuel cell at Goodwood and a 200kWe PAFC combined heat and power (CHP) unit at Transport for London's Palestra building.

There are hydrogen energy, refuelling and electrolyser installations at Levenmouth in Fife and HyTIME in London. They have a bus refueller in Belfast and hydrogen transport in Orkney and in Gencomm, Northern Ireland.

In Tenerife they are obtaining hydrogen by the electrolysis of seawater with renewable energy at a desalination plant.
Hyseas feasibility studies are examining vessels and infrastructure.

Logan Energy are involved in a 90m euro programme entitled Heavenn for the production, storage, distribution and use of green hydrogen in industry, the built environment and the mobility sector. The first project is in The Netherlands.

www.climate-change-solutions.co.uk

BLOOM ENERGY FOR CLEAN TRANSPORT AND HOSPITALS

SAMSUNG PROGRESSING WITH FUEL CELLS

Bloom Energy and Samsung Heavy Industries are progressing with their agreement to design and develop fuel cell-powered ships. "By signing this joint development agreement, Samsung has a plan to develop eco-friendly ships that will lead the future of the industry," said Mr. Haeki Jang of Samsung. "Our goal is to replace all existing main engines and generator engines with these highly efficient solid oxide fuel cells to align with the International Maritime Organization's 2030 and 2050 environmental targets."

Because the fuel cells create electricity through an electrochemical reaction, without combusting the fuel, these ships would be able to improve air quality with a reduction of particulate emissions, including NOx and SOx, by more than 99 percent, and shrink carbon emissions.

Samsung and Bloom Energy are actively working towards the next milestone in this development with a target to present the design to potential customers in 2022.

Following commercialization, the two companies anticipate that the market for Bloom Energy Servers on Samsung's ships could grow to 300 megawatts annually.

"The marine shipping industry has the ability to make a substantial impact on emissions and air quality at ports and across our planet," said KR Sridhar, Chairman of Bloom Energy. "We see a collaboration with one of the world's largest shipbuilders as a moment to make measurable strides in reducing emissions and extending our mission for clean, reliable energy to the seas." The next class of ship to be submitted for design approval is the Liquefied Natural Gas (LNG) carrier.

HYDROGEN FUEL CELLS FOR SOUTH KOREA

Bloom Energy has already sold 120 MW of fuel cells to its partner in South Korea, SK Engineering and Construction (SK E&C). They are now making further sales of fuel cells and solid oxide electrolysers to produce hydrogen.

Jason Ahn, CEO of SK E&C said "Our three year collaboration with Bloom Energy has reinforced our view that Bloom's fuel cell technology is the best in the world. Given the Korean Government's ambitious directive of deploying 15,000MW of fuel cells by 2040, we forecast to sell 400MW per year of fuel cells in the future. The Government roadmap requires the construction of 1,200 hydrogen filling stations to fuel 6.2 million hydrogen cars by 2040."

BLOOM ENERGY SERVERS HELP COVID-19 PATIENTS

Bloom Energy has announced two rapid-deployment fuel cell projects that will support California patients affected by COVID -19. Bloom's Energy Servers provide electricity that can reduce smog-forming pollution and particulate matter by over 99 percent compared with existing combustion-based power generation sources, ensuring that COVID-19 patients with severe respiratory issues breathe clean air.

The COVID-19 crisis is overwhelming existing hospitals, necessitating the deployment of secondary locations to treat patients. Powering these new locations reliably is an immediate challenge that cannot be ignored.

In the first project Bloom deployed a fuel cell-based microgrid capable of powering a field hospital in the main hospital's parking lot to accommodate patient overflow, if needed. Bloom already has 1,200 kilowatts of Energy Servers powering the main hospital and was able to leverage its on-the-ground capabilities to install the microgrid in only three days – five days ahead of schedule.

The microgrid is virtually vibration free and quiet, eliminating potential shaking related damage to sensitive medical equipment and disruption to the local community. It is compact, occupying only three parking spaces at the site.

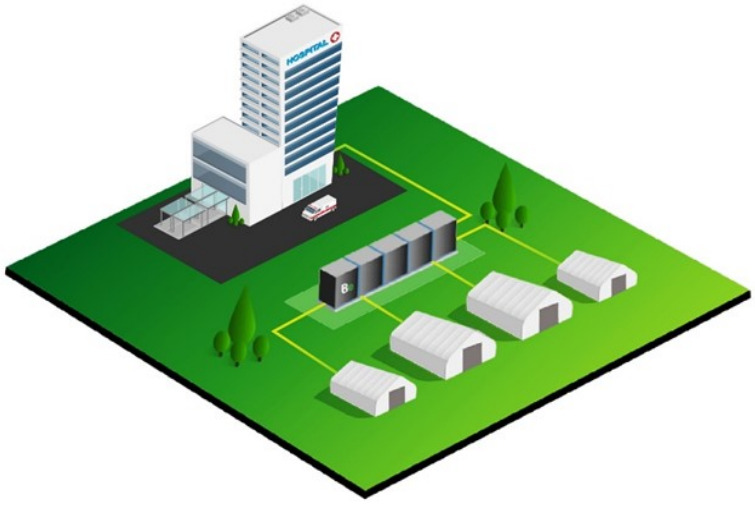
KR Sridhar said that they advanced their rapid deploy microgrid greatly after the Public Safety Power Shutoff events last year to help customers affected by the wildfire related power outages in California. The energy solutions they have spent years developing can be especially useful in this time of national crisis. Bloom has also installed a 400-kilowatt fuel cell-based microgrid to power on site a facility that will hold approximately 100 hospital beds.

Ryan Buras of California Governor's Office of Emergency Services said "Bloom's microgrid solution dramatically reduces electricity costs and greenhouse gas emissions, which fulfils our commitment to providing clean and affordable energy during this pandemic."

A recent study by researchers at Harvard noted a sharply higher mortality rate among coronavirus patients in areas with even slightly increased levels of air pollution.

The microgrid will displace diesel generators, which produce particulates and more than 40 toxic air contaminants, including a variety of carcinogenic compounds. Respiratory disease requires clean air systems.

Bloom Energy is also providing refurbished ventilators to the states of California, Delaware, and Pennsylvania.



Bloom Energy is rapidly deploying fuel cell based microgrids to power existing and temporary hospitals while they care for COVID-19 patients

www.bloomenergy.com

CERES SOFC FOR JAPAN MARKET

Following the successful launch of its combined heat and power product using Ceres Power's solid oxide fuel cell (SOFC) technology, Miura Co. Ltd. has established a specialist maintenance team to support its wider deployment in the Japanese market.

The new fuel cell system has been developed in partnership with Ceres Power in the UK targeting the commercial building sector in Japan. Operating on the main gas supply and capturing heat as hot water, the overall efficiency of the system reaches 90%, delivering both major energy savings and a lower carbon footprint.

Miura believes that the highly efficient fuel cell has an important role to play in energy flexibility and security of supply for its customers and is committed to further work on fuel cell product deployment. Commercial launch of the system took place in October 2019 and the maintenance team is aimed at supporting its longer-term presence in the market. New maintenance departments which specialise in fuel cell products will be established in metropolitan areas such as Tokyo, Osaka, Nagoya and Fukuoka, to enable quick and quality service to customers.

Fuel cell technology generates clean electricity from a chemical reaction of hydrogen and oxygen. Hydrogen can be produced by a variety of methods using either conventional fuels or renewable energy sources and can play a crucial role in reducing the environmental footprint of many power applications. In addition, its potential as an emergency power supply becomes more important given the natural disasters and power outages in 2019.

Miura believes that the highly efficient fuel cell has an important role to play in energy flexibility and security of supply for its customers. www.cerespower.com

EVENTS

9th November 2020 revised provisional date. 16th International Conference Hydrogen and Fuel Cells-Coming of Age
The Conference, Exhibition and Partnering Event will be held in Birmingham, UK
www.climate-change-solutions.co.uk

12th - 16th April 2021
Hydrogen and Fuel Cells Europe
Hannover Fair, Germany. Includes Europe's largest hydrogen and fuel cells exhibition www.h2fc-fair.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.wordpress.com

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, 11 Coopersfield, Aspall Road, Debenham, Suffolk, IP14 6QE