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In these applications, the Jupiter fuel cell hardens the system's power supply: it features reliable full-load operation at temperatures from -33°C to $+46^{\circ}\text{C}$, securing uninterrupted operation of communication equipment even in extremely difficult environmental conditions. This robustness was demonstrated in climate tests on a complete power system integrated into a weatherproof Vertiv cabinet. The tests proved the Jupiter fuel cell based energy system's compliance with the climate-related regulations of several national, European, and international telecommunication standards.

'The telecom and BOS digital radio product qualification is an important milestone for us,' says Dr Peter Podesser, CEO of SFC Energy. 'In these fast-growing markets, systems have to perform autonomously and interruption-

free over long periods of time. Conventional power solutions cannot ensure this high operational security. We expect this latest product qualification to open additional ways for our fuel cells in new demanding industry applications.'

Last autumn SFC and adKor signed a development partnership under which they will both market adKor's Jupiter series fuel cell systems, and together develop a new generation of powerful hydrogen fuel cell systems – up to 100 kW – featuring energy management, for power-intensive industrial off-grid and backup applications [*FCB, December 2018, p13*]. The partnership means that SFC can build on its 30 years of DMFC technology development [*see the SFC feature in January 2013*].

SFC Energy's product portfolio of direct methanol and now also hydrogen fuel cells covers a power spectrum from 40 W to 20 kW, for highly reliable, application-specific, off-grid and backup power solutions in a wide variety of applications including telecom, oil & gas, traffic technology, environmental engineering, defence & security, and clean mobility.

SFC Energy: www.sfc.com/en
adKor GmbH: www.adkor.de/en

Engie acquires fleet of Pragma fuel cell bicycles

Engie Cofely – the energy efficiency and environmental services subsidiary of French electric utility Engie – has signed a commercial partnership with Pragma Industries, which will deliver 200 hydrogen fuel cell bicycles to the company.

The Alpha bikes, manufactured in Biarritz by the startup Pragma Industries, are equipped with a hydrogen fuel cell that gives them a range of more than 100 km (60 miles), and can be fully refueled in less than 3 minutes.

This commercial partnership will enable Engie Cofely and Pragma Industries to commercially launch the hydrogen bicycles in

France. Several communities and companies have already expressed interest in having these bikes in their territories, where they can serve a variety of uses such as eco-tourism, professional fleets, or as an urban self-service system.

The acquisition of this fleet of fuel cell powered bicycles confirms Engie Cofely's commitment to 'green' hydrogen mobility. In 2017 the company was the first in France to acquire a fleet of Renault Kangoo ZE-H2 utility vehicles, featuring hydrogen fuel cell range-extenders [*FCB, July 2018, p2*].

Pragma Industries: www.pragma-industries.com
Engie Cofely: www.engie-cofely.fr [in French]

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ROAD VEHICLES

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The 2019 model of the Honda Clarity Fuel Cell saloon car has started arriving at selected dealerships in California. This next-generation fuel cell electric vehicle has a rated driving range of 360 miles (580 km), and qualifies for the \$5000 California state rebate and/or unrestricted access to high-occupancy vehicle (HOV) lanes.

Retail leasing of the Clarity Fuel Cell – at a competitive \$379 per month – is available through a network of 12 approved Honda dealerships in selected California markets: six in Southern California (Los Angeles and Orange Counties), five in the San Francisco Bay Area, and one in the Sacramento area. The lease terms include an allowance of 20 000 miles (32 200 km) per annum, up to \$15 000 of hydrogen fueling, and eligibility for California's Clean Air Vehicle Stickers to allow single-occupant HOV lane access.

Honda launched the current Clarity Fuel Cell in late 2015 [*FCB, November 2015, p2*], with deliveries starting in Japan the following spring [*April 2016, p2*], and in Europe and California later that year [*January 2017, p2*]. Recent figures from the US Department of Energy show that there are now about 1400 Honda Clarity FCEVs on the road in the US, almost all of them in California [*April 2019, p5*].

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American Honda, Clarity Fuel Cell:
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This initiative is in alignment with the Japanese government's basic hydrogen strategy of promoting the spread and installation of FCEVs and hydrogen refueling stations, and contributes to addressing social issues such as reducing greenhouse gas emissions and delivering the next generation of last-mile transport. It also promotes Yamaha's Transforming Mobility initiative, and is a step towards the targets in its Environmental Plan 2050 of halving product CO₂ emissions and resource usage.

Yamaha Motor Corporation:
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New Flyer's Xcelsior Charge H2 fuel cell bus in Orange County test

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motion to continuously recharge the 100 kWh of batteries, which in turn power a Siemens electric drive motor. The bus operated for 28 hours and achieved 10.4 miles per diesel gallon equivalent. When the hydrogen tanks were fully depleted, the zero-emission bus (ZEB) operated on battery reserve for an additional 20 miles (32 km), to achieve a combined range of 350 miles. The demonstration was completed in April on OCTA's Route 47, operating from Fullerton to Newport Beach in Greater Los Angeles, with a payload representing the fully seated passenger capacity.

New Flyer is delivering 10 of the 40 ft fuel cell electric Xcelsior Charge H2 buses to OCTA, and another 10 to the Alameda-Contra Costa Transit District (AC Transit) in the eastern San Francisco Bay Area, under the Fuel Cell Electric Bus Commercialization Consortium project [*FCB, March 2017, p3*]. The project is being coordinated by the Atlanta-based Center for Transportation and the Environment (CTE).

New Flyer manufactures the Xcelsior Charge H2 bus, which utilises the same reliable drive system as its Xcelsior Charge battery-electric bus, in 40 ft (12 m) and 60 ft (18 m) lengths. Both models successfully completed the Federal Transit Administration's Model Bus Testing Program at Altoona, Pennsylvania in March [*March 2019, p2*], and are eligible for US federal funding [*April 2019, p2*].

New Flyer, Xcelsior Charge H2 bus:
www.newflyer.com/chargeh2

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PowerCell stack orders for Chinese bus firm, German automaker

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In 2017 the vehicle integration company **China Fuel Cell Energy Company** (CFC) received several PowerCell S2 fuel cell stacks, as well as a PS-5 stationary fuel cell system, for alpha tests [*FCB, June 2017, p1*]. The tests have been going well, and CFC has now placed a follow-on order, worth SEK3.8 million (US\$395 000), with deliveries during Q2 of 2019. The stacks will undergo joint beta testing

with one of its end-customers, an unnamed bus manufacturer in northern China. (The PS-5 system is being used for alpha tests with one of China's largest telecom operators.)

The versatile PowerCell S2 PEM fuel cell stack is designed for vehicle applications, with a power output range of 1–35 kW, and can easily be configured for series connection to give higher power. It can run on reformed hydrogen, and has high resilience to elevated levels of contamination. The S2 is made of stainless steel and can withstand vibration and low temperatures much better than stacks with graphite plates, which has been a deciding factor for this latest customer, as the tests will be carried out in a region with a cold climate.

PowerCell has also received an **order for testing fuel cell stacks** for a leading (but also unnamed) German car manufacturer. The order is worth SEK2 million (\$208 000), and the stack tests will be carried out during Q2 of 2019.

The tests will be performed in PowerCell's new fuel cell laboratory [*November 2018, p13*]. This comprises two testbeds, each with a testing capacity for fuel cells and fuel cell systems up to 150 kW, providing PowerCell with an additional total testing capacity of 300 kW. The new facility also enables more realistic test cycles to be run, providing a more accurate basis for evaluation.

PowerCell has also signed a deal with Robert Bosch GmbH in Germany to develop, produce and sell an improved version of the S3 stack [*see page 13*].

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Toyota and Kenworth unveil fuel cell heavy truck at Port of LA

Toyota, Kenworth, the Port of Los Angeles and the California Air Resources Board recently unveiled the first Toyota/Kenworth fuel cell electric heavy-duty trucks at the Port of Los Angeles.

The next-generation truck expands on the capabilities of Toyota's two Project Portal proof-of-concept trucks [*FCB, November 2017, p3 and July 2018, p1*], offering enhanced capability, packaging and performance while offering a range of more than 300 miles (480 km), twice that of a typical drayage truck's average daily duty cycle. The trucks are based on the Kenworth T680 Class 8 tractor unit.

Toyota and Kenworth will deploy 10 trucks as part of the Zero and Near-Zero Emissions Freight Facilities (ZANZEFF) project, hauling

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Hheavy-duty (HD) hydrogen refueling stations might be a subset of the overall hydrogen fueling infrastructure, but serving vehicles such as trucks will be a key part of the large-scale deployment of fuel cell transportation.

This issue features several items on this aspect of hydrogen refueling. **Nel Hydrogen** is a key player in this sector, focusing initially on the US market, and in particular on California. For example, its US subsidiary Nel Hydrogen Inc has received a purchase order from Equilon (Shell Oil Products US) to deliver H2Station[®] units for refueling of heavy-duty fuel cell electric trucks in California [*page 10*]. Nel is also working with Nikola Motor Company to build a network of HD hydrogen stations across the US, to serve trucks and passenger vehicles [*July 2018, p9*].

For its part, **Shell** is participating in the Zero and Near-Zero Emissions Freight Facilities (ZANZEFF) project in California, under which it will develop two new high-capacity, HD hydrogen stations in Wilmington and Ontario as part of an integrated five-station, HD hydrogen refueling network for the Los Angeles basin, where Toyota and Kenworth are demonstrating fuel cell electric heavy trucks for the distribution of cargo from the Ports of LA and Long Beach [*page 3*].

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Other recent developments include the completion of the first stage of a dedicated hydrogen fuel plant by **OneH2** in North Carolina, which will provide deliveries of ready-to-use bulk hydrogen to regional industrial forklift truck and heavy vehicle markets [*April 2019, p9*].

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Since operations began in April 2017, the Project Portal 'alpha' and 'beta' trucks have logged more than 14 000 miles (22 500 km) of testing and real-world drayage operations in and around the Ports of Los Angeles and Long Beach. The first Kenworth/Toyota fuel cell electric truck under ZANZEFF will begin drayage operations in Q4 of 2019, with hydrogen refueling from Shell [May 2018, p8].

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The project will also expand use of zero-emissions technology in cargo terminal and warehouse environments, including the first two zero-emissions yard tractors to be operated at the Port of Hueneme, and expanded use of zero-emissions forklifts at Toyota's port warehouse [see also page 11].

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Hyundai Motor, H₂ Energy JV to deliver 1600 trucks in Europe

H₂ Energy AG in Switzerland and South Korean automaker Hyundai Motor Company have signed a contract to establish a joint venture, called Hyundai Hydrogen Mobility, to tap into Europe's nascent hydrogen mobility ecosystem with fuel cell trucks.

Hyundai Motor will deliver 1600 fuel cell electric heavy-duty trucks to the venture from

2019 through 2025 [FCB, October 2018, p3]. The JV will then lease a large proportion of these fuel cell powered trucks to the H₂ Mobility Switzerland Association, which comprises major refueling station operators, transport and logistics companies, as well as to various other industry players that are promoting hydrogen mobility in Switzerland. The JV will further expand its market presence to other European countries, and could also seek future partnerships in the US.

The establishment of Hyundai Hydrogen Mobility is expected to give Hyundai a foothold in Switzerland, where the demand for fuel cell trucks is expected to grow rapidly thanks to a stiff nationwide road tax on diesel trucks, which will incentivise fleet operators of diesel trucks to switch to zero-emission vehicles. Hyundai Hydrogen Mobility also plans to penetrate the hydrogen sales market through a subsidiary firm that produces and supplies hydrogen in Switzerland, with prospects for entering other European countries. After scaling up to meet demand in Europe, Hyundai will launch its fuel cell commercial vehicle businesses in other regions around the world, including the US and Korea.

Hyundai Motor is a leading developer of automotive hydrogen fuel cell technology, introducing the ix35 (or Tucson) Fuel Cell in 2013 [March 2013, p2], and its next-generation NEXO early last year [January 2018, p2, and see page 8 in this issue].

Hyundai Commercial Vehicle:
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First fuel cell powered garbage trucks in Dutch demonstration

The first hydrogen fuel cell powered garbage truck demonstration under the Life 'N Grab Hy! project has kicked off in the Eindhoven region, in the southern Netherlands. This is the first phase in a series of 10 demonstrations in European cities, which is receiving funding through the European Commission's LIFE programme.

Project partners Baetsen-Groep and Cure Afvalbeheer will collect waste in Eindhoven with two hydrogen powered refuse collection vehicles, built by E-Trucks Europe with

support from Hydrogenics. These will serve the Brainport and Veldhoven districts, in regular daily operation. After collecting waste for two days, the vehicles will be refueled in just 10 minutes at the WaterstofNet hydrogen refueling station on the Automotive Campus in Helmond [FCB, January 2014, p8].

The construction and demonstration of these garbage collection trucks is part of the Life 'N Grab Hy! Project, coordinated by WaterstofNet, a cross-border hydrogen initiative between the southern Netherlands and the Flanders region in Belgium. The project will also demonstrate additional trucks in Cologne, Antwerp and Rotterdam (phase 2), Aberdeen, Bolzano/Merano/Brunico, and Düsseldorf/Herten (phase 3), and possibly in Seville, Oslo and Copenhagen.

The project complements the REVIVE project, launched at the beginning of 2018, which is deploying 15 fuel cell powered refuse collection trucks in seven sites in Belgium, the Netherlands, and Italy [February 2018, p3]. And the HECTOR project will deploy and test seven fuel cell powered garbage collection trucks in selected European locations [see next item].

Life 'N Grab Hy: www.lifeandgrabhy.eu

E-Trucks Europe: www.e-truckseurope.com/en

HECTOR project to demonstrate fuel cells in garbage truck fleets

The HECTOR project – Hydrogen Waste Collection Vehicles in North West Europe – will deploy and test seven fuel cell powered garbage collection trucks in selected locations, to demonstrate that such vehicles can effectively reduce regional emissions from road transport.

Seven trucks will be deployed across northwestern Europe: in Aberdeen (Scotland, UK), Arnhem and Groningen (Netherlands), Duisburg and Herten (Germany), Touraine Vallée de l'Indre (France), and Brussels (Belgium). The first tenders for the garbage collection trucks in the project have already been published, and the first orders will be placed shortly. The first trucks are expected to be in full operation by summer 2020.

The four-year project is coordinated by HyER, the European Association for Hydrogen and Fuel Cells and Electro-mobility in European Regions (formerly HyRaMP), supported by a €5.5 million (US\$6.2 million) grant from the Interreg North West Europe programme. The consortium comprises HyER, the

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Since operations began in April 2017, the Project Portal 'alpha' and 'beta' trucks have logged more than 14 000 miles (22 500 km) of testing and real-world drayage operations in and around the Ports of Los Angeles and Long Beach. The first Kenworth/Toyota fuel cell electric truck under ZANZEFF will begin drayage operations in Q4 of 2019, with hydrogen refueling from Shell [May 2018, p8].

ZANZEFF will help Shell develop two new high-capacity, heavy-duty hydrogen refueling stations in Wilmington and Ontario, joining three stations at Toyota's Long Beach Logistics Services and Gardena R&D facilities to form an integrated, five-station, heavy-duty hydrogen refueling network for the LA basin. These stations will provide hydrogen throughout the region, including >1 tonne/day of renewably produced hydrogen at the Toyota Logistics Services station operated by Shell, and important R&D advances at two stations operated by Air Liquide.

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Kenworth Truck Company: www.kenworth.com

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H₂ Energy AG in Switzerland and South Korean automaker Hyundai Motor Company have signed a contract to establish a joint venture, called Hyundai Hydrogen Mobility, to tap into Europe's nascent hydrogen mobility ecosystem with fuel cell trucks.

Hyundai Motor will deliver 1600 fuel cell electric heavy-duty trucks to the venture from

2019 through 2025 [FCB, October 2018, p3]. The JV will then lease a large proportion of these fuel cell powered trucks to the H₂ Mobility Switzerland Association, which comprises major refueling station operators, transport and logistics companies, as well as to various other industry players that are promoting hydrogen mobility in Switzerland. The JV will further expand its market presence to other European countries, and could also seek future partnerships in the US.

The establishment of Hyundai Hydrogen Mobility is expected to give Hyundai a foothold in Switzerland, where the demand for fuel cell trucks is expected to grow rapidly thanks to a stiff nationwide road tax on diesel trucks, which will incentivise fleet operators of diesel trucks to switch to zero-emission vehicles. Hyundai Hydrogen Mobility also plans to penetrate the hydrogen sales market through a subsidiary firm that produces and supplies hydrogen in Switzerland, with prospects for entering other European countries. After scaling up to meet demand in Europe, Hyundai will launch its fuel cell commercial vehicle businesses in other regions around the world, including the US and Korea.

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ABB and the SINTEF Ocean laboratory in Trondheim will assess how fuel cells and batteries

can best function together for short-distance ferry operations, and how Fiskerstrand can integrate them with other engine room systems.

The ABB-SINTEF joint development programme will also focus on finding solutions to support the hydrogen supply and bunkering infrastructure. In addition, outputs from the new tests are expected to accelerate Norwegian Maritime Authority (NMA) work to modify regulations to better accommodate and approve hydrogen as a fuel.

ABB recently strengthened its collaborative commitment with SINTEF Ocean through additional funding to expand the lab's facilities for future development work [December 2018, p6]. 'Together with the Norwegian Fuel Cell and Hydrogen Test Centre hosted by SINTEF Industry, the extended hybrid lab will help us to further develop, validate, and optimise control strategies for advanced maritime energy system,' says Anders Valland, Research Manager for Maritime Energy Systems at SINTEF Ocean.

Fiskerstrand Verft AS: www.fiskerstrand.no/en

SINTEF Ocean: www.sintef.no/en/ocean

ABB, Integrated Marine Systems:
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Ballard marine centre in Europe, supply deal for Norwegian ferry

Ballard Power Systems Europe A/S – the Danish subsidiary of Canadian-based Ballard Power Systems – is establishing a Marine Centre of Excellence dedicated to fuel cell marine applications, at its engineering, manufacturing and service facility in Hobro. The company has also signed an agreement with Norled A/S, one of Norway's largest ferry and express boat operators, to provide two of its next-generation 200 kW modules to power a hybrid ferry planned to begin operating in 2021.

A new motive fuel cell system manufacturing hall is planned to be constructed and operational in Hobro by the end of 2019, with expected annual production capacity of more than 15 MW of PEM fuel cell modules. Module development work at the **Marine Centre of Excellence** (COE) will be based on Ballard's new FCgen®-LCS fuel cell stack and next-generation heavy-duty power module [FCB, October 2018, p12], which are planned for commercial launch later this year, and will be designed to meet European marine certification requirements.

Ballard Power Systems Europe has also signed an **Equipment Supply Agreement with Norled**, under which it will provide two 200 kW modules that will be used to power a hybrid ferry planned to begin operating in 2021. The vessel – which can carry up to 299 passengers and 80 cars – is expected to be the world's first liquid hydrogen fuel cell powered ferry in commercial operation [see also above item]. The Ballard modules will be designed and manufactured at the new Marine Centre of Excellence in Hobro.

In addition to work on MW-scale marine power solutions with ABB [July 2018, p4], Ballard is involved in a number of sub-MW marine projects, including development of HySeas III, the world's first seagoing renewables-powered car and passenger ferry, which will operate in the Orkney archipelago off the coast of Scotland [July 2018, p5, and see page 12 in this issue]. The company is also participating in the H2Ports project to facilitate a rapid transition at European ports from fossil fuels to low-carbon, zero-emission alternatives based on hydrogen and fuel cells, initially at the Port of Valencia in Spain [February 2019, p3].

Ballard's fuel cell modules offer design flexibility, including modular components and scalable power (from 100 kW to 1 MW-plus) to support vessel propulsion, auxiliary power, and/or system redundancy; extended range; and compatibility of fuel cell DC power with battery hybrid electric architectures. The company's small-scale fuel cell technology is also being targeted at commercial unmanned aerial vehicles [see page 6].

Ballard Power Systems: www.ballard.com

Norled: www.norled.no/en

SMALL STATIONARY

Plug Power partners with CHEM in Taiwan for grid support, backup power

US-based Plug Power is partnering with Chung-Hsin Electric & Machinery Manufacturing Corporation (CHEM) in Taiwan, and has begun fulfilling orders for its 5 kW ProGen hydrogen fuel cell engines, for integration into CHEM's ME2 methanol fuel cell products for grid support and backup power applications.

The ProGen engine supplied to CHEM is an integrated PEM fuel cell system that

includes the fuel cell stack, power conversion, and controls in a single, pre-engineered OEM module. CHEM's system integrates the ProGen engine with its methanol reformer technology to enable on-demand power generation in a turnkey product.

In 2010 CHEM signed a strategic partnership with Oregon-based methanol reformer developer Element One, to incorporate e1's methanol fuel reformers into CHEM's PEM fuel cell systems [FCB, October 2010, p9]. And in 2016, Ballard Power Systems sold its methanol telecom backup power business to CHEM [May 2016, p1].

The CHEM reformer technology enables cost-effective onsite power generation for its core customer base in weak- and off-grid areas. The systems are targeted for use primarily in Asia, Africa and India, where reliable power is critical for communications and village power applications. In 2017 CHEM signed a 10-year, US\$100 million deal with Vodafone, to supply fuel cell electric power for base stations in northeastern India [December 2017, p5].

'This partnership opens up new markets and geography for us,' says Andy Marsh, CEO of Plug Power. 'Beyond e-mobility applications [see page 5, and the Plug Power feature in December 2011], we're continuing to develop solutions for stationary power applications, ensuring reliable next-gen stationary power to people across the globe.'

Plug Power will directly serve the backup power market for communications and other applications through direct sales of its GenSure product line, in addition to the new partnership with CHEM.

Plug Power: www.plugpower.com

CHEM: www.chem.com.tw/?lang=en

LARGE STATIONARY

Bloom powering LA urban community, Agilent Technologies

California-based Bloom Energy is supplying Bloom Energy Server solid oxide fuel cell power systems to The Alhambra mixed-use urban community in the City of Alhambra, a few miles to the east of downtown Los Angeles. Bloom has also provided Bloom Energy Servers that are powering facilities for Agilent Technologies, a global leader in life sciences, diagnostics, and applied chemical markets.

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A new motive fuel cell system manufacturing hall is planned to be constructed and operational in Hobro by the end of 2019, with expected annual production capacity of more than 15 MW of PEM fuel cell modules. Module development work at the **Marine Centre of Excellence** (COE) will be based on Ballard's new FCgen[®]-LCS fuel cell stack and next-generation heavy-duty power module [FCB, October 2018, p12], which are planned for commercial launch later this year, and will be designed to meet European marine certification requirements.

Ballard Power Systems Europe has also signed an **Equipment Supply Agreement with Norled**, under which it will provide two 200 kW modules that will be used to power a hybrid ferry planned to begin operating in 2021. The vessel – which can carry up to 299 passengers and 80 cars – is expected to be the world's first liquid hydrogen fuel cell powered ferry in commercial operation [see also above item]. The Ballard modules will be designed and manufactured at the new Marine Centre of Excellence in Hobro.

In addition to work on MW-scale marine power solutions with ABB [July 2018, p4], Ballard is involved in a number of sub-MW marine projects, including development of HySeas III, the world's first seagoing renewables-powered car and passenger ferry, which will operate in the Orkney archipelago off the coast of Scotland [July 2018, p5, and see page 12 in this issue]. The company is also participating in the H2Ports project to facilitate a rapid transition at European ports from fossil fuels to low-carbon, zero-emission alternatives based on hydrogen and fuel cells, initially at the Port of Valencia in Spain [February 2019, p3].

Ballard's fuel cell modules offer design flexibility, including modular components and scalable power (from 100 kW to 1 MW-plus) to support vessel propulsion, auxiliary power, and/or system redundancy; extended range; and compatibility of fuel cell DC power with battery hybrid electric architectures. The company's small-scale fuel cell technology is also being targeted at commercial unmanned aerial vehicles [see page 6].

Ballard Power Systems: www.ballard.com

Norled: www.norled.no/en

SMALL STATIONARY

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The ProGen engine supplied to CHEM is an integrated PEM fuel cell system that

includes the fuel cell stack, power conversion, and controls in a single, pre-engineered OEM module. CHEM's system integrates the ProGen engine with its methanol reformer technology to enable on-demand power generation in a turnkey product.

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The CHEM reformer technology enables cost-effective onsite power generation for its core customer base in weak- and off-grid areas. The systems are targeted for use primarily in Asia, Africa and India, where reliable power is critical for communications and village power applications. In 2017 CHEM signed a 10-year, US\$100 million deal with Vodafone, to supply fuel cell electric power for base stations in northeastern India [December 2017, p5].

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Plug Power will directly serve the backup power market for communications and other applications through direct sales of its GenSure product line, in addition to the new partnership with CHEM.

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The ABB-SINTEF joint development programme will also focus on finding solutions to support the hydrogen supply and bunkering infrastructure. In addition, outputs from the new tests are expected to accelerate Norwegian Maritime Authority (NMA) work to modify regulations to better accommodate and approve hydrogen as a fuel.

ABB recently strengthened its collaborative commitment with SINTEF Ocean through additional funding to expand the lab's facilities for future development work [December 2018, p6]. 'Together with the Norwegian Fuel Cell and Hydrogen Test Centre hosted by SINTEF Industry, the extended hybrid lab will help us to further develop, validate, and optimise control strategies for advanced maritime energy system,' says Anders Valland, Research Manager for Maritime Energy Systems at SINTEF Ocean.

Fiskerstrand Verft AS: www.fiskerstrand.no/en

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The new Bloom Energy Servers – the fourth generation of the company's SOFC technology – will generate up to 1 MW of power for the campus, with expansion capabilities as the campus grows, meeting approximately 75% of its total demand. The power plants use virtually no water in normal operation, which is an important consideration in drought-prone California.

In other news, **Agilent recently installed 3.5 MW of Bloom Energy Servers** at its corporate headquarters in Santa Clara, California, and a business unit in Little Falls, Delaware. The Energy Servers will reduce net water use and improve air quality by replacing most of the power Agilent previously drew from the grid, while offsetting about 1200 tonnes of CO₂ per annum at Agilent's Silicon Valley headquarters and more than 3500 tonnes of CO₂ per annum at its Delaware facility. The Energy Servers also generate virtually none of the smog-forming particulate emissions that cause air pollution and respiratory distress, an important consideration in Delaware and California, two states that rank among the bottom 10 US states for air pollution.

Bloom Energy recently installed onsite SOFC systems for Extreme Networks Inc in San Jose, California and for a new microgrid at the Warren, New Jersey manufacturing facility of II-VI Inc [*FCB, April 2019, p7*]. And the company's Japanese joint venture has just begun full operation of its first installation in South Korea [*see page 9*].

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FCE deploys SOFC in Pennsylvania, 1.4 MW MCFC in California

Connecticut-based FuelCell Energy has commissioned a sub-MW solid oxide fuel cell project in Pittsburgh, Pennsylvania. The company has also announced a 1.4 MW project with the City of San Bernardino Municipal

Water Department in California, utilising a SureSource™ molten carbonate fuel cell power plant that can operate on onsite biogas.

The advanced, flexible **SOFC power plant in Pittsburgh** employs an easily sited design with significant power density, and can be deployed in a broad range of applications to gain volume and cost scale benefits. The project is supported by the Department of Energy's Office of Fossil Energy, through the National Energy Technology Laboratory. The SOFC product strategically complements FuelCell Energy's existing molten carbonate fuel cells; the MCFC product line provides solutions for multi-MW applications including power generation, carbon capture and distributed hydrogen, whereas the SOFC addresses applications for sub-MW power generation, long-duration energy storage, and distributed hydrogen from electrolysis.

The flexibility of the solid oxide platform stems from the ability of the cells to provide a variety of functions. The common stack can be used in power generation systems such as the Pittsburgh unit. The system can also supply 'waste' heat for onsite combined heat and power (CHP) applications, operating on renewable biogas. The stacks can be deployed in highly efficient solid oxide electrolysis systems; the cells can be operated reversibly in an energy storage system, alternating between electrolysis and fuel cell mode.

In other news, the **1.4 MW MCFC project with the City of San Bernardino** Municipal Water Department will feature a SureSource 1500™ power plant operating on anaerobic digester gas (ADG) and as needed, natural gas, producing clean electricity and thermal energy to support the operation of the SBMWD water reclamation plant. The utility will buy the electricity produced here through a 20-year Power Purchase Agreement. The power plant will use FCE's proprietary conditioning system technology for gas treatment, fuel blending, and quality monitoring.

FuelCell Energy's 1.4 MW MCFC power plant achieved certification operating on biogas in 2017 under the California Air Resources Board (CARB 2013) distributed generation emission standard [*FCB, November 2017, p8*]. The installation is a key element of SBMWD initiatives to comply with South Coast Air Quality Management (SCAQMD) rules related to air pollution control requirements at the water reclamation plant.

FuelCell Energy: www.fuelcellenergy.com

National Energy Technology Laboratory: www.netl.doe.gov

City of San Bernardino Municipal Water Department: www.sbci.org/water

Hyundai NEXO tech to generate electricity in 1 MW Korean plant

South Korean automaker Hyundai Motor Company has signed a Memorandum of Understanding with energy firms Korea East-West Power (EWP) and Deogyang, to build a 1 MW hydrogen fuel cell power generation facility.

Hyundai Motor will supply the PEM fuel cell system, with EWP managing the facility and sale of electricity, and Deogyang supplying the hydrogen. The project marks the first use of locally developed technology in a fuel cell power plant in Korea, rather than the US-sourced technology that the market has been dependent on thus far, from FuelCell Energy [*e.g. FCB, October 2017, p5*] and Bloom Energy [*December 2018, p7, and see page 9 in this issue*].

The 1 MW power facility is scheduled to break ground later this year in the southeastern city of Ulsan, where Hyundai Motor operates the world's largest integrated automobile manufacturing facility. It will consist of two containerised 500 kW generator modules, each loaded with multiple power modules from Hyundai's NEXO fuel cell electric vehicle, which is produced in Ulsan [*January 2018, p2*]. The facility will use byproduct hydrogen piped from a nearby petrochemical complex.

The pilot project represents an opportunity for Hyundai Motor to take its fuel cell technology beyond the automotive industry to achieve economy of scale [*see also page 4*]. EWP will be able to secure an increased share of renewables in its energy mix, while the increased trade volume and stable management of supply and demand will help Deogyang bring down the price of hydrogen.

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Hyundai NEXO: www.hyundai.com/worldwide/en/eco/nexo

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Hyundai Motor will supply the PEM fuel cell system, with EWP managing the facility and sale of electricity, and Deokyang supplying the hydrogen. The project marks the first use of locally developed technology in a fuel cell power plant in Korea, rather than the US-sourced technology that the market has been dependent on thus far, from FuelCell Energy [*e.g. FCB, October 2017, p5*] and Bloom Energy [*December 2018, p7, and see page 9 in this issue*].

The 1 MW power facility is scheduled to break ground later this year in the southeastern city of Ulsan, where Hyundai Motor operates the world's largest integrated automobile manufacturing facility. It will consist of two containerised 500 kW generator modules, each loaded with multiple power modules from Hyundai's NEXO fuel cell electric vehicle, which is produced in Ulsan [*January 2018, p2*]. The facility will use byproduct hydrogen piped from a nearby petrochemical complex.

The pilot project represents an opportunity for Hyundai Motor to take its fuel cell technology beyond the automotive industry to achieve economy of scale [*see also page 4*]. EWP will be able to secure an increased share of renewables in its energy mix, while the increased trade volume and stable management of supply and demand will help Deokyang bring down the price of hydrogen.

Earlier this year Hyundai Mobis – the group's parts and service operation – unveiled a 450 kW power generation system utilising NEXO fuel cell modules at its dedicated fuel cell engine manufacturing facility in Chungju [*February 2019, p1*].

Hyundai NEXO: www.hyundai.com/worldwide/en/eco/nexo

Deokyang Co Ltd: www.deokyang.com/eng

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The Bloom Energy Servers were selected by **The Alhambra's** developer, The Ratkovich Company (TRC), a leading LA real estate development firm, as part of its ongoing strategy to transform the 40 acre (16 ha), former C.F. Braun engineering campus. The Alhambra campus is a LEED Gold certified, mixed-use health-and-wellness-focused community, home to major tenants such as the County of Los Angeles, the University of Southern California's Keck School of Medicine, and the Eastern Los Angeles Regional Center.

The new Bloom Energy Servers – the fourth generation of the company's SOFC technology – will generate up to 1 MW of power for the campus, with expansion capabilities as the campus grows, meeting approximately 75% of its total demand. The power plants use virtually no water in normal operation, which is an important consideration in drought-prone California.

In other news, **Agilent recently installed 3.5 MW of Bloom Energy Servers** at its corporate headquarters in Santa Clara, California, and a business unit in Little Falls, Delaware. The Energy Servers will reduce net water use and improve air quality by replacing most of the power Agilent previously drew from the grid, while offsetting about 1200 tonnes of CO₂ per annum at Agilent's Silicon Valley headquarters and more than 3500 tonnes of CO₂ per annum at its Delaware facility. The Energy Servers also generate virtually none of the smog-forming particulate emissions that cause air pollution and respiratory distress, an important consideration in Delaware and California, two states that rank among the bottom 10 US states for air pollution.

Bloom Energy recently installed onsite SOFC systems for Extreme Networks Inc in San Jose, California and for a new microgrid at the Warren, New Jersey manufacturing facility of II-VI Inc [*FCB, April 2019, p7*]. And the company's Japanese joint venture has just begun full operation of its first installation in South Korea [*see page 9*].

Bloom Energy: www.bloomenergy.com

The Ratkovich Company: www.ratkovich.com

Agilent Technologies: www.agilent.com

FCE deploys SOFC in Pennsylvania, 1.4 MW MCFC in California

Connecticut-based FuelCell Energy has commissioned a sub-MW solid oxide fuel cell project in Pittsburgh, Pennsylvania. The company has also announced a 1.4 MW project with the City of San Bernardino Municipal

Water Department in California, utilising a SureSource™ molten carbonate fuel cell power plant that can operate on onsite biogas.

The advanced, flexible **SOFC power plant in Pittsburgh** employs an easily sited design with significant power density, and can be deployed in a broad range of applications to gain volume and cost scale benefits. The project is supported by the Department of Energy's Office of Fossil Energy, through the National Energy Technology Laboratory. The SOFC product strategically complements FuelCell Energy's existing molten carbonate fuel cells; the MCFC product line provides solutions for multi-MW applications including power generation, carbon capture and distributed hydrogen, whereas the SOFC addresses applications for sub-MW power generation, long-duration energy storage, and distributed hydrogen from electrolysis.

The flexibility of the solid oxide platform stems from the ability of the cells to provide a variety of functions. The common stack can be used in power generation systems such as the Pittsburgh unit. The system can also supply 'waste' heat for onsite combined heat and power (CHP) applications, operating on renewable biogas. The stacks can be deployed in highly efficient solid oxide electrolysis systems; the cells can be operated reversibly in an energy storage system, alternating between electrolysis and fuel cell mode.

In other news, the **1.4 MW MCFC project with the City of San Bernardino** Municipal Water Department will feature a SureSource 1500™ power plant operating on anaerobic digester gas (ADG) and as needed, natural gas, producing clean electricity and thermal energy to support the operation of the SBMWD water reclamation plant. The utility will buy the electricity produced here through a 20-year Power Purchase Agreement. The power plant will use FCE's proprietary conditioning system technology for gas treatment, fuel blending, and quality monitoring.

FuelCell Energy's 1.4 MW MCFC power plant achieved certification operating on biogas in 2017 under the California Air Resources Board (CARB 2013) distributed generation emission standard [*FCB, November 2017, p8*]. The installation is a key element of SBMWD initiatives to comply with South Coast Air Quality Management (SCAQMD) rules related to air pollution control requirements at the water reclamation plant.

FuelCell Energy: www.fuelcellenergy.com

National Energy Technology Laboratory: www.netl.doe.gov

City of San Bernardino Municipal Water Department: www.sbci.org/water

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Nel is also working with Nikola Motor Company to build a network of heavy-duty hydrogen refueling stations across the US, to serve trucks and passenger vehicles [July 2018, p9]. Another Nel subsidiary, Nel Hydrogen Electrolyser, is supplying a 4.5 MW electrolyser for a fossil-free steel production project in Sweden [see page 12].

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twice as many fuel cell electric vehicles as in Japan [April 2019, p5, and see page 2 in this issue]. The state currently has 39 commercial hydrogen stations [April 2019, p5, and see page 9 in this issue], about one-third of the total in Japan [March 2019, p7]; Iwatani operates 26 of the latter.

The company has also recently **added two stations in Japan**, at Osaka Itami Airport in the southern Kansai region and in Niigata City on the northwestern coast. The Iwatani Hydrogen Station Osaka Itami Airport will help to connect the airport with the nearby Kansai International Airport. The station is the first that Iwatani has developed jointly with the Japan H₂ Mobility consortium (JHyM) [April 2018, p9], and utilises compressed hydrogen brought in from offsite. The Iwatani Hydrogen Station Niigata Chuo is the first in the Hokushinetsu region, along the Sea of Japan, and has also been developed jointly with JHyM. It utilises liquefied hydrogen brought in from offsite. Both stations have a supply capacity of 300 Nm³/h, sufficient to refuel six FCEVs per hour.

Iwatani Corporation: www.iwatani.co.jp/eng

McPhy's Augmented McFilling stations for heavy-duty vehicles

French hydrogen production and distribution equipment specialist McPhy launched its new range of Augmented McFilling hydrogen refueling stations at the recent Hannover Messe trade fair in Germany. The new product line is intended to decarbonise heavy transportation and long-distance vehicles such as trains, trucks, and buses.

Augmented McFilling is a new, 'smart' hydrogen station architecture for heavy-duty vehicles, with integrated software intelligence that makes the station dynamically reconfigurable for any usage scenario and with real-time adaptation to customer needs, with no limit on the available capacity – 2000, 4000, 10 000 kg/day or more.

'Our smart supervision software greatly increases the availability and flexibility of hydrogen stations, and therefore meets the 24/7 needs of heavy transports, while optimising the system's energy efficiency, as well as investment and operating costs,' says Pascal Mauberger, Chairman and CEO of McPhy. 'Following the launch of the Augmented McLyzer range in 2018 [FCB, May 2018, p13], our new generation of Augmented McFilling stations

allow us to offer a complete range of smart, modular, without capacity limits, low-carbon hydrogen production and distribution solutions, already fit-for-purpose and ready for the future.'

McPhy provides turnkey solutions tailored to its clients' applications, such as renewable energy surplus storage and valorisation in Power-to-Gas (P2G) applications [July 2018, p9], refueling of fuel cell electric vehicles [April 2019, p14], and zero-carbon hydrogen as a raw material for industry [August 2018, p12, and see the EDF item on page 12 in this issue]. The company has development, engineering and production sites in France, Italy and Germany, as well as international subsidiaries to provide global sales coverage of its innovative hydrogen solutions.

McPhy: <https://mcphy.com>

SimpleFuel for green hydrogen at Toyota's Motomachi Plant

Japanese automaker Toyota Motor Corporation has installed a SimpleFuel™ hydrogen refueling station at its Motomachi Plant in Toyota City, Aichi Prefecture, which utilises a fleet of fuel cell powered forklifts.

The SimpleFuel product is a compact hydrogen refueling station that uses electricity from solar photovoltaic (PV) panels at the plant site to produce low-carbon hydrogen from alkaline electrolysis of water, which is then compressed to 350 bar and supplied to the fuel cell powered forklifts. It can produce up to 99 Nm³/day (8.8 kg/day) of hydrogen, enough to fuel seven or eight forklifts. Its small size means it can be installed in small spaces, making it suitable for refueling forklifts within the plant.

Toyota aims to reduce CO₂ emissions at its plants by replacing conventional forklifts with fuel cell powered forklifts [see also page 3]. This endeavour began at the Motomachi Plant, with the introduction in early 2017 of two forklifts manufactured by Toyota Industries Corporation [FCB, February 2017, p3], followed by an additional 20 forklifts a year later [April 2018, p4]. A hydrogen station has been running at the Motomachi Plant – where the Toyota *Mirai* fuel cell electric vehicle is assembled – since March 2018, in conjunction with the increasing numbers of fuel cell powered forklifts in use. This year, the Ministry of the Environment's is offering a subsidy for measures to combat CO₂ emissions that utilise renewable energy-based hydrogen, which is supporting the introduction of the SimpleFuel unit and an additional 50 fuel cell powered forklifts.

SimpleFuel has been jointly developed and manufactured by Ivys Energy Solutions and PDC Machines in the US, and won the \$1 million H₂ Refuel H-Prize in 2017 [February 2017, p6]. The Motomachi system is the second unit exported to Japan, following an appliance being used with a Toyota Industries fuel cell powered forklift truck at a wood products manufacturer [April 2018, p9].

SimpleFuel, Ivys Energy Solutions:
www.ivysinc.com/simplefuel-main-page

Toyota Industries Corporation: www.toyota-industries.com

ENERGY STORAGE & P2G

Green hydrogen plans for German region in GET H2 initiative

The GET H2 initiative in Germany aims to use hydrogen to advance the national 'energy transition', and its first project is a planned Power-to-Gas (P2G) plant with 105 MW capacity, transport, storage and hydrogen utilisation in the Emsland district of Lower Saxony, in northwestern Germany.

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Iwatani Corporation: www.iwatani.co.jp/eng

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Hydrogenious Technologies: www.hydrogenious.net

GREEN HYDROGEN

Orkney integrates tidal, grid and hydrogen, virtual energy project

Two major projects have been launched in Orkney, Scotland, UK to demonstrate clean energy technologies and eventually eliminate the need for fossil fuels. The €11 million (US\$12.4 million) Integrating Tidal Energy into the European Grid (ITEG) project will develop an all-in-one solution for generation of clean predictable energy, grid management, and production of hydrogen from excess capacity at an existing tidal energy test site. And the ReFLEX (Responsive Flexibility) Orkney project will demonstrate a first-of-its-kind Virtual Energy System (VES) interlinking local electricity, transport, and heat networks into one controllable, overarching system.

The ITEG project is led by the European Marine Energy Centre (EMEC) in Orkney, and brings together partners from the UK, France, Belgium, and the Netherlands to address energy-related carbon emissions in North-West Europe and tackle grid export limitations in remote areas such as Orkney [FCB, July 2018, p10]. The project consortium includes Scotrenewables, AREVA H₂Gen, Energy Systems Catapult, Energy Valley/New Energy Coalition, University of Caen Normandy, University of Le Havre Normandy, Ghent University, and the Normandy Development Agency.

The project, funded by the Interreg North-West Europe (NWE) programme, part of the European Regional Development Fund (ERDF), will deliver an onshore energy management system at EMEC's Fall of Warness tidal test site, off the northern island of Eday. This will support hydrogen production using an AREVA H₂Gen electrolyser, powered by Scotrenewables' 2 MW SR2-2000 floating tidal energy converter.

Meanwhile, the first phase of the £28.5 million (US\$37 million) ReFLEX Orkney project – funded by UK Research & Innovation's Industrial Strategy Challenge Fund – will create a Virtual Energy System

(VES) in Orkney to digitally link distributed and intermittent renewable generation to flexible demand. The project – also led by EMEC [see the News Focus in October 2017, and June 2018, p8 and January 2019, p9] – brings together a consortium of Scottish partners – Solo Energy, Aquatera, Community Energy Scotland, Heriot-Watt University in Edinburgh, and Orkney Islands Council – as well as multinational energy company Doosan Babcock.

The project will demonstrate flexible energy balancing technologies, utilising domestic, business and large-scale batteries, vehicle-to-grid (V2G) chargers, electric vehicles, an island community-powered electric bus and e-bike integrated transport system, flexible heating systems, and a Doosan industrial-scale hydrogen fuel cell.

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EDF's new Hynamics subsidiary to produce, market low-carbon H₂

French electric utility EDF used the recent Hannover Messe trade fair in Germany to launch its Hynamics subsidiary, which will act as the Group's focus for offering low-carbon hydrogen for industry and mobility customers. EDF aims to become a key player in the hydrogen sector in France and worldwide.

Hynamics offers two low-carbon hydrogen solutions. For industrial clients, for whom hydrogen is a necessity (refinery, glassware, agri-food, chemistry etc.), it will install, run and maintain hydrogen production plants, by investing in the necessary infrastructure. For mobility providers, both public and professional, Hynamics will help to link different areas with service stations to provide hydrogen to refuel fleets of commercial vehicles, such as trains, buses, garbage lorries [e.g. see page 4], utility vehicles, and waterway transport.

Last summer EDF acquired a stake in the French hydrogen specialist McPhy, a leading player in this market, establishing an industrial and commercial partnership to develop zero-

carbon hydrogen for use in France and around the world [FCB, July 2018, p10, and see page 11 in this issue]. The creation of Hynamics will apply low-carbon hydrogen to new uses.

Hynamics teams have identified and worked on some 40 target projects, in France as well as Belgium, Germany, and the UK. Hynamics is the result of an 'intrapreneurial' project led by 10 or so employees and nurtured within EDF Pulse Expansion, the Group's startup incubator. EDF (Électricité de France) joined the Hydrogen Council last autumn, at steering member level [October 2018, p14].

Hynamics: <https://hynamics.com/en>

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Nel awarded 4.5 MW electrolyser order for HYBRIT steel project

Hybrit Development AB in Sweden, a joint venture between steel producer SSAB, mining company LKAB and power company Vattenfall, has ordered a 4.5 MW electrolyser solution from Nel Hydrogen Electrolyser, for its pilot plant in the northern city of Luleå.

The HYBRIT (Hydrogen Breakthrough Ironmaking Technology) initiative, supported by the Swedish Energy Agency, aims to develop the world's first fossil-free, ore-based steelmaking technology. The use of coal will be replaced with zero-carbon electricity and hydrogen, eliminating CO₂ emissions from steel production.

The venture began construction of the unique plant in Luleå in June 2018. The pilot plant will produce fossil-free steel between 2021 and 2024, at which point the project will enter a demonstration phase; the goal is to have an industrial process in place by 2035. The steel industry is currently one of the highest carbon emitting industries, accounting for up to 7% of global CO₂ emissions. If successful, the HYBRIT project could cut Sweden's CO₂ emissions by 10%.

In today's ore-based steelmaking process, iron ore pellets are converted to metallic iron by reduction in a blast furnace. The iron oxide and carbon react to form metallic iron, as well as CO₂ gas; the iron is further processed before a semi-finished steel product is produced. The HYBRIT process is based on direct reduction of iron ore using fossil-free energy and hydrogen. Hydrogen gas is produced by water electrolysis using fossil-free electricity, and reacts with the oxygen in the iron ore, forming metallic iron and water vapour.

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Hydrogenious Technologies: www.hydrogenious.net

GREEN HYDROGEN

Orkney integrates tidal, grid and hydrogen, virtual energy project

Two major projects have been launched in Orkney, Scotland, UK to demonstrate clean energy technologies and eventually eliminate the need for fossil fuels. The €11 million (US\$12.4 million) Integrating Tidal Energy into the European Grid (ITEG) project will develop an all-in-one solution for generation of clean predictable energy, grid management, and production of hydrogen from excess capacity at an existing tidal energy test site. And the ReFLEX (Responsive Flexibility) Orkney project will demonstrate a first-of-its-kind Virtual Energy System (VES) interlinking local electricity, transport, and heat networks into one controllable, overarching system.

The ITEG project is led by the European Marine Energy Centre (EMEC) in Orkney, and brings together partners from the UK, France, Belgium, and the Netherlands to address energy-related carbon emissions in North-West Europe and tackle grid export limitations in remote areas such as Orkney [*FCB, July 2018, p10*]. The project consortium includes Scotrenewables, AREVA H₂Gen, Energy Systems Catapult, Energy Valley/New Energy Coalition, University of Caen Normandy, University of Le Havre Normandy, Ghent University, and the Normandy Development Agency.

The project, funded by the Interreg North-West Europe (NWE) programme, part of the European Regional Development Fund (ERDF), will deliver an onshore energy management system at EMEC's Fall of Warness tidal test site, off the northern island of Eday. This will support hydrogen production using an AREVA H₂Gen electrolyser, powered by Scotrenewables' 2 MW SR2-2000 floating tidal energy converter.

Meanwhile, the first phase of the £28.5 million (US\$37 million) ReFLEX Orkney project – funded by UK Research & Innovation's Industrial Strategy Challenge Fund – will create a Virtual Energy System

(VES) in Orkney to digitally link distributed and intermittent renewable generation to flexible demand. The project – also led by EMEC [*see the News Focus in October 2017, and June 2018, p8 and January 2019, p9*] – brings together a consortium of Scottish partners – Solo Energy, Aquatera, Community Energy Scotland, Heriot-Watt University in Edinburgh, and Orkney Islands Council – as well as multinational energy company Doosan Babcock.

The project will demonstrate flexible energy balancing technologies, utilising domestic, business and large-scale batteries, vehicle-to-grid (V2G) chargers, electric vehicles, an island community-powered electric bus and e-bike integrated transport system, flexible heating systems, and a Doosan industrial-scale hydrogen fuel cell.

European Marine Energy Centre: www.emec.org.uk

Solo Energy: www.solo-energy.com

Aquatera: www.aquatera.co.uk

Community Energy Scotland:
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Heriot-Watt University, Electrical, Electronic & Computer Engineering: <https://tinyurl.com/hw-eece>

Orkney Islands Council: www.orkney.gov.uk

Doosan Babcock: www.doosanbabcock.com

EDF's new Hynamics subsidiary to produce, market low-carbon H₂

French electric utility EDF used the recent Hannover Messe trade fair in Germany to launch its Hynamics subsidiary, which will act as the Group's focus for offering low-carbon hydrogen for industry and mobility customers. EDF aims to become a key player in the hydrogen sector in France and worldwide.

Hynamics offers two low-carbon hydrogen solutions. For industrial clients, for whom hydrogen is a necessity (refinery, glassware, agri-food, chemistry etc.), it will install, run and maintain hydrogen production plants, by investing in the necessary infrastructure. For mobility providers, both public and professional, Hynamics will help to link different areas with service stations to provide hydrogen to refuel fleets of commercial vehicles, such as trains, buses, garbage lorries [*e.g. see page 4*], utility vehicles, and waterway transport.

Last summer EDF acquired a stake in the French hydrogen specialist McPhy, a leading player in this market, establishing an industrial and commercial partnership to develop zero-

carbon hydrogen for use in France and around the world [*FCB, July 2018, p10, and see page 11 in this issue*]. The creation of Hynamics will apply low-carbon hydrogen to new uses.

Hynamics teams have identified and worked on some 40 target projects, in France as well as Belgium, Germany, and the UK. Hynamics is the result of an 'intrapreneurial' project led by 10 or so employees and nurtured within EDF Pulse Expansion, the Group's startup incubator. EDF (Électricité de France) joined the Hydrogen Council last autumn, at steering member level [*October 2018, p14*].

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COMMERCIALISATION

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The Protos site, which is near Ellesmere Port in Cheshire, is being developed by Peel Environmental, a subsidiary of one of the UK's leading infrastructure, transport, and real estate companies. The £700 million (US\$890 million) energy hub clusters complementary businesses, including energy-intensive industries, associated supply chain, and energy generation.

'This project sums up the vision for Protos – a closed-loop solution where innovative technologies are used to create value from waste and provide low-carbon energy sources,' says Myles Kitcher, Managing Director of Peel Environmental. 'Not only will this help tackle the problem of waste plastics, it will provide a local source of hydrogen which could be used as a clean and low-cost fuel for buses and HGVs [heavy goods vehicles] across the region.'

In 2014 PowerHouse Energy ordered an initial alkaline fuel cell system from AFC Energy, to test its operation with PHE's ultra-high-temperature gasification technology [FCB, May 2014, p4]. AFC subsequently confirmed its first commercial sale of a small-scale hydrogen

alkaline fuel cell system to PowerHouse [April 2017, p6; also see the AFC Energy feature in December 2015, and page 14 in this issue].

Waste2Tricity: www.waste2tricity.com

Powerhouse Energy: www.powerhouseenergy.net

Protos: www.thisisprotos.com

AFC Energy: www.afcenergy.com

COMMERCIALISATION

First Grove FCEVs produced in China, distribution deals

The Chinese car manufacturer Grove Hydrogen Automotive Company Ltd has produced its first fuel cell electric vehicles at its factory in Chongqing. The company has also signed an agreement to partner with Clickdrive in Australia to distribute its vehicles in Australia and New Zealand, and with the State of Minas Gerais in Brazil to serve that market.

Grove's new manufacturing facility, in the Nan'an district of the central city municipality of Chongqing, features state-of-the-art technology for installation of its hydrogen fuel cell powertrain, and incorporates the use of advanced carbon fibre materials in the car frame in a very low environmental impact facility. In the coming months the company will fine-tune the site to ensure the highest quality production of vehicles. This is the company's first factory outside its home city of Wuhan, Hubei Province [FCB, April 2019, p2], and will be both a key production and market focus site. Production of road-going vehicles will begin towards the end of 2019, before ramping up to full production during 2020 for local, national, and international distribution.

Grove has also signed a **cooperation agreement with Clickdrive Pty Ltd**, for the distribution of Grove vehicles in Australia and New Zealand. The partners want to become a leading part of the hydrogen roadmaps for both countries, by developing a series of vehicles which support the growth of their hydrogen refueling infrastructures, and providing vehicles which match the requirements of Australian and New Zealand consumers. These imports are expected to start in 2020. Sydney-based Clickdrive is a subsidiary of a major vehicle distribution company, representing several brands in Australia and New Zealand.

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Brazil, to proceed with development planning for production and distribution of Grove FCEVs and hydrogen refueling infrastructure in Brazil, and potentially across South America in the future. The partners will establish a joint body to evaluate and plan a programme to establish the entire scope of a hydrogen economy, from clean energy production of hydrogen, distribution, and development of vehicles suited to Brazilian needs, and integrating opportunities for Brazilian companies to take part in the overall chain. The transnational working group aims to start testing in the state capital Belo Horizonte by early 2020, and establish operations by the end of 2020.

Grove Hydrogen Automotive Co Ltd: www.grove-auto.com

Clickdrive: www.clickdrive.io

PowerCell, Bosch sign for joint development, licensing of S3 stack, but Nikola deal is off

PowerCell Sweden and Robert Bosch GmbH in Germany have signed an agreement regarding the development, production, and sale of the PowerCell S3 PEM fuel cell stack for the automotive segment. However, PowerCell has been informed that US-based Nikola Motor Company does not plan to use PowerCell stacks in its trucks once they begin series production.

The agreement with Bosch includes joint development of the PowerCell S3, and licenses Bosch the exclusive right to produce and sell the new, improved version of the S3 for automotive applications such as cars, trucks, and buses for seven years following the start of production. Bosch will pay PowerCell a €50 million (US\$55.8 million) lump sum for the licence, and a royalty fee for every product sold during the contract period.

Bosch is the world's largest automotive industry supplier, and is developing components for automotive fuel cell systems. Bosch has previously received deliveries of PowerCell stacks for its systems, and last December the companies agreed to joint development cooperation of the S3 stack for the automotive segment [FCB, January 2019, p12].

PowerCell will maintain its rights to commercialise the S3 stack and the jointly developed new version in non-automotive applications, like stationary [e.g. July 2018, p6] and marine [e.g. September 2018, p4], which are not covered by the agreement. The agreement

does not cover the stack being developed by PowerCell within the German Autostack Industrie (ASI) project [July 2018, p15], nor does it cover the PowerCell S2 stack.

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solutions, under which they will jointly design and deploy an integrated turnkey off-grid EV charger incorporating Rolec's EV charging platform and AFC's fuel cell system. The first demonstration system is expected to be deployed by June.

The partners will define a series of customer-driven products, which will be modular and allow EV charging from a base unit for two vehicles, up to larger mass-scale deployment. Under the agreement, a reference system will be delivered that can be deployed on a temporary basis for marketing and business development purposes.

AFC Energy: www.afcenergy.com

Rolec Services Ltd: www.rolecserv.com

Atrex demos 1.5 kW SOFC running on JP-8 fuel to US military

Massachusetts-based Atrex Energy has successfully demonstrated its advanced solid oxide fuel cell power source for US Department of Defense (DOD) use. The company's commercial SOFC generator was operated on desulfurised JP-8 jet fuel at 1.5 kW, with net DC efficiency of ~40% (fuel LHV to electricity).

The demonstration was attended by representatives of the Office of Secretary of Defense (OSD), US Army Engineering and Research Development Center (ERDC), US Army Communications Electronics Research Development Center (CERDEC), US Army Research Lab (ARL), and the US Army Ground Vehicle Systems Center (GVSC).

Atrex has developed a new reforming technology for liquid logistic fuels, whereby an integral reformer is intimately connected to each tubular SOFC in such a way that 'waste' heat generated in the cell is readily used by the reformer, and vice versa. 'The rapid heat transfer maintains almost isothermal conditions in the reformer. This enables a sub-stoichiometric oxygen-to-carbon (O/C) ratio in the fuel reforming stage, since the exothermicity of the reaction is less important,' explains Dr Praveen Cheekatamarla, Director of Research & Product Development. 'By the integration of any reforming process directly with the operation of the fuel cell, a new paradigm is achieved, resulting in efficient power production.'

Atrex Energy – formerly Acumentrics SOFC Corporation – has been developing SOFCs for defence applications for more than eight years, and has demonstrated innovative

technology for high efficiency, power density, and reliability. The company has delivered more than 650 commercial fuel cell systems in various remote power markets utilising well-head natural gas or liquefied petroleum gas (LPG) as fuels, collectively accumulating >6 million hours of operational lifetime [e.g. *FCB*, June 2015, p5].

Atrex has brought these innovations to DOD's requirements for SOFC power sources in the 500 W to 3 kW range, using hydrocarbon fuels such as desulfurised JP-8, F24, diesel, natural gas, LPG, biogas, syngas, butane, and hydrogen. The company aims to continue development of prototypes in this power range as fuel-flexible, lightweight, hybrid configurations designed to meet DOD's efficiency and ruggedisation needs.

Atrex recently demonstrated an ultra-low degradation, high-efficiency SOFC stack with a novel capability for energy storage, under a programme sponsored by the Department of Energy's National Energy Technology Laboratory [March 2019, p13].

Atrex Energy: www.atrexenergy.com

Horiba FuelCon to boost Barleben facility

German-based Horiba FuelCon has acquired 2.9 ha (7.2 acres) of land next to its current R&D and manufacturing facility in Magdeburg-Barleben, in the eastern state of Saxony-Anhalt. The additional land is intended for future plant expansion, in response to increasing global demand for the company's testing solutions.

Horiba FuelCon is a leading manufacturer of battery and fuel cell test systems used for R&D, series development, and production verification. Its customers include the automotive industry [e.g. *FCB*, February 2018, p12], NASA Glenn Research Center in Ohio [August 2017, p10], and various research projects [e.g. *February 2015*, p11 and *April 2015*, p13].

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technology for high efficiency, power density, and reliability. The company has delivered more than 650 commercial fuel cell systems in various remote power markets utilising well-head natural gas or liquefied petroleum gas (LPG) as fuels, collectively accumulating >6 million hours of operational lifetime [e.g. *FCB*, June 2015, p5].

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motion to continuously recharge the 100 kWh of batteries, which in turn power a Siemens electric drive motor. The bus operated for 28 hours and achieved 10.4 miles per diesel gallon equivalent. When the hydrogen tanks were fully depleted, the zero-emission bus (ZEB) operated on battery reserve for an additional 20 miles (32 km), to achieve a combined range of 350 miles. The demonstration was completed in April on OCTA's Route 47, operating from Fullerton to Newport Beach in Greater Los Angeles, with a payload representing the fully seated passenger capacity.

New Flyer is delivering 10 of the 40 ft fuel cell electric Xcelsior Charge H2 buses to OCTA, and another 10 to the Alameda-Contra Costa Transit District (AC Transit) in the eastern San Francisco Bay Area, under the Fuel Cell Electric Bus Commercialization Consortium project [*FCB, March 2017, p3*]. The project is being coordinated by the Atlanta-based Center for Transportation and the Environment (CTE).

New Flyer manufactures the Xcelsior Charge H2 bus, which utilises the same reliable drive system as its Xcelsior Charge battery-electric bus, in 40 ft (12 m) and 60 ft (18 m) lengths. Both models successfully completed the Federal Transit Administration's Model Bus Testing Program at Altoona, Pennsylvania in March [*March 2019, p2*], and are eligible for US federal funding [*April 2019, p2*].

New Flyer, Xcelsior Charge H2 bus:
www.newflyer.com/chargeh2

CTE, Fuel Cell Electric Bus Commercialization Consortium: <http://tinyurl.com/cte-fcebcc>

PowerCell stack orders for Chinese bus firm, German automaker

PowerCell Sweden has received an order for PowerCell S2 stacks from China Fuel Cell Energy Company, for beta testing in a number of buses by a bus manufacturer in northern China. PowerCell has also received an order for stack testing from a leading German car manufacturer.

In 2017 the vehicle integration company **China Fuel Cell Energy Company** (CFC) received several PowerCell S2 fuel cell stacks, as well as a PS-5 stationary fuel cell system, for alpha tests [*FCB, June 2017, p1*]. The tests have been going well, and CFC has now placed a follow-on order, worth SEK3.8 million (US\$395 000), with deliveries during Q2 of 2019. The stacks will undergo joint beta testing

with one of its end-customers, an unnamed bus manufacturer in northern China. (The PS-5 system is being used for alpha tests with one of China's largest telecom operators.)

The versatile PowerCell S2 PEM fuel cell stack is designed for vehicle applications, with a power output range of 1–35 kW, and can easily be configured for series connection to give higher power. It can run on reformed hydrogen, and has high resilience to elevated levels of contamination. The S2 is made of stainless steel and can withstand vibration and low temperatures much better than stacks with graphite plates, which has been a deciding factor for this latest customer, as the tests will be carried out in a region with a cold climate.

PowerCell has also received an **order for testing fuel cell stacks** for a leading (but also unnamed) German car manufacturer. The order is worth SEK2 million (\$208 000), and the stack tests will be carried out during Q2 of 2019.

The tests will be performed in PowerCell's new fuel cell laboratory [*November 2018, p13*]. This comprises two testbeds, each with a testing capacity for fuel cells and fuel cell systems up to 150 kW, providing PowerCell with an additional total testing capacity of 300 kW. The new facility also enables more realistic test cycles to be run, providing a more accurate basis for evaluation.

PowerCell has also signed a deal with Robert Bosch GmbH in Germany to develop, produce and sell an improved version of the S3 stack [*see page 13*].

PowerCell Sweden: www.powercell.se

Toyota and Kenworth unveil fuel cell heavy truck at Port of LA

Toyota, Kenworth, the Port of Los Angeles and the California Air Resources Board recently unveiled the first Toyota/Kenworth fuel cell electric heavy-duty trucks at the Port of Los Angeles.

The next-generation truck expands on the capabilities of Toyota's two Project Portal proof-of-concept trucks [*FCB, November 2017, p3 and July 2018, p1*], offering enhanced capability, packaging and performance while offering a range of more than 300 miles (480 km), twice that of a typical drayage truck's average daily duty cycle. The trucks are based on the Kenworth T680 Class 8 tractor unit.

Toyota and Kenworth will deploy 10 trucks as part of the Zero and Near-Zero Emissions Freight Facilities (ZANZEFF) project, hauling

EDITORIAL

Hheavy-duty (HD) hydrogen refueling stations might be a subset of the overall hydrogen fueling infrastructure, but serving vehicles such as trucks will be a key part of the large-scale deployment of fuel cell transportation.

This issue features several items on this aspect of hydrogen refueling. **Nel Hydrogen** is a key player in this sector, focusing initially on the US market, and in particular on California. For example, its US subsidiary Nel Hydrogen Inc has received a purchase order from Equilon (Shell Oil Products US) to deliver H2Station[®] units for refueling of heavy-duty fuel cell electric trucks in California [*page 10*]. Nel is also working with Nikola Motor Company to build a network of HD hydrogen stations across the US, to serve trucks and passenger vehicles [*July 2018, p9*].

For its part, **Shell** is participating in the Zero and Near-Zero Emissions Freight Facilities (ZANZEFF) project in California, under which it will develop two new high-capacity, HD hydrogen stations in Wilmington and Ontario as part of an integrated five-station, HD hydrogen refueling network for the Los Angeles basin, where Toyota and Kenworth are demonstrating fuel cell electric heavy trucks for the distribution of cargo from the Ports of LA and Long Beach [*page 3*].

French company **McPhy** is also now targeting the heavy-duty sector, with the launch of its range of Augmented McFilling hydrogen stations, to serve heavy transportation and long-distance vehicles such as trains, trucks, and buses [*page 11*].

In Switzerland, the **Hyundai Hydrogen Mobility** joint venture will soon start delivering the first of 1600 fuel cell heavy trucks [*page 4*]. The JV plans to enter the hydrogen sales market through a subsidiary firm to produce and supply hydrogen in Switzerland, with prospects for entering other European countries.

Other recent developments include the completion of the first stage of a dedicated hydrogen fuel plant by **OneH2** in North Carolina, which will provide deliveries of ready-to-use bulk hydrogen to regional industrial forklift truck and heavy vehicle markets [*April 2019, p9*].

Meanwhile, a **cross-industry group** comprising Air Liquide, Hyundai, Nel, Nikola Motor, Shell, and Toyota are collaborating on testing state-of-the-art HD hydrogen fueling hardware, to assist in standardisation and bringing fuel cell trucks to market [*March 2019, p8*]. The partners intend to test pre-commercial 700 bar hydrogen heavy-duty vehicle, high-flow (H70HF) fueling hardware for future Class 8 (40 tonne) trucks. The group has created specifications for the fueling nozzle, vehicle receptacle, dispenser hose, and breakaway device components, for the purpose of developing Requests for Proposals for suppliers.

Steve Barrett

Municipality of Groningen, Touraine Vallée de l'Indre Municipalities, Metropole AGR Waste Management Services, Aberdeen City Council, Municipality of Duisburg, Suez Netherlands, Propreté-Brussels, and the HAN University of Applied Sciences in Arnhem and Nijmegen.

The project will test the vehicles in normal operating conditions, and utilise existing hydrogen refueling infrastructure. When possible, the pilot sites will use 'green' hydrogen to fuel the trucks, maximising the emission reductions. The pilot sites will cover a wide range of operational contexts. Some trucks will be operated in city centres and others in rural areas; some will collect municipal waste on a fixed schedule, while others will collect industrial waste on a flexible schedule. The vehicles will range from container trucks to front-arm-loading trucks. Replication will be an important part of the project, paving the way for the deployment of more vehicles across the region and elsewhere in Europe.

The project complements the Life 'N Grab Hy! Project, which has just unveiled its first hydrogen fuel cell powered garbage trucks, kicking off the first phase in a series of 10 demonstrations in European cities [see above item]. And the REVIVE project is deploying 15 fuel cell powered refuse collection trucks in seven sites in Belgium, the Netherlands, and Italy [FCB, February 2018, p3].

HECTOR project: <https://tinyurl.com/hector-project>

HyER: www.hyer.eu Interreg North West Europe: www.nweurope.eu

MOBILE APPLICATIONS

Plug Power GenDrive for materials handling fleet at Lipari Foods

Michigan-based food distributor Lipari Foods has selected Plug Power's GenDrive fuel cells and GenFuel hydrogen fueling station solutions to power the electric materials handling vehicles at its campus in Warren.

The partnership allows Lipari Foods to 'green' its facilities, reducing greenhouse gas emissions while achieving operational savings. Previously, space constraints and business growth have meant that Lipari Foods has had to load up all of its pallet jacks on a dozen 53 ft (16 m) trailers, and ship them to another warehouse to recharge every day. The fast fueling characteristic of Plug Power's GenDrive hydrogen PEM fuel cell technology

– harnessing space-efficient GenFuel hydrogen dispensers – will allow Lipari Foods to double the usage of its materials handling fleet, without using real estate for batteries, charging, and charging equipment.

In 2018 Lipari validated the fuel cell value proposition with a pilot deployment of GenDrive fuel cells. This new agreement will result in full conversion of the Warren campus to Plug Power hydrogen fuel cell technology. The installation of the GenFuel hydrogen station and delivery of the GenDrive fuel cell units are expected to be completed in Q2 of 2019.

Plug Power recently began standard production of its family of next-generation Class 1 GenDrive systems for industrial lift trucks [FCB, March 2019, p11]. The next-generation units are designed with the proven ProGen hydrogen fuel cell engine technology [December 2016, p11, and see the Plug Power feature in December 2011], which delivers increased efficiency and higher reliability.

Plug Power's fuel cells are also used to power electric airport ground support equipment [see next item], and increasingly in stationary power [see page 7].

In other news, Plug Power has announced **\$100 million in debt financing** with sustainable infrastructure investor Generate Capital, which is expected to fund new fuel cell project deployments. Generate Capital also recently signed a project finance facility with molten carbonate fuel cell manufacturer FuelCell Energy in Connecticut [January 2019, p6].

Plug Power: www.plugpower.com

Lipari Foods: www.liparifoods.com

Generate Capital: www.generatecapital.com

Plug Power, Charlante provide Albany airport with tuggers for FedEx

Plug Power and Charlante America, a leading manufacturer of battery powered electric airport ground support equipment (GSE) throughout Europe and the US, have delivered hydrogen fuel cell powered electric cargo tuggers for use by FedEx at Albany International Airport in upstate New York. These new airport vehicles, powered by Plug Power's ProGen engines, will transport packages from the airport sorting facility to FedEx aircraft.

The ground support vehicles were built by Charlante America – a member of the Fayat Group – and operate using Plug Power's zero-emission ProGen hydrogen PEM fuel

IN BRIEF

Toyota partners with Foton, SinoHytec to launch fuel cell buses in China

Japanese carmaker Toyota Motor Corporation (<http://tinyurl.com/toyota-fcevs>) is collaborating with Beiqi Foton Motor Co Ltd (www.foton-global.com) and Beijing SinoHytec Co Ltd (www.sinohytec.com/en) in China, to jointly develop fuel cell electric buses for the fast-growing Chinese market. Fuel cell buses manufactured by Foton – a subsidiary of Beijing Automotive Group (BAIC, www.baicgroup.com.cn/en), a major Chinese automaker – will feature components supplied by Toyota (including its Toyota FC Stack) and SinoHytec.

Foton's first-generation fuel cell buses were used at the 2008 Summer Olympics in Beijing. Its second-generation, 12 m (40 ft) fuel cell buses were launched in 2014, offering greatly reduced production costs and improved battery life. In 2016, its third-generation, 8.5 m (28 ft) fuel cell city buses entered commercial operation, with an order for 100 fuel cell buses. Foton's fourth-generation fuel cell bus can continue to operate in extreme weather conditions, down to temperatures of -30°C , and achieves unprecedented safety standards. It has a range of 450 km (280 miles), with hydrogen refueling taking 10–15 min.

In 2016 SinoHytec partnered with Canadian-based Hydrogenics, for the supply of fuel cells to be integrated into buses and trucks from several leading Chinese vehicle manufacturers [FCB, July 2016, p3].

DOE funding fuel cell, hydrogen projects

The latest Phase II grants under the US Department of Energy's Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programmes, each worth about \$1 million, include half-a-dozen in the field of fuel cells and hydrogen R&D.

Giner Inc (www.ginerinc.com) is working on a novel fluorinated ionomer for PEM fuel cells. Physical Sciences Inc (www.psincorp.com) will study controlled porosity and surface coatings for advanced gas diffusion layers in PEMFCs. NexTech Materials/Nexceris (www.nexceris.com) will develop functionally gradient seals for solid oxide fuel cells. Southwest Sciences Inc (www.swsociences.com) is working on a diode laser sensor for contaminants in hydrogen fuel. NuMat Technologies (www.numat-tech.com) will study general techniques for increasing packing density of metal-organic frameworks (MOFs) for enhanced volumetric storage of hydrogen in fuel cell electric vehicles. And Xergy Inc (www.xergyinc.com) is developing novel membranes for electrochemical hydrogen compression, enabling increased pressure capability and high pumping efficiency.

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German-based Horiba FuelCon has acquired 2.9 ha (7.2 acres) of land next to its current R&D and manufacturing facility in Magdeburg-Barleben, in the eastern state of Saxony-Anhalt. The additional land is intended for future plant expansion, in response to increasing global demand for the company's testing solutions.

Horiba FuelCon is a leading manufacturer of battery and fuel cell test systems used for R&D, series development, and production verification. Its customers include the automotive industry [e.g. *FCB*, February 2018, p12], NASA Glenn Research Center in Ohio [August 2017, p10], and various research projects [e.g. *February 2015*, p11 and *April 2015*, p13].

The company is now part of the Horiba Automotive Test Systems division following its acquisition last autumn by Horiba, a Japanese manufacturer of precision instruments for measurement and analysis [September 2018, p12]. The company has been manufacturing at its current facility, close to Magdeburg, for nine years, and the acquisition of prime industrial land close to the site will allow for expansion in manufacturing capacity with minimal disruption to staff and customer operations.

Horiba FuelCon: www.horiba-fuelcon.com/en

IN BRIEF

DOE Hydrogen and Fuel Cells Program presents Annual Merit Review awards

The US Department of Energy's Hydrogen and Fuel Cells Program presented its annual awards at the recent 2019 DOE Hydrogen and Fuel Cells Program Annual Merit Review and Peer Evaluation Meeting (AMR). The two overall Hydrogen and Fuel Cells Program Awards went to Glenn Scheffler (GWS Solutions of Tolland LLC), for his contributions to the domestic and international codes & standards communities, and Dave Edwards (Air Liquide), for leadership in advancing hydrogen technologies, including DOE's H2@Scale initiative.

In addition, several Program Area Awards were presented (<https://tinyurl.com/doi-amr-awards-2019>). For *Hydrogen Fuel R&D – Storage*, this went jointly to Thomas Gennett, Philip Parilla and Katherine Hurst at the National Renewable Energy Laboratory. For *Fuel Cell R&D*, awards were made to Jacob Spendelov (Los Alamos National Laboratory) and Shawn Litster (Carnegie Mellon University), and the award for *Technology Acceleration* went to Kevin Centeck (US Army, Combat Capabilities Development Command Ground Vehicle Systems Center, formerly TARDEC). The *Safety, Codes and Standards* award was presented jointly to Kevin Simmons (Pacific Northwest National Lab), Nalini Menon (Sandia National Labs), Barton Smith (Oak Ridge National Lab), and Mike Veenstra (Ford Motor Company).

Nedstack unveils PEMGEN UPS product

Dutch fuel cell manufacturer Nedstack (www.nedstack.com) has been showcasing its new PEMGEN™ unit, a zero-emission UPS (uninterruptible power supply) solution based on hydrogen PEM fuel cells, for protecting mission-critical applications such as data centres.

PEMGEN was introduced at Data Centre World 2019 in London, UK in March, and was presented at the recent Hannover Messe trade fair in Germany by its Dutch partner Contour (www.contour.eu/en).

Hydrogen Europe vision on economic role of hydrogen and gas infrastructure

Hydrogen Europe (www.hydrogeneurope.eu) has published a vision paper that aims to inform and start the discussion with stakeholders about the key role of the gas market in the deployment of hydrogen. The report (<https://tinyurl.com/h2-europe-vision>, PDF), elaborates on the future role of new and existing infrastructures as EU stakeholders strive to future-proof their businesses and 'green' the European gas grid, making it fit-for-purpose and in line with EU objectives. The paper lays down concrete suggestions in the search for a purposeful framework for hydrogen, including definitions, market ownership models, and targets.

Patents

Gas-liquid separator to remove and discharge water in off-gas from automotive PEMFC system

Assignee: **Toyota Motor Corporation, Japan**

Inventors: *Y. Hotta et al.*

Patent number: *US 10236520*

Published: 19 Mar. 2019 (Filed: 12 Nov. 2015)

SOFC-reformer system that can continue to operate when water self-sustaining operation is difficult due to environmental and operating conditions

Assignee: **Panasonic, Japan**

Inventors: *J. Morita et al.*

Patent number: *US 10236521*

Published: 19 Mar. 2019 (Filed: 10 Nov. 2015)

Hydrogen dispensing methods and systems for compact, stand-alone hydrogen refueling station utilising readily accessible water and electricity to generate hydrogen

Assignee: **Ivys Inc, USA**

Inventors: *C.J. O'Brien et al.*

Patent number: *US 10236522*

Published: 19 Mar. 2019 (Filed: 17 Jan. 2018)

Simplified electrical system in automotive (PEM) fuel cell system by depletion of cathode air supply at end of startup process

Assignee: **Robert Bosch GmbH, Germany**

Inventor: *H. Kemmer*

Patent number: *US 10236523*

Published: 19 Mar. 2019 (Filed: 30 June 2014)

Method and device for purging (automotive) fuel cell to reduce water content, by low-pressure suction of purge gas through fuel cell, for improved subzero startup

Assignee: **BMW, Germany**

Inventors: *J. Schmid et al.*

Patent number: *US 10236524*

Published: 19 Mar. 2019 (Filed: 3 Aug. 2016)

Control method and apparatus for SOFC system, to save fuel when powering auxiliaries when idling

Assignee: **Kyocera Corporation, Japan**

Inventors: *K. Nakamura et al.*

Patent number: *US 10236525*

Published: 19 Mar. 2019 (Filed: 26 June 2013)

One-step process for preparing Nafion membrane with monolithic porous structure, for improved membrane/catalyst interfacial area and transport

Assignee: **Korea Institute of**

Science & Technology, Korea

Inventors: *D. Henkensmeier et al.*

Patent number: *US 10236527*

Published: 19 Mar. 2019 (Filed: 29 Dec. 2015)

Solid oxide cells comprising stacked functional layers formed by combination of 3D extrusion printing and 2D casting techniques

Assignee: **Northwestern University, USA**

Inventors: *A.E. Jakus et al.*

Patent number: *US 10236528*

Published: 19 Mar. 2019 (Filed: 18 July 2016)

Automotive PEMFC stack capable of suppressing seal damage, reactant leakage or water entry for long period of time

Assignee: **Honda Motor Co, Japan**

Inventor: *H. Naito*

Patent number: *US 10236529*

Published: 19 Mar. 2019 (Filed: 8 Feb. 2017)

Control method for automotive SOFC system, performs insulation test of power supply line before external power unit charges battery

Assignee: **Nissan Motor Co, Japan**

Inventors: *K. Suzuki et al.*

Patent number: *US 10239405*

Published: 26 Mar. 2019 (Filed: 10 Nov. 2016)

Production of carbon-supported core-shell (Pd-Pt) fine catalyst particles for PEMFC electrode, to inhibit performance deterioration at operating temperature

Assignees: **Toyota Motor Corporation,**

Japan and Audi, Germany

Inventors: *A. Iio et al.*

Patent number: *US 10243218*

Published: 26 Mar. 2019 (Filed: 16 Nov. 2011)

Bipolar fluid flow plate for (PEM) fuel cell with less complex cathode assemblies, cheaper manufacturing

Assignee: **Intelligent Energy, UK**

Inventors: *P.D. Hood et al.*

Patent number: *US 10243219*

Published: 26 Mar. 2019 (Filed: 18 Dec. 2013)

PEMFC bipolar plates to limit reactants bypassing flow channels

Assignee: **CEA, France**

Inventors: *J.-P. Poirot-Crouvezier et al.*

Patent number: *US 10243220*

Published: 26 Mar. 2019 (Filed: 15 Nov. 2016)

Resin-framed MEA for PEMFC, manufacturing method to maintain long-term bonding strength

Assignee: **Honda Motor Co, Japan**

Inventors: *N. Mitsuta et al.*

Patent number: *US 10243221*

Published: 26 Mar. 2019 (Filed: 4 Dec. 2015)

Gasket for automotive (PEM) fuel cell, reduces drop in sealing performance caused by corrosion where gasket seals end plate

Assignee: **Toyota Boshoku KK, Japan**

Inventors: *K. Yamaura et al.*

Patent number: *US 10243222*

Published: 26 Mar. 2019 (Filed: 12 June 2017)

Simpler automotive PEMFC stack with improved heat distribution and uniform temperature between cells

Assignee: **Hyundai Motor Company, Korea**

Inventors: *H.R. Kwon et al.*

Patent number: *US 10243223*

Published: 26 Mar. 2019 (Filed: 20 June 2016)

Low-cost method for switching off PEMFC stack, using oxygen-depleted gas mix to extend stack protection after shutdown

Assignee: **Audi, Germany**

Inventors: *T. Schwarz et al.*

Patent number: *US 10243224*

Published: 26 Mar. 2019 (Filed: 9 Nov. 2015)

System and method to effectively control coolant operating pressure, enhancing lifetime and reducing noise for automotive fuel cell stack

Assignee: **Hyundai Motor Company, Korea**

Inventors: *S.D. Han et al.*

Patent number: *US 10243225*

Published: 26 Mar. 2019 (Filed: 28 June 2016)

Fuel cell system ride-through of electric grid disturbances, with variable frequency drive coupled to output of inverter(s), e.g. for MCFC power plants

Assignee: FuelCell Energy, USA

Inventors: G. Berntsen et al.

Patent number: US 10243226

Published: 26 Mar. 2019 (Filed: 9 Sep. 2015)

Apparatus for reducing hydrogen concentration in exhaust gas from automotive PEMFC system

Assignees: Hyundai Motor Company, Korea and Kia Motors Corporation, Korea

Inventor: M.J. Jung

Patent number: US 10243227

Published: 26 Mar. 2019 (Filed: 3 July 2017)

MEA manufacturing device bonds anode and cathode catalyst layers continuously formed in upper and lower electrode films to respective PEM surfaces

Assignee: Hyundai Motor Company, Korea

Inventor: S.H. Cho

Patent number: US 10243228

Published: 26 Mar. 2019 (Filed: 6 Nov. 2015)

Polyazole-based PEM with excellent chemical stability, proton conductivity under low humidity, mechanical strength and durability

Assignee: Toray Industries, Japan

Inventors: T. Kunita et al.

Patent number: US 10243229

Published: 26 Mar. 2019 (Filed: 6 Mar. 2015)

Automotive (PEM) fuel cell system with robustly located anti-rust plate between cell body and current collector plate, suppresses corrosion

Assignee: Toyota Motor Corporation, Japan

Inventors: M. Kobayashi et al.

Patent number: US 10243230

Published: 26 Mar. 2019 (Filed: 9 Nov. 2015)

Automotive fuel cell system with control device connected to cell monitor placed inside fuel cell housing, in low-cost configuration

Assignee: Toyota Motor Corporation, Japan

Inventor: M. Imanishi

Patent number: US 10243231

Published: 26 Mar. 2019 (Filed: 24 May 2017)

System and method for measuring insulation resistance of FCEV, to prevent driver getting electric shock

Assignees: Hyundai Motor Company, Korea and Kia Motors Corporation, Korea

Inventors: K.I. Lee et al.

Patent number: US 10247768

Published: 2 Apr. 2019 (Filed: 2 Sep. 2016)

SOFC cathode compositions with improved resistance to degradation

Assignee: Bloom Energy Corporation, USA

Inventors: A. Leming et al.

Patent number: US 10249883

Published: 2 Apr. 2019 (Filed: 9 Nov. 2015)

SOFC cathode current collector, in porous metal foam of CoNi, CoMn and/or CuMn alloys, or CoNiMn and/or CoCuMn ternary alloys

Assignees: Research Institute of Industrial Science & Technology, Korea

and Alantum Corporation, Korea

Inventors: I.-S. Lee et al.

Patent number: US 10249885

Published: 2 Apr. 2019 (Filed: 24 Dec. 2014)

PEMFC GDL for increased through-plane gas diffusivity and water removal, preventing gas short cuts between bipolar plate channels

Assignee: Toray Industries, Japan

Inventors: Y. Okano et al.

Patent number: US 10249886

Published: 2 Apr. 2019 (Filed: 7 Feb. 2014)

SOFC with suppressed corrugated deformation of seal member with no need to process seal member

Assignee: Sumitomo Precision

Products Co Ltd, Japan

Inventors: S. Mizukawa et al.

Patent number: US 10249887

Published: 2 Apr. 2019 (Filed: 22 Feb. 2016)

Passive recirculation device integrated into fuel cell system, to control anode recirculation flow based on anode exhaust pressure

Assignee: Nuvera Fuel Cells, USA

Inventor: B.S. Lunt

Patent number: US 10249888

Published: 2 Apr. 2019 (Filed: 2 Feb. 2018)

Automotive PEMFC system with control of compressor to realise air supply at target flow rate

Assignee: Honda Motor Co, Japan

Inventors: K. Ueda et al.

Patent number: US 10249889

Published: 2 Apr. 2019 (Filed: 12 Apr. 2013)

Cold-start method for automotive PEMFC stack, reduces ice build-up in startup under freezing conditions

Assignees: Daimler, Germany, Ford, USA, and Nissan Motor Co, Japan

Inventors: M. Procter et al. [AFCC, Canada]

Patent number: US 10249890

Published: 2 Apr. 2019 (Filed: 19 June 2015)

Method and system for power distribution in FCEV, determining PEMFC stack state based on amount of moisture, power from drive motor regenerative braking

Assignee: Hyundai Motor Company, Korea

Inventors: D.H. Lee et al.

Patent number: US 10249892

Published: 2 Apr. 2019 (Filed: 19 Aug. 2016)

Fuel cell architectures, monitoring systems, and control logic for characterising fluid flow in automotive PEMFC stacks

Assignee: General Motors, USA

Inventors: J.J. Gagliardo et al.

Patent number: US 10249893

Published: 2 Apr. 2019 (Filed: 26 Apr. 2017)

Automotive PEM or SOFC system with step-up stack to allow stack voltage to be stepped up, improving output voltage stability

Assignee: Nissan Motor Co, Japan

Inventors: D. Tanaka et al.

Patent number: US 10249894

Published: 2 Apr. 2019 (Filed: 28 July 2015)

Apparatus and method to diagnose state of automotive PEMFC stack using stack voltage monitor, based on impedance of each channel

Assignee: Hyundai Motor Company, Korea

Inventors: S.B. Won et al.

Patent number: US 10249895

Published: 2 Apr. 2019 (Filed: 8 Dec. 2016)

FCEV control system and method, based on derived reaction area, to prevent over-humidifying PEMFC

Assignees: Hyundai Motor Company, Korea and Kia Motors Corporation, Korea

Inventors: S.W. Kwon et al.
Patent number: US 10249896
Published: 2 Apr. 2019 (Filed: 10 July 2017)

PEMFC MEA with carrier-less porous catalyst layer for optimum catalyst layer/electrolyte membrane interface, improves robustness

Assignee: Toshiba, Japan
Inventors: W. Mei et al.
Patent number: US 10249898
Published: 2 Apr. 2019 (Filed: 19 Aug. 2016)

Fabrication of PEMFC module with curved MEA, for larger contacting surface with reactant gas

Assignees: Tsinghua University, China and Hon Hai Precision Industry Co Ltd, Taiwan
Inventors: L.-N. Zhang et al.
Patent number: US 10249899
Published: 2 Apr. 2019 (Filed: 15 Dec. 2015)

Low-cost preparation of composite ion-exchange membranes, with comparable PEMFC performance, improved membrane characteristics

Assignee: Agfa-Gevaert, Belgium
Inventors: G. Desie et al.
Patent number: US 10249900
Published: 2 Apr. 2019 (Filed: 25 Aug. 2014)

Improving FCEV efficiency by integrating Rankine cycle system to enhance cooling of fuel cell system

Assignee: Toyota Motor Engineering & Manufacturing North America, USA
Inventors: F. Zhou et al.
Patent number: US 10252610
Published: 9 Apr. 2019 (Filed: 7 Mar. 2017)

PEM with azole ring-containing compound and transition metal-containing additive, with excellent low-humidity proton conductivity

Assignee: Toray Industries, Japan
Inventors: T. Kunita et al.
Patent number: US 10253147
Published: 9 Apr. 2019 (Filed: 27 Mar. 2015)

Inspection method for automotive PEMFCs under transient operating conditions, for manufacturing

Assignee: Toyota Motor Corporation, Japan
Inventors: S. Usami et al.
Patent number: US 10254347
Published: 9 Apr. 2019 (Filed: 20 Oct. 2015)

SOFC cathode composition for excellent sheet resistance and low reactivity with electrolyte, long-term performance and durability

Assignee: LG Chem, Korea
Inventors: S. Im et al.
Patent number: US 10256474
Published: 9 Apr. 2019 (Filed: 10 June 2016)

PEMFC core-shell (Pd-Pt) electrode catalyst with good performance, suitable for mass production, even when containing relatively high Cl concentration

Assignee: NE Chemcat Corporation, Japan
Inventors: K. Nagamori et al.
Patent number: US 10256475
Published: 9 Apr. 2019 (Filed: 12 July 2017)

PEMFC electrode structure that prevents gas flowing into sealing space on edge of MEA, metal separator, fuel cell fabrication

Assignee: Nissan Motor Co, Japan
Inventors: T. Oku et al.
Patent number: US 10256476
Published: 9 Apr. 2019 (Filed: 26 May 2016)

PEMFC gas diffusion electrode substrate, comprising microporous layer with carbon-based filler and fluororesin on substrate surface

Assignee: Toray Industries, Japan
Inventors: M. Utsunomiya et al.
Patent number: US 10256477
Published: 9 Apr. 2019 (Filed: 17 Feb. 2015)

PEMFC separator with stainless steel substrate coated with Sn alloy featuring microcracks, for excellent corrosion resistance and adhesion

Assignee: JFE Steel Corporation, Japan
Inventors: T. Yano et al.
Patent number: US 10256478
Published: 9 Apr. 2019 (Filed: 18 Dec. 2015)

PEMFC bipolar plates to limit reactants bypassing flow channels

Assignee: CEA, France
Inventors: J.-P. Poirot-Crouvezier et al.
Patent number: US 10256479
Published: 9 Apr. 2019 (Filed: 15 Nov. 2016)

Flow element and bipolar plate in PEMFC, for distribution of reactant

or coolant over plate surface as uniformly as possible

Assignee: ElringKlinger AG, Germany
Inventors: J. Kraft et al.
Patent number: US 10256480
Published: 9 Apr. 2019 (Filed: 26 Feb. 2017)

SOFC seal structure receives compressive force but prevents shearing force, limiting damage and ensuring seal performance

Assignee: Nissan Motor Co, Japan
Inventors: K. Iritsuki et al.
Patent number: US 10256481
Published: 9 Apr. 2019 (Filed: 13 July 2015)

Robust sealants for automotive PEMFC stacks, methods using thin elastomeric seals, for improved reactant and coolant flow sealing within bipolar plates

Assignee: General Motors, USA
Inventors: Y.-H. Lai et al.
Patent number: US 10256482
Published: 9 Apr. 2019 (Filed: 9 Feb. 2016)

Manufacturing method for PEMFC assembly, to prevent resin member melting during joining with MEA and causing burrs

Assignee: Honda Motor Co, Japan
Inventors: R. Uozumi et al.
Patent number: US 10256483
Published: 9 Apr. 2019 (Filed: 13 Jan. 2017)

Automotive PEMFC system and control method, to pulsate anode gas supply for discharging impurities such as water

Assignee: Nissan Motor Co, Japan
Inventor: H. Chikugo
Patent number: US 10256484
Published: 9 Apr. 2019 (Filed: 9 May 2014)

Automotive PEMFC purge line system for integrated purge and drain, allowing repeated startup in freezing conditions

Assignee: Ford, USA
Inventors: C.M. Mathie et al.
Patent number: US 10256485
Published: 9 Apr. 2019 (Filed: 18 May 2016)

Automotive PEMFC system for improved fatigue resistance without reducing cross-sectional

area for reactant flow even under repeated differential pressure

Assignee: Nissan Motor Co, Japan

Inventors: T. Oku et al.

Patent number: US 10256486

Published: 9 Apr. 2019 (Filed: 3 Apr. 2012)

Method to accelerate activation of automotive PEMFCs and reduce amount of hydrogen consumed, using cyclic voltammetry

Assignee: Hyundai Motor Company, Korea

Inventor: H.S. Choo

Patent number: US 10256487

Published: 9 Apr. 2019 (Filed: 2 Nov. 2016)

Automotive (PEM) fuel cell system and control method, to suppress overshoot in cathode gas flow rate

Assignee: Toyota Motor Corporation, Japan

Inventors: A. Iio et al.

Patent number: US 10256488

Published: 9 Apr. 2019 (Filed: 7 Mar. 2017)

Residential reformer/SOFC system with reduced size and cost

Assignee: Panasonic, Japan

Inventors: T. Kakuwa et al.

Patent number: US 10256489

Published: 9 Apr. 2019 (Filed: 5 Aug. 2016)

PEMFC MEA tolerant to performance degradation caused by repeated startup/shutdown cycles

Assignee: Johnson Matthey Fuel Cells, UK

Inventor: R.L. O'Malley

Patent number: US 10256491

Published: 9 Apr. 2019 (Filed: 20 May 2015)

PEMFC MEA with combined metal GDL and microporous layer, for use as transport layer

Assignee: University of Cape Town, South Africa

Inventors: S. Tanaka et al.

Patent number: US 10256492

Published: 9 Apr. 2019 (Filed: 30 Mar. 2015)

PEMFC reinforced by nonwoven fabric, to reduce swelling in both in-plane and through-plane directions of electrolyte membrane

Assignee: Panasonic, Japan

Inventors: M. Mori et al.

Patent number: US 10256494

Published: 9 Apr. 2019 (Filed: 20 July 2012)

SOFC stack with interconnects which can maintain favourable long-term electrical connection

Assignee: NGK Spark Plug Co Ltd, Japan

Inventors: N. Hotta et al.

Patent number: US 10256495

Published: 9 Apr. 2019 (Filed: 7 Aug. 2012)

Power generation systems and methods utilising cascaded SOFCs and reformers, increased efficiency

Assignee: General Electric, USA

Inventors: I.S. Hussaini et al.

Patent number: US 10256496

Published: 9 Apr. 2019 (Filed: 1 July 2014)

Method of making packaged fuel unit for hydrogen generator in PEMFC-powered portable device

Assignee: Intelligent Energy Inc, USA

Inventors: T.J. Kmetich et al. [Energizer]

Patent number: US 10258950

Published: 16 Apr. 2019 (Filed: 8 Dec. 2014)

Fuel unit, refillable hydrogen generator, for portable (PEM) fuel cell system

Assignee: Intelligent Energy Inc, USA

Inventors: R.A. Langan et al. [Energizer]

Patent number: US 10259705

Published: 16 Apr. 2019 (Filed: 17 Feb. 2016)

Calcium silicate hydrate anion-exchange membrane for water electrolysis and solid alkaline fuel cells, process for production from Portland cement

Assignee: Council of Scientific &

Industrial Research, India

Inventors: J. Swaminathan et al. [Central

Electro Chemical Research Institute]

Patent number: US 10260155

Published: 16 Apr. 2019 (Filed: 30 Jan. 2017)

System and method for tuning electrochemical cell stack, e.g. PEM electrochemical hydrogen compressor (EHC)

Assignee: Nuvera Fuel Cells, USA

Inventors: S. Blanchet et al.

Patent number: US 10260157

Published: 16 Apr. 2019 (Filed: 24 Jan. 2018)

Arrangement and method for operating hydrogen fueling stations utilising Liquid Organic Hydrogen Carrier (LOHC) technology

Assignee: Hydrogenious Technologies

GmbH, Germany

Inventors: W. Arlt et al.

Patent number: US 10260680

Published: 16 Apr. 2019 (Filed: 15 Nov. 2017)

Cathode material for PEMFCs and metal-air batteries, with low internal resistance for excellent discharge characteristics

Assignee: Sharp, Japan

Inventor: K. Mitamura

Patent number: US 10263258

Published: 16 Apr. 2019 (Filed: 10 July 2017)

Method for producing core-shell (Pd-Pt) catalyst particles with high catalytic activity per unit mass of Pt, for (PEM) fuel cell electrodes

Assignee: Toyota Motor Corporation, Japan

Inventors: K. Kaneko et al.

Patent number: US 10263259

Published: 16 Apr. 2019 (Filed: 22 Dec. 2014)

Treatment method for improved performance of Pt-Pt alloy catalyst for PEMFC electrode

Assignees: Toyota Motor Corporation,

Japan and Cataler Corporation, Japan

Inventors: T. Nagami et al.

Patent number: US 10263260

Published: 16 Apr. 2019 (Filed: 18 July 2016)

EVENTS CALENDAR

2–7 June 2019
WHTC 2019, World Hydrogen Technologies Convention
 Tokyo, Japan
 More information: www.whtc2019.jp

2–7 June 2019
11th International Symposium on Electrochemical Impedance Spectroscopy, EIS 2019
 Lège-Cap-Ferret, France
 More information: www.eis2019.org

9–13 June 2019
2nd International Conference on Electrolysis, ICE 2019
 Loen, Norway
 More information: www.sintef.no/projectweb/ice2019

11–13 June 2019
ARIEMA Course on Hydrogen and Fuel Cells [in Spanish]
 Madrid, Spain
 More information: www.cursoh2.com

13–14 June 2019
5th International Symposium on Hydrogen Energy, Renewable Energy & Materials, HEREM 2019
 Bangkok, Thailand
 More information: www.herem.org

16–20 June 2019
6th Nano Today Conference (including Nanomaterials for Energy and Environmental Applications)
 Lisbon, Portugal
 More information: www.elsevier.com/events/conferences/nano-today-conference

23–28 June 2019
H₂ Mobility Hydrogen Week: 6 Days, 7 Actions (and see 27 June below) [in German]
 North Rhine-Westphalia, Germany
 More information: www.energieagentur.nrw/content/anlagen/20190425_Woche_des_Wasserstoffs_NRW.PDF

26–27 June 2019
2019 Ohio Fuel Cell Symposium
 Columbus, Ohio, USA
 More information: www.fuelcellcorridor.com

27 June 2019
Annual Mobility Conference of the NRW Fuel Cells, Hydrogen, Electromobility Networks (part of Hydrogen Week, see above) [in German]
 Düsseldorf, Germany
 More information: www.energieagentur.nrw/mobilitaet/jahrestagung_mobilitaet

1–4 July 2019
Journées d'Electrochimie 2019 [in French]
 Université Paul Sabatier de Toulouse, France
 More information: <http://je-toulouse2019.sciencesconf.org>

2–5 July 2019
EFCF 2019, Low-Temperature Fuel Cells, Electrolysers & H₂ Processing: Fundamentals and Engineering Design

[including FCH Tutorial and EIS Tutorial on 2 July]
 Lucerne, Switzerland
 More information: www.efcf.com

10–11 July 2019
US Hydrogen & Fuel Cells Energy Summit 2019
 Boston, Massachusetts, USA
 More information: www.wplgroup.com/aci/event/us-hydrogen-and-fuel-cells-energy-summit

22–24 July 2019
International Congress on Advanced Materials Sciences and Engineering 2019, AMSE-2019
 Osaka, Japan
 More information: www.istci.org/ICAMSE2019
 Abstract deadline: 31 May 2019

22–24 July 2019
BIT's 8th Annual World Congress of Advanced Materials Japan 2019, WCAM-2019: Redefining Next Generation Disruptive Materials, including Session 3-6: Advanced Materials for Batteries, Fuel Cells and Electrolyser Technologies
 Osaka, Japan
 More information: www.bitcongress.com/wcam2019
 Abstract deadline: 15 June 2019

24–26 July 2019
International Conference on Green Energy & Environmental Technology, GEET 19
 Paris, France
 More information: <https://geet-19.com>
 Abstract deadline: 1 June 2019

4–9 August 2019
70th Annual Meeting of the International Society of Electrochemistry: Electrochemistry – Linking Resources to Sustainable Development
 Durban, South Africa
 More information: <http://annual70.ise-online.org>

26–28 August 2019
Electrochem 2019, organised jointly by RSC Electrochemistry Group and SCI Electrochemical Technology Group
 Glasgow, Scotland, UK
 More information: www.strath.ac.uk/engineering/chemicalprocessengineering/electrochem2019

27–30 August 2019
6th CARISMA International Conference on Medium and High Temperature Proton Exchange Membrane Fuel Cells, CARISMA 2019
 Duisburg, Germany
 More information: www.uni-due.de/carisma

8–13 September 2019
16th International Symposium on Solid Oxide Fuel Cells, SOFC-XVI
 Kyoto, Japan
 More information: www.eguchi-lab.ehcc.kyoto-u.ac.jp/SOFC_XVI

10–11 September 2019
f-cell 2019, The Impulse Summit for Hydrogen & Fuel Cells

Stuttgart, Germany
 More information: www.f-cell.de

15–18 September 2019
EFGD 2019, Electrolysis and Fuel Cell Discussions: Towards Catalysts Free of Critical Raw Materials for Fuel Cells & Electrolysers
 La Grande-Motte, France
 More information: www.efcd2019.eu

23–26 September 2019
Hydrogen + Fuel Cells North America Exhibition, within Solar Power International
 Salt Lake City, Utah, USA
 More information: www.h2fc-fair.com/usa

24–26 September 2019
8th International Conference on Hydrogen Safety, ICHS 2019
 Adelaide, Australia
 More information: www.hysafe.info/ichs2019

13–17 October 2019
236th ECS Meeting, including Symposia I01: Polymer Electrolyte Fuel Cells & Electrolysers 19 (PEFC&E19), and I03: Ionic & Mixed Conducting Ceramics 12
 Atlanta, Georgia, USA
 More information: www.electrochem.org/236

23–24 October 2019
Power2Gas Conference
 Marseille, France
 More information: <https://p2gconference.com>

23–25 October 2019
Ibero-American Congress of Hydrogen and Fuel Cells, IBERCONAPPICE 2019, Spanish Fuel Cells Association [in Spanish]
 CIEMAT, Madrid, Spain
 More information: <https://iberconappice.appice.es> [in Spanish]

23–26 October 2019
Hydrogen + Fuel Cells Asia Exhibition, within CeMAT 2019 (materials handling & logistics exhibition)
 Shanghai, China
 More information: www.cemat-asia.com/h2/show.php?lang=en&id=478

5–7 November 2019
2019 Fuel Cell Seminar & Energy Exposition
 Long Beach, California, USA
 More information: www.fuelcellseminar.com
 Abstract deadline: 31 May 2019

19–21 November 2019
Fuel Cells and Hydrogen Joint Undertaking: Programme Review Days [19–20 November], and Stakeholder Forum [21 November]
 Brussels, Belgium
 More information: www.fch.europa.eu

9–11 December 2019
8th European Fuel Cell Technology & Applications Piero Lunghi Conference, EFC19
 Naples, Italy
 More information: www.europeanfuelcell.it