ELSEVIER

# fuelCELLS BULLETIN

ISSN 1464-2859 January 2020

www.fuelcellsbulletin.com

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Scania and ASKO have been exploring technology options for electrification of heavy commercial vehicles. ASKO aims to run its entire groceries distribution operation with zero-emission vehicles – battery electric and hydrogen – by 2026. The pilot project – supported by the Norwegian government through its Enova SF agency – will be the basis for further learning and development for both companies.

In the trucks deployed with ASKO, the diesel engine is replaced by an electric motor, powered by a 90 kW PEM fuel cell supplied by Canadian company Hydrogenics [*FCB, June 2017, p2*], and by 56 kWh of Li-ion rechargeable batteries. The hydrogen tanks – holding 33 kg at 350 bar – come from Hexagon Composites in Norway [*September 2017, p8*], and give an estimated range of 400–500 km (250–310 miles).

ASKO has also developed a hydrogen refueling station and additional infrastructure, ensuring a supply of 'green' hydrogen. The hydrogen is produced using 9000 $m^2$ of rooftop solar photovoltaic (PV) cells at ASKO Midt-Norge's headquarters in Trondheim.

Scania, Hydrogen Trucks: www.scania.com/group/en/hydrogen-a-fuel-of-the-future

ASKO Norge: www.asko.no/en

Hydrogenics: www.hydrogenics.com

Hexagon Composites: www.hexagon.no

Nel Hydrogen: www.nelhydrogen.com

Enova SF: www.enova.no/about-enova

## Resato plans six hydrogen stations for Drenthe

**Dutch high-pressure technology company Resato will build six hydrogen refueling stations in the northeastern province of Drenthe in 2020–2021. Five stations will be available for public refueling, forming a comprehensive network, with one station on the site of sustainable installations company Vriend.**

The initiative is the brainchild of Resato, which produces hydrogen refueling stations, and filling station operator OrangeGas. The partners aim to expand the network to the neighbouring provinces of Groningen and Friesland, working with Gasunie and Friesland Lease.

The five public stations will be located at existing filling stations across Drenthe. Their flexible design means that the dispensers can easily be moved to another location. The partners aim to commission the first station in July.

Vriend employees will be able to refuel the company's six hydrogen cars as early as May, at its dedicated station in Coevorden. The company will also work with the Technical Installation Companies Training and Development Fund (OTIB) to set up an educational space that will introduce students and other interested parties to hydrogen. The Province of Drenthe is acquiring four fuel cell electric vehicles as part of its support for the initiative.

Last summer regional bus operator Qbuzz ordered 20 fuel cell buses for operation in Groningen and Drenthe, which are expected to enter service in December [*FCB, August 2019, p2, and see page 3 in this issue*].

Resato International BV: www.resato.com

OrangeGas: www.orangegas.nl/en

Vriend BV: www.vriendbv.nl [in Dutch]

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**ROAD VEHICLES**

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The Fébus vehicles are Exqui.City 18 Fuel Cell articulated tram-buses, specifically created for Pau by Belgian bus builder Van Hool [*FCB, October 2019, p4, and see the News Focus in September 2017*]. The hybrid tram-buses use fuel cells – 100 kW FCveloCity®-HD PEM fuel cell modules supplied by Ballard Power Systems [*see also pages 3, 7 and 11*] – for primary power, and lithium-ion batteries for additional power when needed. Each tram-bus can carry up to 125 passengers, and has an operating range of more than 300 km (185 miles).

The fuel cell powered tram-buses are being operated by SMTU-PPP (Syndicat Mixte des Transports Urbains, Pau-Portes des Pyrénées) and STAP (Société de Transport de l'Agglomération Paloise). Testing and driver training had been under way since September, before entering revenue service. These tests have improved performance and ensured compliance with safety, traffic flow, and energy performance requirements.

Three of the buses in the Fébus fleet will be operated in the framework of the 3Emotion project [*February 2015, p1*], and five as part of the JIVE project [*see the News Feature in February 2017, and March 2018, p2*], both co-financed by the Fuel Cells and Hydrogen Joint Undertaking (FCH JU).

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**Georgia has collaborated with the Midwest Hydrogen Center of Excellence (MHCoE), Cleveland State University (CSU), and the Stark Area Regional Transit Authority (SARTA) in Ohio to release a study evaluating the relationship between ambient temperature and fuel economy for zero-emission buses. This study builds on previous efforts by incorporating daily-level data into the analysis, allowing the team to capture extreme temperature values that would be masked in an evaluation of monthly data.**

All transit buses, regardless of fuel source, experience some loss of range in extreme weather. As transit agencies plan to replace their diesel-fueled buses with zero-emission buses, they will need to consider the effects of extreme weather on their replacement buses. 'Hydrogen fuel cell buses appear to offer cold weather ranges that will be most compatible with traditional route planning,' says Andrew Thomas, Director of MHCoE and one of the co-authors. The study therefore compares the fuel economy of battery-electric and fuel cell electric buses in relation to varying temperature trends.

The study seeks to provide transit agencies with planning insights as they consider strategies for replacing existing fleets, without recommending one technology over another. The study team collected data from eight transit agencies: four that deployed hydrogen fuel cell powered buses, and four that deployed battery-electric buses. The results of the analysis show that the loss in range during a temperature change from 50–60°F (10–16°C) down to 22–32°F (–6 to 0°C) was greater for battery-electric buses (37.8% decrease) than for fuel cell electric buses (23.1% decrease). Since battery-electric buses typically have a shorter range than fuel cell electric buses even under optimal conditions, this is an important consideration for transit agencies that are seeking one-for-one bus replacements.

This work was funded under a National Fuel Cell Bus Program grant provided by the Federal Transit Administration.

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FTA, National Fuel Cell Bus Program: www.transit.dot.gov/research-innovation/about-national-fuel-cell-bus-program

# Van Hool orders 20 Ballard modules for Dutch fuel cell buses

**Canadian-based Ballard Power Systems has received a purchase order from Van Hool, a leading bus OEM and Ballard partner headquartered in Belgium, for 20 FCveloCity®-HD 85 kW fuel cell modules to power buses in Groningen, the Netherlands, under the JIVE2 funding programme.**

The heavy-duty fuel cell modules will power 20 Van Hool A330 fuel cell electric buses that are planned for deployment with Qbuzz, the transit agency for the northern city of Groningen, by the end of 2020 [*FCB, August 2019, p2*]. Shell has been contracted to build a hydrogen refueling station at the Peizerweg bus depot in Groningen to support this fleet of fuel cell buses, which will have a range of 350–400 km (220–250 miles).

'We are delighted to provide fuel cell power modules to Van Hool, a long-standing Ballard partner in Europe [*see also page 2, and pages 7 and 11*], as an important sign of continued progress in the deployment of zero-emission buses under the JIVE2 programme,' says Rob Campbell, Chief Commercial Officer at Ballard. 'This is a follow-on order for modules, after the deployment of two Ballard-powered Van Hool buses with Qbuzz in 2017' [*see the News Feature in March 2017*].

Ballard PEM fuel cell modules have demonstrated excellent on-road performance in fuel cell buses, including earlier generation modules operating in some European buses for more than 35 000 hours with only minimal fuel cell maintenance required.

The European JIVE (Joint Initiative for hydrogen Vehicles across Europe) funding programmes aim to pave the way to commercialisation of fuel cell buses by coordinating procurement activities to unlock economies of scale and reduce costs, as well as supporting new hydrogen refueling stations [*see the News Feature in February 2017, and March 2018, p2*]. The programmes – supported by a total of €57 million (US$63 million) in grants from the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) – are expected to demonstrate the technical readiness of fuel cell technology to bus operators, and the economic viability of hydrogen as a zero-emission bus fuel to policy makers.

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## EDITORIAL

**Trucks are an increasingly active focus for fuel cell power systems, with development and demonstrations going on around the world.**

For example, in this issue we report on Norwegian wholesaler **ASKO** using four 26 tonne hydrogen fuel cell electric trucks, manufactured by Scania, to make deliveries to grocery stores in Trondheim [*page 1*]. ASKO aims to run its entire groceries distribution operation with zero-emission battery electric and hydrogen vehicles by 2026.

Meanwhile, the joint venture and collaboration between **Nikola, Iveco and FPT Industrial** aims to deploy fuel cell technology to accelerate industry transformation towards emission neutrality of Class 8 heavy-duty trucks in North America and Europe [*page 4*]. The JV has also unveiled a scale model of the Nikola Tre battery electric truck, which should see first deliveries next year, and the hydrogen fuel cell version available to customers by 2023.

At the top end of the scale, French electric utility **Engie** is developing the hydrogen refueling infrastructure for Anglo American's 300 tonne capacity fuel cell powered mining haul truck [*page 4*]. Engie has ordered a 3.5 MW electrolyser from Nel Hydrogen Electrolyser, and a custom hydrogen refueling system from Plug Power, to provide renewably produced hydrogen for the Ultra-class mining truck, which will be demonstrated at the Mogalakwena platinum mine in South Africa.

Nel is also involved in the **Green H2 Norway** joint venture, which will establish several renewable hydrogen production facilities in Norway, to supply 'green' hydrogen to the Hyundai trucks that are expected to be deployed later this year [*page 8*]. The sites will also be capable of delivering renewable hydrogen for cars, buses and ferries.

In China, the **Weichai Ballard** Hy-Energy Technologies joint venture has placed a significant order with Ballard in Canada for MEAs, which will enable the JV to begin large-scale manufacturing of fuel cell products this year at its new production facility in Shandong Province [*page 11*]. The JV will assemble fuel cell modules to support initial deliveries in Weichai's commitment to supply modules for bus, commercial truck and forklift applications in China.

And in Germany, Hochschule Esslingen has been awarded funding for the **Reallabor Hylix-B** project, which will study whether fuel cell technology is suitable for everyday goods transport in trucks [*page 15*]. The project team plans to equip a prototype 26 tonne electric truck with a fuel cell drivetrain, which will be tested in the Stuttgart area to identify obstacles to wider deployment.

***Steve Barrett***

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'We are delighted to provide fuel cell power modules to Van Hool, a long-standing Ballard partner in Europe [*see also page 2, and pages 7 and 11*], as an important sign of continued progress in the deployment of zero-emission buses under the JIVE2 programme,' says Rob Campbell, Chief Commercial Officer at Ballard. 'This is a follow-on order for modules, after the deployment of two Ballard-powered Van Hool buses with Qbuzz in 2017' [*see the News Feature in March 2017*].

Ballard PEM fuel cell modules have demonstrated excellent on-road performance in fuel cell buses, including earlier generation modules operating in some European buses for more than 35 000 hours with only minimal fuel cell maintenance required.

The European JIVE (Joint Initiative for hydrogen Vehicles across Europe) funding programmes aim to pave the way to commercialisation of fuel cell buses by coordinating procurement activities to unlock economies of scale and reduce costs, as well as supporting new hydrogen refueling stations [*see the News Feature in February 2017, and March 2018, p2*]. The programmes – supported by a total of €57 million (US$63 million) in grants from the Fuel Cells and Hydrogen Joint Undertaking (FCH JU) – are expected to demonstrate the technical readiness of fuel cell technology to bus operators, and the economic viability of hydrogen as a zero-emission bus fuel to policy makers.

Ballard Power Systems: www.ballard.com

Van Hool, Fuel Cell Buses: https://tinyurl.com/vanhool-fuelcell

## EDITORIAL

**Trucks are an increasingly active focus for fuel cell power systems, with development and demonstrations going on around the world.**

For example, in this issue we report on Norwegian wholesaler **ASKO** using four 26 tonne hydrogen fuel cell electric trucks, manufactured by Scania, to make deliveries to grocery stores in Trondheim [*page 1*]. ASKO aims to run its entire groceries distribution operation with zero-emission battery electric and hydrogen vehicles by 2026.

Meanwhile, the joint venture and collaboration between **Nikola, Iveco and FPT Industrial** aims to deploy fuel cell technology to accelerate industry transformation towards emission neutrality of Class 8 heavy-duty trucks in North America and Europe [*page 4*]. The JV has also unveiled a scale model of the Nikola Tre battery electric truck, which should see first deliveries next year, and the hydrogen fuel cell version available to customers by 2023.

At the top end of the scale, French electric utility **Engie** is developing the hydrogen refueling infrastructure for Anglo American's 300 tonne capacity fuel cell powered mining haul truck [*page 4*]. Engie has ordered a 3.5 MW electrolyser from Nel Hydrogen Electrolyser, and a custom hydrogen refueling system from Plug Power, to provide renewably produced hydrogen for the Ultra-class mining truck, which will be demonstrated at the Mogalakwena platinum mine in South Africa.

Nel is also involved in the **Green H2 Norway** joint venture, which will establish several renewable hydrogen production facilities in Norway, to supply 'green' hydrogen to the Hyundai trucks that are expected to be deployed later this year [*page 8*]. The sites will also be capable of delivering renewable hydrogen for cars, buses and ferries.

In China, the **Weichai Ballard** Hy-Energy Technologies joint venture has placed a significant order with Ballard in Canada for MEAs, which will enable the JV to begin large-scale manufacturing of fuel cell products this year at its new production facility in Shandong Province [*page 11*]. The JV will assemble fuel cell modules to support initial deliveries in Weichai's commitment to supply modules for bus, commercial truck and forklift applications in China.

And in Germany, Hochschule Esslingen has been awarded funding for the **Reallabor Hylix-B** project, which will study whether fuel cell technology is suitable for everyday goods transport in trucks [*page 15*]. The project team plans to equip a prototype 26 tonne electric truck with a fuel cell drivetrain, which will be tested in the Stuttgart area to identify obstacles to wider deployment.

***Steve Barrett***

Qbuzz: www.qbuzz.nl/english

Shell, Hydrogen Fuel: http://tinyurl.com/shell-h2

JIVE: www.fuelcellbuses.eu/projects/jive

Fuel Cells and Hydrogen Joint Undertaking: www.fch.europa.eu

# Nikola, Iveco and FPT launch partnership, Nikola Tre truck model

**US-based Nikola Corporation and Iveco and FPT Industrial in Italy have presented the scope and plans of their joint venture and collaboration agreement, established to accelerate industry transformation towards emission neutrality of Class 8 heavy-duty trucks in North America and Europe through the adoption of fuel cell technology. The joint venture also unveiled a scale model of the Nikola Tre battery electric truck.**

Last autumn CNH Industrial took a $250 million strategic stake in Nikola [*FCB, October 2019, p12*]. The latest announcement builds on this strategic partnership, involving its Iveco commercial vehicles brand and its powertrain division FPT Industrial. The partnership includes the creation of a European joint venture to develop and distribute cab-over hydrogen fuel cell and battery electric trucks for the European market. Nikola will provide its fuel cell expertise and advanced technologies, as well as its disruptive business model that foresees an all-inclusive lease rate. Iveco and FPT Industrial will contribute their engineering and manufacturing expertise to industrialise the fuel cell and battery electric trucks.

Iveco, FPT Industrial, and Nikola have started development of the JV's first truck: the battery electric Nikola Tre, which is based on the new Iveco S-Way platform and integrates Nikola's truck technology, controls, and infotainment [*December 2018, p4*]. Testing is expected to begin this summer, with the European public launch planned for the IAA 2020 Commercial Vehicles trade show in Hannover, Germany in September, and the first units reaching customers in 2021; the hydrogen fuel cell version will be available to customers by 2023. Sales and aftersales support of the Nikola Tre will be provided by Iveco's extensive European dealer network.

The vehicle displayed at the launch was a *maquette* (scale model) of the Nikola Tre 4×2 tractor unit, with a range of up to 400 km (250 miles) and dynamic performance at least as good as an equivalent diesel model. The partners have adopted a modular approach, with Nikola's fuel cell as the starting point for the design, so that the Nikola Tre battery electric vehicle can be subsequently converted to hydrogen fuel cell technology.

Nikola Corporation: www.nikolamotor.com

CNH Industrial: www.cnhindustrial.com

Iveco: www.iveco.com

FPT Industrial: www.fptindustrial.com

## MOBILE APPLICATIONS

# Engie orders 3.5 MW Nel electrolyser, Plug Power refueling unit for giant mining truck

**French electric utility Engie has ordered a 3.5 MW electrolyser from Nel Hydrogen Electrolyser in Norway, and a custom hydrogen refueling system from US-based Plug Power, to provide renewably produced hydrogen for the world's largest fuel cell powered mining haul truck for Anglo American.**

The Anglo American–Engie project involves retrofitting the Ultra-class heavy-duty mining truck operating at Anglo American's Mogalakwena platinum group metals mine in South Africa, to become a zero-emissions fuel cell electric truck, powered by 800 kW of PEM fuel cell modules from Ballard Power Systems in Canada [*FCB, November 2019, p6*]. Electricity for hydrogen production will partly come from local solar power and the grid, and the electrolyser capacity surpasses the daily demand of the truck, enabling storage for fueling during the night or when solar irradiation is poor, maximising the renewable share of the hydrogen. If successful, the long-term target is to convert the entire fleet of haul trucks at the mine to hydrogen, and at Anglo American's other mining operations around the world.

**Nel Hydrogen Electrolyser** – a subsidiary of Nel ASA [*see also page 8*] – has now received a purchase order from Engie, following a previously announced contract for a 3.5 MW alkaline electrolyser. The electrolyser is an element of Engie's hydrogen solution to produce renewable hydrogen for the mining haul truck, and is scheduled to be installed this year.

'When scaled up, more than 100 MW of electrolyser capacity will be needed for this mine alone, representing an attractive new market opportunity,' says Henning Langås, Sales Director of Nel Hydrogen Electrolyser.

In addition, Engie has selected **Plug Power** to provide a custom hydrogen refueling system for the mine haul truck, which is set to begin operation this year. The project has emerged from the companies' recently announced global partnership agreement [*October 2019, p15*].

Plug Power has been tasked with building a full compression, storage, and dispensing system to serve the vehicle. The system will be the first of its kind, and the largest refueling system built by Plug Power to date, with an expected output of 1000 kg/day of hydrogen. The first fueling of the new truck is currently scheduled for the second half of 2020, followed by a rigorous testing and validation programme at the open-pit mine.

Anglo American, FutureSmart Mining: www.angloamerican.com/futuresmart

Engie: www.engie.com/en

Nel ASA: www.nelhydrogen.com

Plug Power: www.plugpower.com

# PKN Orlen and Pesa cooperate on hydrogen technology for trains

**Polish oil refiner and petrol retailer PKN Orlen and rail vehicle manufacturer Pesa Bydgoszcz SA have signed a Letter of Intent to cooperate in the development of hydrogen fuel cell powered trains.**

The agreement covers the exchange of information and research that will lead to Pesa developing a rail vehicle equipped with a hydrogen fuel cell drive system. Both companies will then test hydrogen powered rail vehicles, and eventually implement them in commercial solutions. The technology will first be developed for use in freight locomotives, and eventually in a traction unit for passenger traffic.

'We have already decided to build a hydrogen purification plant, to be built at the plant in Trzebinia owned by Orlen Południe,' says Daniel Obajtek, President of PKN Orlen. 'The start of production of pure hydrogen fuel, which will be used to drive electric vehicles, including locomotives, is planned in 2021.'

'PKN Orlen already produces nearly 45 tonnes of high-quality hydrogen per hour in the production process. We sell this raw material for passenger cars at two stations in Germany,' adds Józef Węgrecki, Board Member for Operations. 'Soon hydrogen drivers will also be able to refuel in the Czech Republic, because Unipetrol from the Orlen Group will start construction

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**Georgia has collaborated with the Midwest Hydrogen Center of Excellence (MHCoE), Cleveland State University (CSU), and the Stark Area Regional Transit Authority (SARTA) in Ohio to release a study evaluating the relationship between ambient temperature and fuel economy for zero-emission buses. This study builds on previous efforts by incorporating daily-level data into the analysis, allowing the team to capture extreme temperature values that would be masked in an evaluation of monthly data.**

All transit buses, regardless of fuel source, experience some loss of range in extreme weather. As transit agencies plan to replace their diesel-fueled buses with zero-emission buses, they will need to consider the effects of extreme weather on their replacement buses. 'Hydrogen fuel cell buses appear to offer cold weather ranges that will be most compatible with traditional route planning,' says Andrew Thomas, Director of MHCoE and one of the co-authors. The study therefore compares the fuel economy of battery-electric and fuel cell electric buses in relation to varying temperature trends.

The study seeks to provide transit agencies with planning insights as they consider strategies for replacing existing fleets, without recommending one technology over another. The study team collected data from eight transit agencies: four that deployed hydrogen fuel cell powered buses, and four that deployed battery-electric buses. The results of the analysis show that the loss in range during a temperature change from 50–60°F (10–16°C) down to 22–32°F (–6 to 0°C) was greater for battery-electric buses (37.8% decrease) than for fuel cell electric buses (23.1% decrease). Since battery-electric buses typically have a shorter range than fuel cell electric buses even under optimal conditions, this is an important consideration for transit agencies that are seeking one-for-one bus replacements.

This work was funded under a National Fuel Cell Bus Program grant provided by the Federal Transit Administration.

Center for Transportation and the Environment: www.cte.tv

Midwest Hydrogen Center of Excellence: www.midwesthydrogen.org/mhcoe

Stark Area Regional Transit Authority: www.sartaonline.com/hydrogen-fuel-cell

Study: https://engagedscholarship.csuohio.edu/urban_facpub/1630

FTA, National Fuel Cell Bus Program: www.transit.dot.gov/research-innovation/about-national-fuel-cell-bus-program

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***Steve Barrett***

of three hydrogen stations next year [in Prague, Litwinów and Brno].'

Last autumn PKN Orlen signed an LOI with Górnośląsko-Zagłębiowska Metropolia (GZM, Silesian Metropolis) to cooperate on the development of hydrogen-powered public transport, and implement projects using hydrogen in the Upper Silesian and Zagłębie Metropolis. This LOI covers the exchange of know-how, and preparing for implementation of projects regarding infrastructure and logistics for hydrogen supply.

PKN Orlen: www.orlen.pl/en

Pesa SA: www.pesa.pl/index.php/en

## Inlandsbanan, Statkraft study hydrogen fuel cell power for freight trains in Sweden

**Swedish train operator Inlandsbanan ('Inland Line') and energy utility Statkraft have signed a Letter of Intent for a joint investment in hydrogen-powered heavy goods transport, that would enable zero-carbon transport of heavy goods across Sweden, without the need for power contact lines.**

Inlandsbanan and the Swedish arm of Statkraft aim to conduct a joint pilot project to investigate hydrogen-powered freight traffic in 2020–2021, looking at the conversion of an Inlandsbanan diesel-powered locomotive to hydrogen fuel cell power. If this initial work goes well, the next stage will be to establish hydrogen production and associated infrastructure, and testing of hydrogen-powered rail freight traffic.

The investment is in line with Inlandsbanan's ambition to create a prioritised freight corridor in central Sweden with no $CO_2$ emissions, while avoiding the need to establish expensive contact lines along the track. In 2019, the company conducted its first *passenger* transport, with diesel power.

There is growing interest in powering trains using hydrogen fuel cells [*see the Editorial in FCB, June 2019*]. Alstom's Coradia iLint is the world's first fuel cell powered passenger train [*see the News Feature in March 2017*], with two trains in regular passenger service in Germany since September 2018 [*September 2018, p1*]. And Swiss-based Stadler Rail recently signed a contract to supply what will be the first fuel cell powered passenger train in the US [*November 2019, p1*].

Inlandsbanan AB: www.inlandsbanan.se/en

Statkraft: www.statkraft.com

## Nedstack partners with DSMS for maritime logistics, Koedood for inland navigation

**In the Netherlands, fuel cell technology company Nedstack has entered into a cooperation with Damen Schelde Marine Services (DSMS) – part of the Damen Shipyards Group – and Maritime Logistics, to develop and deploy a logistics and service network for Nedstack maritime hydrogen PEM fuel cell technology. Nedstack is also partnering with Koedood Marine Group, with which it has been jointly developing fuel cell power solutions for the inland navigation and short-sea shipping sector for the past two years.**

The use of hydrogen fuel cell technology onboard maritime vessels will enable zero-emissions operation with acceptable range, endurance at sea, fast turnaround, and low weather sensitivity. Nedstack has long been active in maritime fuel cell technology [*e.g. FCB, December 2019, p4, and see the feature in August 2014*], and is currently commercialising its portfolio of maritime PemGen fuel cell power solutions [*May 2019, p15*].

The **Nedstack-DSMS partnership** will enable both new-build opportunities with a global spare parts and service organisation, as well as providing zero-emission retrofit upgrade packages. Talks are ongoing with leading shipowners on simultaneous development of zero-emission shipping solutions and their respective service organisations. The DSMS logistics and service network provides access to warehouses in the Netherlands, Singapore, and associated outlets close to other major global shipping and ship repair hubs.

For two years **Nedstack and Koedood** – a leading distributor of marine engines for inland shipping – have been jointly developing fuel cell power solutions for the inland navigation and short-sea shipping sector. After a successful period of prototyping, pilot installations and demonstrations, this year the focus will move to commercialisation and deployment, making good use of their complementary knowledge and expertise to provide an optimised product and service environment for shipowners.

Nedstack fuel cell technology BV: www.nedstack.com

Damen Schelde Marine Services: www.damenscheldeparts.com

Koedood Marine Group: www.koedood.nl [in Dutch]

## IN BRIEF

### Hyundai studies FCEV feasibility in India

Hyundai Motor India Ltd (www.hyundai.com/in) is evaluating the feasibility of bringing fuel cell electric vehicles to India, to strengthen its commitment to a more sustainable transport ecosystem as part of the Government of India's vision of zero-emissions mobility.

South Korean automaker Hyundai Motor Company [*see also pages 8 and 12*] unveiled its NEXO fuel cell SUV (www.hyundai.com/worldwide/en/eco/nexo) two years ago [*FCB, January 2018, p2*]. One was recently used in a world record attempt on the longest distance driven in a hydrogen powered vehicle on a single fueling, driving 778 km (483.4 miles) across France [*December 2019, p2*].

### First hydrogen stations for San Francisco

Two hydrogen refueling stations were opened in San Francisco at the end of 2019, with a third expected to open shortly. In early November the city's first hydrogen station opened at 551 3rd Street, in the South Park neighbourhood. The station, developed by Shell [*see also the Hamburg item on page 8*], has a larger capacity (513 kg of hydrogen) and more fueling positions (two 700 bar/H70 fueling nozzles) than earlier stations in California, to meet the needs of the growing fuel cell passenger car market in the Bay Area.

A month later the city's second hydrogen station opened at 1201 Harrison Street, also developed by Shell and with the same storage and dispensing capacity, and offering 100% renewably produced hydrogen. California requires that at least 33% of hydrogen fuel come from renewable sources; for stations that qualify for the Low Carbon Fuel Standard ZEV (zero emission vehicle) Infrastructure Credit, this increases to 40%.

### ARENA pushes commercial-scale green hydrogen in Australia, for export market

The Australian Renewable Energy Agency (ARENA, https://arena.gov.au/renewable-energy/hydrogen) has announced a funding round of up to A$70 million (US$48 million) to help fast-track the country's development of renewably produced hydrogen. The funding round is expected to support commercial-scale deployments of 'green' hydrogen in Australia [*FCB, September 2018, p14*].

ARENA will investigate funding for projects that involve commercial-scale deployments of electrolysers, in particular above 10 MW in capacity, to drive the commercialisation of key component technologies and facilitate cost reductions for producing renewable hydrogen. It is currently launching a stakeholder consultation process to help inform the parameters of a large-scale funding round, with formal applications expected to open in March.

on the use of hydrogen powered cars, buses and waste collection vehicles in Bremen and Oldenburg. The Metropolitan Region Rhine-Neckar (around Mannheim, Ludwigshafen and Heidelberg) in Baden-Württemberg has the €61 million ($68 million) $H_2$Rivers project, focused on the sustainability, local and integrated generation aspects of diverse mobile fuel cell applications. And the €45 million ($50 million) HyBayern initiative in the Landshut Region in Bavaria (with the Districts of Munich and Ebersberg) plans to implement a closed cycle of 'green' hydrogen generation, distribution, and use in hydrogen vehicle fleets.

HyLand – Hydrogen Regions in Germany: https://tinyurl.com/now-hyland

NOW GmbH: www.now-gmbh.de

National Innovation Programme Hydrogen and Fuel Cell Technology: http://tinyurl.com/nip-h2fc-tech

RESEARCH

# German project on use of fuel cells in trucks

**The Esslingen University of Applied Sciences (*Hochschule Esslingen*) in Germany has been awarded a contract by the Baden-Württemberg Ministry of the Environment [*see also the next item*] to lead the Reallabor Hylix-B research project, which will study whether fuel cell technology is suitable for everyday goods transport in trucks.**

The project team plans to equip a prototype 26 tonne electric truck with a fuel cell drivetrain, which will be tested in the Stuttgart area, to identify and hopefully remove obstacles to wider deployment. The researchers will look at both the technical and organisational challenges in practice.

'Electrical operation with hydrogen technology is ideal for heavy commercial vehicles or larger buses,' says project manager Professor Dr Ralf Wörner, Head of the Institute for Sustainable Energy Technology and Mobility (INEM) at Hochschule Esslingen. 'The greater the load and the further the distance, the more it is worth using hydrogen. Otherwise the battery would have to be oversized.'

The two-year project, with a budget of some €840 000 (US$930 000), comprises the construction of the truck, which will take around 18 months, and an operational phase lasting six months. The research consortium plans to bring in other experts to build a user- and market-oriented vehicle, with the various forms of participation acting as a 'practical laboratory' (*Reallabor*). Several partners are involved in the project, including the local utility Stadtwerke Esslingen and the Electrify-BW electromobility association.

Hochschule Esslingen, Institute for Sustainable Energy Technology and Mobility: https://tinyurl.com/esslingen-inem

Stadtwerke Esslingen: www.swe.de [in German]

Electrify-BW: www.electrify-bw.de [in German]

# ZSW, Fraunhofer in HyFab project to scale up fuel cell production

**In Germany, the Baden-Württemberg Ministry of the Environment [*see also the above item*] is funding the 'HyFab-Baden-Württemberg – Research Factory for Fuel Cells and Hydrogen' project, to support the scaling-up of fuel cell production for hydrogen mobility.**

Scientists at the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the Fraunhofer Institute for Solar Energy Systems ISE are developing and testing automated manufacturing and quality assurance processes for fuel cells, in collaboration with industry and research partners. The ministry is providing €7.9 million (US$8.8 million) in funding: ZSW in Stuttgart will receive €4.9 million ($5.5 million), with €3 million ($3.3 million) going to Fraunhofer ISE in Freiburg.

The HyFab project will prepare for scaling-up to fuel cell mass production, with production-focused research and support for market participants in their production development. The aim is to set up a platform for production research from components to complete stacks, offering the fuel cell industry and machine and plant manufacturers opportunities for coordinated and collaborative research on series production, including quality assurance.

ZSW [*see also page 12*] and Fraunhofer ISE will coordinate work with industrial control partners to study the quality features along the process chain from the membrane to the fuel cell stack, and jointly develop training plans and workshops to transfer know-how to industry. ZSW will focus on the stack process and Fraunhofer ISE on the membrane-electrode assembly, i.e. the processes in the production chain between the raw materials and stack assembly.

Center for Solar Energy and Hydrogen Research Baden-Württemberg: www.zsw-bw.de/en

Fraunhofer ISE, Hydrogen Technologies and Electrical Energy Storage: http://tinyurl.com/ise-h2fuelcell

## IN BRIEF

### Arup reviews case for UK hydrogen trains

The UK's Rail Safety and Standards Board (RSSB, www.rssb.co.uk) has appointed international consulting giant Arup (www.arup.com/expertise/industry/rail) to develop a 'route map to enter service' for hydrogen powered trains on the Great Britain mainline. The work will involve establishing a high-level operational concept, and taking into account associated operational hazards and regulatory obligations.

Alongside electrified rail and battery powered trains, the deployment of hydrogen powered trains offers a lower-carbon alternative to diesel. Working closely with manufacturers, regulators, rolling stock owners and train operators, Arup's work will inform the specific design solutions of hydrogen powered trains, factoring in operational and safety risks. The study, which is due to finish in February, will also determine what level of standardisation is needed across the UK's railway system.

Last summer Vivarail announced a collaboration with Arcola Energy to develop a fuel cell-battery hybrid train [*FCB, June 2019, p5*], and Porterbrook is partnering with the University of Birmingham's Centre for Railway Research and Education to test the UK's first hydrogen train, called HydroFLEX, on the mainline railway following a successful proof-of-concept [*July 2019, p4*].

### American Bureau of Shipping publishes fuel cell guidance to help decarbonisation

The American Bureau of Shipping (www.eagle.org) recently published its *Guide for Fuel Cell Power Systems for Marine and Offshore Applications* (https://tinyurl.com/abs-guide-fuel-cell-power), to support the design, evaluation, and construction of fuel cell systems on vessels and offshore assets. The guide, which covers all fuel cell types, focuses on the use of fuel cell systems and arrangements for propulsion and auxiliary systems, in both new-build and retrofit projects, while maintaining key safety principles.

ABS has just completed a joint development project with Korean giant Daewoo Shipbuilding & Marine Engineering, to investigate the use of hybrid solid oxide fuel cell–gas turbine generator technology and explore its potential installation onboard future generations of LNG (liquefied natural gas) carrier ships. This theoretical work demonstrated high efficiency of electricity and heat cogeneration.

Fuel cells are also addressed in the *ABS Advisory on Hybrid Electric Power Systems*, published in 2017 (https://tinyurl.com/abs-hybrid-electric), which takes a measured approach to evaluating the potential advantages and disadvantages, challenges, and level of readiness for the primary hybrid electric power systems and components that are most suited for marine and offshore applications.

# Patents

## Fabrication method to prevent GDL intrusion in bipolar plate channels, even with narrow GDL rolls, for improved PEMFC performance

*Assignee:* **Hyundai Motor Company, Korea**
*Inventors: B.K. Hong et al.*
*Patent number: US 10431838*
*Published: 1 Oct. 2019 (Filed: 18 Feb. 2014)*

## Method for fabricating very fine channels in PEMFC MEA, with good resin workability and conductivity

*Assignee:* **Futamura Kagaku KK, Japan [Futamura Chemical Co Ltd]**
*Inventors: T. Imaizumi et al.*
*Patent number: US 10431839*
*Published: 1 Oct. 2019 (Filed: 2 Nov. 2015)*

## Manufacturing method for SOFC electrolyte-electrode assembly with fewer parts and lower production cost, but improved performance

*Assignees:* **Sumitomo Electric Industries Ltd, Japan** *and* **Kyushu University, Japan**
*Inventors: C. Hiraiwa et al.*
*Patent number: US 10431840*
*Published: 1 Oct. 2019 (Filed: 23 June 2015)*

## SOFC manufacturing method with simultaneous sintering and pattern formation of electrolyte layer with wide surface layer, for improved cell efficiency

*Assignee:* **LG Chem, Korea**
*Inventors: J.M. Choi et al.*
*Patent number: US 10431841*
*Published: 1 Oct. 2019 (Filed: 5 Nov. 2015)*

## Economical, fast method for producing catalyst coated membranes for PEMFC MEAs

*Assignees:* **Volkswagen, Germany** *and* **Audi, Germany**
*Inventors: M. Kusy et al.*
*[Ballard Power Systems, Canada]*
*Patent number: US 10431844*
*Published: 1 Oct. 2019 (Filed: 26 Jan. 2016)*

## Polymers with superior mechanical properties and chemical stability, for anion-exchange membranes, e.g. for use in AEMFCs

*Assignee:* **Rensselaer Polytechnic Institute, USA**
*Inventors: C. Bae et al.*
*Patent number: US 10435504*
*Published: 8 Oct. 2019 (Filed: 17 Nov. 2015)*

## Metallic component surface modification to reduce electrical contact resistance, e.g. for PEMFC or electrolyser bipolar plates

*Assignee:* **Treadstone Technologies, USA**
*Inventors: C. Wang et al.*
*Patent number: US 10435782*
*Published: 8 Oct. 2019 (Filed: 15 Apr. 2016)*

## Simple method to synthesise Pt or Pt alloy nanocatalysts with high metal loading and surface particle density on support, for PEMFCs

*Assignee:* **Nanyang Technological University, Singapore**
*Inventors: W. Zhou et al.*
*Patent number: US 10439228*
*Published: 8 Oct. 2019 (Filed: 18 July 2014)*

## Fabrication of carbon nanotubes doped with iron, nitrogen and sulfur for ORR catalyst in PEMFC

*Assignee:* **City University of Hong Kong, Hong Kong**
*Inventors: J. Lu et al.*
*Patent number: US 10439229*
*Published: 8 Oct. 2019 (Filed: 15 Mar. 2017)*

## Method for manufacturing PEMFC electrode, with improved slurry dispersibility and stability by allowing binder and metal catalyst to flow together in slurry

*Assignees:* **Hyundai Motor Company, Korea** *and* **Kia Motors Corporation, Korea**
*Inventors: D.-Y. Son et al.*
*Patent number: US 10439230*
*Published: 8 Oct. 2019 (Filed: 17 July 2017)*

## PEMFC metal separator comprises Fe with Cr, Sn, Ta and V, with excellent corrosion resistance even at high voltage

*Assignee:* **Toyota Motor Corporation, Japan**
*Inventors: T. Kono et al.*
*Patent number: US 10439231*
*Published: 8 Oct. 2019 (Filed: 15 Mar. 2017)*

## Selectively sealing porous plate, e.g. PEMFC water transport plate, to prevent undesired leakage from porous structure and migration of seal adhesive

*Assignee:* **Audi, Germany**
*Inventors: S.P. Victor et al.*
*[UTC Power, USA]*
*Patent number: US 10439232*
*Published: 8 Oct. 2019 (Filed: 6 Apr. 2009)*

## Connector unit for mating with cell stack of automotive (PEM) fuel cell

*Assignees:* **Tyco Electronics Japan, Japan** *and* **Toyota Motor Corporation, Japan**
*Inventors: D. Hotta et al.*
*Patent number: US 10439233*
*Published: 8 Oct. 2019 (Filed: 20 Feb. 2018)*

## Modular planar SOFC interconnect for enhanced power density, fuel utilisation and power efficiency

*Assignee:* **National Taipei University of Technology, Taiwan**
*Inventors: S.-F. Wang et al.*
*Patent number: US 10439234*
*Published: 8 Oct. 2019 (Filed: 27 July 2017)*

## Air supply device using cooling water heater in FCEV, for faster cold-starting and effective removal of stack moisture in cold shutdown

*Assignee:* **Hyundai Motor Company, Korea**
*Inventors: S.D. Han et al.*
*Patent number: US 10439236*
*Published: 8 Oct. 2019 (Filed: 9 Dec. 2014)*

## Control of fuel vapour collector and burner when automotive SOFC system is stopped, to suppress oxidation deterioration in anode

*Assignee:* **Nissan Motor Co, Japan**
*Inventor: T. Yaguchi*
*Patent number: US 10439237*
*Published: 8 Oct. 2019 (Filed: 26 Sep. 2016)*

## Control of automotive PEMFC cooling system, to cool stack on shutdown in response to anticipated upcoming cold-start

*Assignee:* **Ford, USA**
*Inventors: M. Riley et al.*
*Patent number: US 10439238*
*Published: 8 Oct. 2019 (Filed: 15 July 2016)*

## Shutdown method for automotive PEMFC system, to remove excess $H_2$ in stack if leak is detected

*Assignees:* **General Motors, USA** *and* **Honda Motor Co, Japan**
*Inventors: M. Sinha et al.*
*Patent number: US 10439239*
*Published: 8 Oct. 2019 (Filed: 18 June 2015)*

### Methods and processes to recover voltage loss due to CO contamination of anode catalyst in automotive PEMFC

*Assignee:* **General Motors, USA**
*Inventors: J. Zhang et al.*
*Patent number: US 10439241*
*Published: 8 Oct. 2019 (Filed: 28 Oct. 2015)*

### Hybrid high-temperature swing adsorption to separate high-purity $CO_2$ in recycled MCFC exhaust in combined cycle power system

*Assignee:* **ExxonMobil Research and Engineering Company, USA**
*Inventors: N. Sundaram et al.*
*Patent number: US 10439242*
*Published: 8 Oct. 2019 (Filed: 1 Nov. 2016)*

### Automated PEMFC MEA manufacturing method and device for improved productivity

*Assignee:* **Hyundai Motor Company, Korea**
*Inventors: S.H. Jeong et al.*
*Patent number: US 10439243*
*Published: 8 Oct. 2019 (Filed: 3 June 2016)*

### Membrane for PEMFC MEA with increased power density, production method

*Assignees:* **Volkswagen, Germany** *and* **Audi, Germany**
*Inventor: C.M. Zillich*
*Patent number: US 10439244*
*Published: 8 Oct. 2019 (Filed: 21 July 2016)*

### Ion transport material for polymer electrolyte membrane for PEMFC or redox flow battery, production

*Assignee:* **LG Chem, Korea**
*Inventors: H. Choi et al.*
*Patent number: US 10439245*
*Published: 8 Oct. 2019 (Filed: 17 Oct. 2014)*

### PEMFC stack configured to suppress water entering case in contact with end plate

*Assignees:* **Toyota Motor Corporation, Japan, Taiho Kogyo Co Ltd, Japan** *and* **Toyoda Gosei Co Ltd, Japan**
*Inventors: T. Shimizu et al.*
*Patent number: US 10439247*
*Published: 8 Oct. 2019 (Filed: 24 July 2017)*

### Semi-tractor truck with multiple hydrogen (PEM) fuel cell power modules

*Assignee:* **Toyota Motor Engineering & Manufacturing North America, USA**
*Inventors: S.Z. Brown et al.*
*Patent number: US 10442297*
*Published: 15 Oct. 2019 (Filed: 28 Mar. 2018)*

### Nanostructured PEMFC electrode, comprising ionomer-free active metal-loaded carbon nanostructures and active metal-free ionomer-coated carbon nanostructures

*Assignee:* **Ford, USA**
*Inventors: Z. Lu et al.*
*Patent number: US 10446851*
*Published: 15 Oct. 2019 (Filed: 17 Oct. 2016)*

### Membrane-free, metal-free cathode direct fed fuel cell system operating on crude glycerol and bio-oil, and membrane-free direct alcohol fuel cell with PTFE thin film

*Assignee:* **Iowa State University, USA**
*Inventors: W. Li et al.*
*Patent number: US 10446852*
*Published: 15 Oct. 2019 (Filed: 14 Mar. 2017)*

### Coatings for metal interconnects to reduce SOFC degradation, plasma spraying air side of interconnect with MnCoO spinel coating

*Assignee:* **Bloom Energy Corporation, USA**
*Inventors: J. Wilson et al.*
*Patent number: US 10446854*
*Published: 15 Oct. 2019 (Filed: 30 Sep. 2015)*

### SOFC multilayer interconnect comprising doped ceria, doped lanthanum chromite and/or doped yttrium chromite on anode side, and Co–Mn spinel and/or $ABO_3$ perovskite on cathode side

*Assignee:* **LG Fuel Cell Systems, USA**
*Inventors: Z. Liu et al.*
*Patent number: US 10446855*
*Published: 15 Oct. 2019 (Filed: 13 Dec. 2013)*

### SOFC with longitudinal and lateral channels in separator plate, for uniform reaction area and deterioration, extended service life

*Assignee:* **POSCO Energy, Korea**
*Inventors: H.M. Son et al.*
*Patent number: US 10446856*
*Published: 15 Oct. 2019 (Filed: 8 July 2013)*

### PEMFC structure in which product water is less likely to block flow path, inhibiting increased pressure loss in oxidant off-gas

*Assignee:* **Toyota Motor Corporation, Japan**
*Inventors: T. Yoshizumi et al.*
*Patent number: US 10446857*
*Published: 15 Oct. 2019 (Filed: 22 Sep. 2015)*

### SOFC using high thermal conductivity materials (e.g. Cu) to increase thermal energy transfer by thermal conduction, with Ni electroplating to prevent oxidation

*Assignee:* **Upstart Power Inc, USA**
*Inventors: N. Palumbo et al.* *[Protonex Technology]*
*Patent number: US 10446858*
*Published: 15 Oct. 2019 (Filed: 7 Oct. 2014)*

### Gas inlet manifold drain to remove condensate liquid, manage effects of moisture in air introduced into PEM or PAFC

*Assignee:* **Audi, Germany**
*Inventors: T. Skiba et al.* *[UTRC/UTC Power, USA]*
*Patent number: US 10446859*
*Published: 15 Oct. 2019 (Filed: 24 May 2012)*

### Flow-field for porous bipolar plate in PEMFC, with blocking plate to create terminated flow channels and thus interdigitated flow-fields

*Assignee:* **Audi, Germany**
*Inventors: T.H. Madden et al.* *[UTC Power, USA]*
*Patent number: US 10446860*
*Published: 15 Oct. 2019 (Filed: 23 June 2011)*

### Flowing oxygen-saturated electrolyte, direct hydrocarbon fuel cell (DHCFC-Flow) with improved performance and stability

*Assignee:* **Palo Alto Research Center, USA**
*Inventors: D. Desai et al.*
*Patent number: US 10446861*
*Published: 15 Oct. 2019 (Filed: 28 Dec. 2015)*

### Fuel cell architectures, thermal subsystems, and control logic for efficiently regulating temperature in automotive PEMFC stacks

*Assignee:* **General Motors, USA**
*Inventors: S. Arisetty et al.*
*Patent number: US 10446862*
*Published: 15 Oct. 2019 (Filed: 8 May 2017)*

### Aircraft auxiliary power system, with PEMFC(s), compressor and electric motor interconnected to provide electric power and pressurised air while on the ground

*Assignee:* **Airbus Operations GmbH, Germany**
*Inventors: C. Hoffjann et al.*
*Patent number: US 10446863*
*Published: 15 Oct. 2019 (Filed: 18 Dec. 2015)*

### PEM with hydrophilic channel efficiently formed by controlling phase separation structure, for excellent proton conductivity, use in PEMFC or redox flow battery

*Assignee:* **LG Chem, Korea**
*Inventors: E. Kang et al.*
*Patent number: US 10446864*
*Published: 15 Oct. 2019 (Filed: 4 Dec. 2015)*

### Liquid composition comprising polymer bearing $-SO_3H$ groups and perfluoroelastomer, for PEMFC separator, manufacturing method

*Assignee:* **Solvay Specialty Polymers Italy SpA, Italy**
*Inventors: L. Merlo et al.*
*Patent number: US 10446865*
*Published: 15 Oct. 2019 (Filed: 14 Oct. 2015)*

### Proton conductor comprising $BaZr_{1-x-y}Y_xIn_yO_3$, with small amount of In added to reduce overall resistance, SOFC electrolyte

*Assignee:* **Panasonic, Japan**
*Inventors: T. Kamata et al.*
*Patent number: US 10446866*
*Published: 15 Oct. 2019 (Filed: 9 May 2016)*

### Automated roll-to-roll method of manufacturing PEMFC subassemblies incorporating subgasketed thrifted membranes

*Assignee:* **3M, USA**
*Inventors: E.J. Iverson et al.*
*Patent number: US 10446868*
*Published: 15 Oct. 2019 (Filed: 25 Jan. 2016)*

### PtCoMn catalyst for durable PEMFC cathodes with high initial activity, production method

*Assignee:* **Tanaka Kikinzoku Kogyo KK, Japan [Tanaka Precious Metals]**
*Inventors: M. Ishida et al.*
*Patent number: US 10454113*
*Published: 22 Oct. 2019 (Filed: 19 June 2013)*

### Method of producing stable, active, mass-producible $Pt_3Ni$ catalysts by preferential co-etching, for formic acid and methanol oxidation, ORR

*Assignee:* **State University of New York at Binghamton, USA**
*Inventors: J. Fang et al.*
*Patent number: US 10454114*
*Published: 22 Oct. 2019 (Filed: 21 Dec. 2017)*

### Sulfur-tolerant anode current collectors for SOFC stacks, with cermet mesh or foam, improves performance on hydrocarbon fuels

*Assignee:* **Nexceris, USA**
*Inventors: M.J. Day et al.*
*Patent number: US 10454118*
*Published: 22 Oct. 2019 (Filed: 8 Dec. 2009)*

### Automotive PEMFC system able to remove large amount of cationic impurities in intake air or in water within fuel cell

*Assignee:* **Toyota Motor Corporation, Japan**
*Inventors: M. Matsusue et al.*
*Patent number: US 10454119*
*Published: 22 Oct. 2019 (Filed: 15 Dec. 2016)*

### Multifunction valve in cathode loop of automotive PEMFC system, to accomplish cathode blocking and bypass function at single location

*Assignee:* **Ford, USA**
*Inventors: C.M. Mathie et al.*
*Patent number: US 10454120*
*Published: 22 Oct. 2019 (Filed: 3 May 2016)*

### Control method for automotive SOFC system, to reduce oxidative degradation of anode on stopping

*Assignee:* **Nissan Motor Co, Japan**
*Inventors: K. Yajima et al.*
*Patent number: US 10454121*
*Published: 22 Oct. 2019 (Filed: 26 Sep. 2016)*

### Reinforced MEA for automotive PEMFC, with improved durability, fabrication methods

*Assignee:* **General Motors, USA**
*Inventors: S.C. Moose et al.*
*Patent number: US 10454122*
*Published: 22 Oct. 2019 (Filed: 19 May 2017)*

### Metal-supported SOFC with high ion conductivity, and high adhesion between electrolyte layer and metal support prevents interfacial peeling

*Assignee:* **Honda Motor Co, Japan**
*Inventors: A. Koizumi et al.*
*Patent number: US 10454123*
*Published: 22 Oct. 2019 (Filed: 2 Aug. 2016)*

### Automotive PEMFC stack structure prevents foreign substances entering vent opening, and reduces risk of it being blocked or damaged

*Assignee:* **Honda Motor Co, Japan**
*Inventor: H. Naito*
*Patent number: US 10454125*
*Published: 22 Oct. 2019 (Filed: 27 Jan. 2017)*

### Clamp assembly for securing fuel cell stack in compressed condition, assembly method

*Assignee:* **University of Cape Town, South Africa**
*Inventor: S. Tanaka*
*Patent number: US 10454126*
*Published: 22 Oct. 2019 (Filed: 28 Oct. 2014)*

### SOFC module with spring-mounted busbars for reduced degradation due to thermal stress

*Assignees:* **Toshiba Energy Systems & Solutions, Japan** *and* **Toshiba, Japan**
*Inventor: T. Matsuno*
*Patent number: US 10454127*
*Published: 22 Oct. 2019 (Filed: 22 June 2017)*

### Compact device for measuring hydrogen ion conductivity of electrolyte membrane for PEM, direct methanol, direct borohydride or solid alkaline fuel cell

*Assignee:* **Korea Institute of Science and Technology, Korea**
*Inventors: S.Y. Lee et al.*
*Patent number: US 10458943*
*Published: 29 Oct. 2019 (Filed: 4 Jan. 2018)*

### GDE resistant to drying-out and flooding, for automotive PEMFC

### with excellent power generation across wide temperature range

*Assignee:* **Toray Industries, Japan**
*Inventors: Y. Tanimura et al.*
*Patent number: US 10461334*
*Published: 29 Oct. 2019 (Filed: 16 Dec. 2016)*

### SOFC cathode functional layers to reduce interfacial resistance between cathode and electrolyte

*Assignees:* **Redox Power Systems, USA** *and* **University of Maryland, College Park, USA**
*Inventors: K.-J. Pan et al.*
*Patent number: US 10461335*
*Published: 29 Oct. 2019 (Filed: 17 Mar. 2017)*

### Process for producing catalyst layer-forming coating liquid, which prevents PEM breaking when drying, use in MEA for PEMFC

*Assignee:* **AGC Inc, Japan [Asahi Glass Company]**
*Inventors: H. Watabe et al.*
*Patent number: US 10461336*
*Published: 29 Oct. 2019 (Filed: 26 Feb. 2018)*

### Energy management system with power management method to control SOFC temperature within predetermined range

*Assignee:* **Kyocera Corporation, Japan**
*Inventors: K. Nakamura et al.*
*Patent number: US 10461340*
*Published: 29 Oct. 2019 (Filed: 28 Sep. 2012)*

### SOFC (or PEM or MCFC) system with hydrodesulfuriser to remove sulfur from hydrocarbon fuel (e.g. city gas or propane), heated using fuel cell exhaust gas

*Assignee:* **Panasonic, Japan**
*Inventors: T. Kakuwa et al.*
*Patent number: US 10461341*
*Published: 29 Oct. 2019 (Filed: 5 Dec. 2014)*

### External manifold for minimising external leakage of reactant from PEMFC stack

*Assignee:* **Audi, Germany**
*Inventor: R.J. Guthrie [USA]*
*Patent number: US 10461342*
*Published: 29 Oct. 2019 (Filed: 13 Oct. 2016)*

### Automotive PEMFC assembly with cooling system

*Assignee:* **Ford, USA**
*Inventors: C.M. Mathie et al.*
*Patent number: US 10461343*
*Published: 29 Oct. 2019 (Filed: 11 Feb. 2015)*

### Multi-tank, explosion-proof, methanol-water mixture storage system for FCEV, safe in event of traffic collisions, rollover accidents or military attacks

*Assignee:* **Guangdong Hydrogen Energy Science and Technology Co Ltd, China**
*Inventor: H. Xiang*
*Patent number: US 10461344*
*Published: 29 Oct. 2019 (Filed: 28 Feb. 2017)*

### Hydrogen storage and supply system on FCEV, prevents leakage when refueling

*Assignee:* **Toyota Motor Corporation, Japan**
*Inventor: K. Komiya*
*Patent number: US 10461345*
*Published: 29 Oct. 2019 (Filed: 7 Nov. 2017)*

### Battery-sized PEMFC power generator and fuel (e.g. hydride) cartridge

*Assignee:* **Honeywell International, USA**
*Inventor: S.J. Eickhoff*
*Patent number: US 10461346*
*Published: 29 Oct. 2019 (Filed: 21 Mar. 2018)*

### Real-time monitoring and automated intervention platform for long-term operability of SOFCs for industrial power generation

*Assignee:* **Bloom Energy Corporation, USA**
*Inventors: A. Venkat et al.*
*Patent number: US 10461347*
*Published: 29 Oct. 2019 (Filed: 1 July 2016)*

### Control method for automotive fuel cell system, to detect impurities in fuel or air supply and recover stack performance accordingly

*Assignee:* **Hyundai Motor Company, Korea**
*Inventors: S.J. Im et al.*
*Patent number: US 10461348*
*Published: 29 Oct. 2019 (Filed: 2 May 2016)*

### Control method for automotive PEMFC system, based on impedance or coolant temperature

*Assignee:* **Honda Motor Co, Japan**
*Inventors: N. Koiwa et al.*
*Patent number: US 10461349*
*Published: 29 Oct. 2019 (Filed: 9 Feb. 2017)*

### PEM comprising polyhedral oligomeric silsequioxane (POSS) crosslinked with hydrocarbon-based polymer, use in MEA for PEMFC

*Assignee:* **Seoul National University, Korea**
*Inventors: J.-C. Lee et al.*
*Patent number: US 10461351*
*Published: 29 Oct. 2019 (Filed: 1 Nov. 2016)*

### Automotive PEMFC stack, with control of where fluid manifold member breaks to reduce risk of short-circuit through liquid

*Assignee:* **Honda Motor Co, Japan**
*Inventor: H. Naito*
*Patent number: US 10461353*
*Published: 29 Oct. 2019 (Filed: 5 Sep. 2014)*

### Compact, lightweight automotive PEMFC system with simple, reliable sealing of space between stack and stack case

*Assignee:* **Honda Motor Co, Japan**
*Inventor: H. Naito*
*Patent number: US 10461354*
*Published: 29 Oct. 2019 (Filed: 9 Dec. 2016)*

### Fuel cell powered life jacket, using electricity, heat and water generated from PEMFC with metal hydride storage

*Assignee:* **Daegu Gyeongbuk Institute of Science & Technology, Korea**
*Inventors: B.R. Son et al.*
*Patent number: US 10464643*
*Published: 5 Nov. 2019 (Filed: 20 Sep. 2016)*

# EVENTS CALENDAR

28–30 January 2020
**SAE Hybrid and Electric Vehicle Technologies Symposium**
*Pasadena, California, USA*
**More information:** www.sae.org/attend/hybrid

4–5 February 2020
**HyVolution 2020, Hydrogen Event for Energy, Industry and Mobility**
*Paris, France*
**More information:**
www.hyvolution-event.com/en

11 February 2020
**24. Fachkongress Zukunftsenergien (24th Conference on Future Energies, including Forum C: Possible Uses of Hydrogen for Urban Energy Solutions) [in German]**
*Essen, Germany*
**More information:** https://www.energieagentur.nrw/energiewirtschaft/24._fachkongress_zukunftsenergien

12–14 February 2020
**2nd Congress of the Italian Chemical Society, Interdivisional Group on Chemistry for Renewable Energy, EnerCHEM 2**
*Padua, Italy*
**More information:**
https://enerchem-2.icmate.cnr.it

25 February 2020
**8th International Fuel Cell Meeting, Fuel Cell Development Information Center (FCDIC) [before FC EXPO]**
*Tokyo, Japan*
**More information:** www.fcdic.com/infometion

26–28 February 2020
**FC EXPO 2020, 16th International Hydrogen & Fuel Cell Expo, within World Smart Energy Week 2020**
*Tokyo, Japan*
**More information:** www.fcexpo.jp/en-gb.html

1–4 March 2020
**The International Coalition for Energy Storage and Innovation Conference, ICESI 2020**
*Sydney, Australia*
**More information:** www.icesi2020.com

4–5 March 2020
**4th ACI Hydrogen & Fuel Cells Energy Summit 2020**
*Lisbon, Portugal*
**More information:** www.wplgroup.com/aci/event/hydrogen-fuel-cells-energy-summit

10–11 March 2020
**World Hydrogen Fuels Summit 2020: The Meeting Place for the Hydrogen Industry**
*Amsterdam, The Netherlands*
**More information:** www.worldhydrogenfuels.com

10–12 March 2020
**14th International Renewable Energy Storage Conference (IRES 2020), with Energy Storage Europe International Trade Fair**
*Düsseldorf, Germany*
**More information:** www.eseexpo.com
**More information:**
www.energystorageconference.org

17 March 2020
**16th UK Hydrogen and Fuel Cell Conference: Hydrogen & Fuel Cells – Coming of Age, CCSHFC2020**
*NEC, Birmingham, UK*
**More information:**
www.climate-change-solutions.co.uk/events

18 March 2020
**Laser Colloquium Hydrogen, $LKH_2$ [in German]**
*Fraunhofer Institute for Laser Technology ILT, Aachen, Germany*
**More information:** https://tinyurl.com/ilt-lkh2

25–26 March 2020
**Hydrogen & Fuel Cells for Heavy Duty Transport Conference [site visit to E-Trucks Europe on 24 March]**
*Brussels, Belgium*
**More information:** www.h2-transport.com

29 March–2 April 2020
**2020 AIChE Spring Meeting, including Topical Conferences on Emerging Technologies in Clean Energy, and Hydrogen Safety**
*Houston, Texas, USA*
**More information:** www.aiche.org/spring

1–2 April 2020
**f-cell + HFC Vancouver 2020, The Hydrogen and Fuel Cell Event**
*Vancouver, BC, Canada*
**More information:** www.hyfcell.com

20–24 April 2020
**Hydrogen+Fuel Cells Europe 2020, within Hannover Messe 2020**
*Hannover, Germany*
**More information:** www.h2fc-fair.com

21–23 April 2020
**SAE 2020 WCX**
*Detroit, Michigan, USA*
**More information:** www.sae.org/attend/wcx

29–30 April 2020
**2020 Ohio Fuel Cell Symposium**
*North Canton, Ohio, USA*
**More information:** www.fuelcellcorridor.com

3–6 May 2020
**HYPOTHESIS XV Cape Town 2020 South Africa, HYdrogen POwer THeoretical & Engineering Solutions International Symposium**
*Cape Town, South Africa*
**More information:** www.hypothesis.ws

10–13 May 2020
**5th Green and Sustainable Chemistry Conference**
*Bonn, Germany*
**More information:** www.elsevier.com/events/conferences/green-and-sustainable-chemistry-conference

10–15 May 2020
**237th ECS Meeting, The Electrochemical Society**
*Montreal, Canada*
**More information:** www.electrochem.org/237

13–14 May 2020
**All-Energy Exhibition & Conference 2020**
*Glasgow, Scotland, UK*
**More information:** www.all-energy.co.uk

19–21 May 2020
**US DOE Hydrogen and Fuel Cells Program 2020 Annual Merit Review and Peer Evaluation Meeting**
*Crystal City, Virginia, USA*
**More information:**
www.annualmeritreview.energy.gov

21–22 May 2020
**27th Fuel Cell Symposium, Fuel Cell Development Information Center (FCDIC)**
*Tokyo, Japan*
**More information:** www.fcdic.com/infometion

25–27 May 2020
**9th Meeting of Electrochemistry in Nanoscience, ElecNano9: Electrochemistry for Nano & Nano for Electrochemistry**
*Paris, France*
**More information:**
http://elecnano.univ-paris-diderot.fr

14–17 June 2020
**33rd World Electric Vehicle Symposium & Exposition, EVS33**
*Portland, Oregon, USA*
**More information:** https://evs33portland.org

14–18 June 2020
**12th European Symposium on Electrochemical Engineering, Electrochemistry for Electrification and Energy Transition Toward a Sustainable Future**
*Leeuwarden, The Netherlands*
**More information:**
www.electrochemical-engineering.eu/2020

22–24 June 2020
**8th Workshop on Ion Exchange Membranes for Energy Applications: Fuel Cells, Electrolyers, Flow Batteries, EMEA 2020 [and see next item]**
*Bad Zwischenahn, Germany*
**More information:** www.emea-workshop.de

24–26 June 2020
**Workshop on High Temperature Polymer Electrolyte Membrane Fuel Cell Technology – Materials and Applications, HiPEM-TECH 2020 [and see above item]**
*Bad Zwischenahn, Germany*
**More information:**
https://dlr-oldenburg.de/#/event/4

30 June–3 July 2020
**14th European SOFC & SOE Forum, EFCF 2020, Featuring Solid Oxide Technologies: Fuel Cells, Electrolysers & Membrane Reactors, $CO_2$ Emission Reduction & Reuse**
*Lucerne, Switzerland*
**More information:** www.efcf.com

11–14 August 2020
**2020 World Fuel Cell Conference, WFCC 2020: Fuel Cell Division of the International Association for Hydrogen Energy (IAHE)**
*Toronto, Ontario, Canada*
**More information:** www.iahe-fcd.org/wfcc2020
**Abstract deadline:** 15 February 2020

Qbuzz: www.qbuzz.nl/english

Shell, Hydrogen Fuel: http://tinyurl.com/shell-h2

JIVE: www.fuelcellbuses.eu/projects/jive

Fuel Cells and Hydrogen Joint Undertaking: www.fch.europa.eu

# Nikola, Iveco and FPT launch partnership, Nikola Tre truck model

**US-based Nikola Corporation and Iveco and FPT Industrial in Italy have presented the scope and plans of their joint venture and collaboration agreement, established to accelerate industry transformation towards emission neutrality of Class 8 heavy-duty trucks in North America and Europe through the adoption of fuel cell technology. The joint venture also unveiled a scale model of the Nikola Tre battery electric truck.**

Last autumn CNH Industrial took a $250 million strategic stake in Nikola [*FCB, October 2019, p12*]. The latest announcement builds on this strategic partnership, involving its Iveco commercial vehicles brand and its powertrain division FPT Industrial. The partnership includes the creation of a European joint venture to develop and distribute cab-over hydrogen fuel cell and battery electric trucks for the European market. Nikola will provide its fuel cell expertise and advanced technologies, as well as its disruptive business model that foresees an all-inclusive lease rate. Iveco and FPT Industrial will contribute their engineering and manufacturing expertise to industrialise the fuel cell and battery electric trucks.

Iveco, FPT Industrial, and Nikola have started development of the JV's first truck: the battery electric Nikola Tre, which is based on the new Iveco S-Way platform and integrates Nikola's truck technology, controls, and infotainment [*December 2018, p4*]. Testing is expected to begin this summer, with the European public launch planned for the IAA 2020 Commercial Vehicles trade show in Hannover, Germany in September, and the first units reaching customers in 2021; the hydrogen fuel cell version will be available to customers by 2023. Sales and aftersales support of the Nikola Tre will be provided by Iveco's extensive European dealer network.

The vehicle displayed at the launch was a *maquette* (scale model) of the Nikola Tre 4×2 tractor unit, with a range of up to 400 km (250 miles) and dynamic performance at least as good as an equivalent diesel model. The partners have adopted a modular approach, with Nikola's fuel cell as the starting point for the design, so that the Nikola Tre battery electric vehicle can be subsequently converted to hydrogen fuel cell technology.

Nikola Corporation: www.nikolamotor.com

CNH Industrial: www.cnhindustrial.com

Iveco: www.iveco.com

FPT Industrial: www.fptindustrial.com

## MOBILE APPLICATIONS

# Engie orders 3.5 MW Nel electrolyser, Plug Power refueling unit for giant mining truck

**French electric utility Engie has ordered a 3.5 MW electrolyser from Nel Hydrogen Electrolyser in Norway, and a custom hydrogen refueling system from US-based Plug Power, to provide renewably produced hydrogen for the world's largest fuel cell powered mining haul truck for Anglo American.**

The Anglo American–Engie project involves retrofitting the Ultra-class heavy-duty mining truck operating at Anglo American's Mogalakwena platinum group metals mine in South Africa, to become a zero-emissions fuel cell electric truck, powered by 800 kW of PEM fuel cell modules from Ballard Power Systems in Canada [*FCB, November 2019, p6*]. Electricity for hydrogen production will partly come from local solar power and the grid, and the electrolyser capacity surpasses the daily demand of the truck, enabling storage for fueling during the night or when solar irradiation is poor, maximising the renewable share of the hydrogen. If successful, the long-term target is to convert the entire fleet of haul trucks at the mine to hydrogen, and at Anglo American's other mining operations around the world.

**Nel Hydrogen Electrolyser** – a subsidiary of Nel ASA [*see also page 8*] – has now received a purchase order from Engie, following a previously announced contract for a 3.5 MW alkaline electrolyser. The electrolyser is an element of Engie's hydrogen solution to produce renewable hydrogen for the mining haul truck, and is scheduled to be installed this year.

'When scaled up, more than 100 MW of electrolyser capacity will be needed for this mine alone, representing an attractive new market opportunity,' says Henning Langås, Sales Director of Nel Hydrogen Electrolyser.

In addition, Engie has selected **Plug Power** to provide a custom hydrogen refueling system for the mine haul truck, which is set to begin operation this year. The project has emerged from the companies' recently announced global partnership agreement [*October 2019, p15*].

Plug Power has been tasked with building a full compression, storage, and dispensing system to serve the vehicle. The system will be the first of its kind, and the largest refueling system built by Plug Power to date, with an expected output of 1000 kg/day of hydrogen. The first fueling of the new truck is currently scheduled for the second half of 2020, followed by a rigorous testing and validation programme at the open-pit mine.

Anglo American, FutureSmart Mining: www.angloamerican.com/futuresmart

Engie: www.engie.com/en

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# PKN Orlen and Pesa cooperate on hydrogen technology for trains

**Polish oil refiner and petrol retailer PKN Orlen and rail vehicle manufacturer Pesa Bydgoszcz SA have signed a Letter of Intent to cooperate in the development of hydrogen fuel cell powered trains.**

The agreement covers the exchange of information and research that will lead to Pesa developing a rail vehicle equipped with a hydrogen fuel cell drive system. Both companies will then test hydrogen powered rail vehicles, and eventually implement them in commercial solutions. The technology will first be developed for use in freight locomotives, and eventually in a traction unit for passenger traffic.

'We have already decided to build a hydrogen purification plant, to be built at the plant in Trzebinia owned by Orlen Południe,' says Daniel Obajtek, President of PKN Orlen. 'The start of production of pure hydrogen fuel, which will be used to drive electric vehicles, including locomotives, is planned in 2021.'

'PKN Orlen already produces nearly 45 tonnes of high-quality hydrogen per hour in the production process. We sell this raw material for passenger cars at two stations in Germany,' adds Józef Węgrecki, Board Member for Operations. 'Soon hydrogen drivers will also be able to refuel in the Czech Republic, because Unipetrol from the Orlen Group will start construction

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PKN Orlen: www.orlen.pl/en

Pesa SA: www.pesa.pl/index.php/en

## Inlandsbanan, Statkraft study hydrogen fuel cell power for freight trains in Sweden

**Swedish train operator Inlandsbanan ('Inland Line') and energy utility Statkraft have signed a Letter of Intent for a joint investment in hydrogen-powered heavy goods transport, that would enable zero-carbon transport of heavy goods across Sweden, without the need for power contact lines.**

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The investment is in line with Inlandsbanan's ambition to create a prioritised freight corridor in central Sweden with no $CO_2$ emissions, while avoiding the need to establish expensive contact lines along the track. In 2019, the company conducted its first *passenger* transport, with diesel power.

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## Nedstack partners with DSMS for maritime logistics, Koedood for inland navigation

**In the Netherlands, fuel cell technology company Nedstack has entered into a cooperation with Damen Schelde Marine Services (DSMS) – part of the Damen Shipyards Group – and Maritime Logistics, to develop and deploy a logistics and service network for Nedstack maritime hydrogen PEM fuel cell technology. Nedstack is also partnering with Koedood Marine Group, with which it has been jointly developing fuel cell power solutions for the inland navigation and short-sea shipping sector for the past two years.**

The use of hydrogen fuel cell technology onboard maritime vessels will enable zero-emissions operation with acceptable range, endurance at sea, fast turnaround, and low weather sensitivity. Nedstack has long been active in maritime fuel cell technology [*e.g. FCB, December 2019, p4, and see the feature in August 2014*], and is currently commercialising its portfolio of maritime PemGen fuel cell power solutions [*May 2019, p15*].

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Hyundai Motor India Ltd (www.hyundai.com/in) is evaluating the feasibility of bringing fuel cell electric vehicles to India, to strengthen its commitment to a more sustainable transport ecosystem as part of the Government of India's vision of zero-emissions mobility.

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Two hydrogen refueling stations were opened in San Francisco at the end of 2019, with a third expected to open shortly. In early November the city's first hydrogen station opened at 551 3rd Street, in the South Park neighbourhood. The station, developed by Shell [*see also the Hamburg item on page 8*], has a larger capacity (513 kg of hydrogen) and more fueling positions (two 700 bar/H70 fueling nozzles) than earlier stations in California, to meet the needs of the growing fuel cell passenger car market in the Bay Area.

A month later the city's second hydrogen station opened at 1201 Harrison Street, also developed by Shell and with the same storage and dispensing capacity, and offering 100% renewably produced hydrogen. California requires that at least 33% of hydrogen fuel come from renewable sources; for stations that qualify for the Low Carbon Fuel Standard ZEV (zero emission vehicle) Infrastructure Credit, this increases to 40%.

### ARENA pushes commercial-scale green hydrogen in Australia, for export market

The Australian Renewable Energy Agency (ARENA, https://arena.gov.au/renewable-energy/hydrogen) has announced a funding round of up to A$70 million (US$48 million) to help fast-track the country's development of renewably produced hydrogen. The funding round is expected to support commercial-scale deployments of 'green' hydrogen in Australia [*FCB, September 2018, p14*].

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Two hydrogen refueling stations were opened in San Francisco at the end of 2019, with a third expected to open shortly. In early November the city's first hydrogen station opened at 551 3rd Street, in the South Park neighbourhood. The station, developed by Shell [*see also the Hamburg item on page 8*], has a larger capacity (513 kg of hydrogen) and more fueling positions (two 700 bar/H70 fueling nozzles) than earlier stations in California, to meet the needs of the growing fuel cell passenger car market in the Bay Area.

A month later the city's second hydrogen station opened at 1201 Harrison Street, also developed by Shell and with the same storage and dispensing capacity, and offering 100% renewably produced hydrogen. California requires that at least 33% of hydrogen fuel come from renewable sources; for stations that qualify for the Low Carbon Fuel Standard ZEV (zero emission vehicle) Infrastructure Credit, this increases to 40%.

### ARENA pushes commercial-scale green hydrogen in Australia, for export market

The Australian Renewable Energy Agency (ARENA, https://arena.gov.au/renewable-energy/hydrogen) has announced a funding round of up to A$70 million (US$48 million) to help fast-track the country's development of renewably produced hydrogen. The funding round is expected to support commercial-scale deployments of 'green' hydrogen in Australia [*FCB, September 2018, p14*].

ARENA will investigate funding for projects that involve commercial-scale deployments of electrolysers, in particular above 10 MW in capacity, to drive the commercialisation of key component technologies and facilitate cost reductions for producing renewable hydrogen. It is currently launching a stakeholder consultation process to help inform the parameters of a large-scale funding round, with formal applications expected to open in March.

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The new mobile 30 kW pure hydrogen fuel cell system developed by Toshiba ESS will be available to install in maritime vessels, rail vehicles, and trucks. The zero-carbon system is much quieter than standard ship engines, and it can start generating power in as quickly as a minute. The greatly reduced volume per unit power compared to the stationary fuel cell system is a result of its simplified design and packaging improvements. The system complies with the safety guidelines formulated by the Japanese Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

The fuel cell powered ship, which passed the Temporary Navigation Permit Inspection of the Japan Craft Inspection Organization in October, has started verification demonstrations with NREG Toshiba Building Corporation (part of the Nomura Real Estate Group) and the Tokyo University of Marine Science and Technology (TUMSAT).

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MOL has been working to realise zero emissions from vessels while in port since it announced its future vision for the next-generation series ISHIN-1 car carrier in 2009. In 2012 it launched the world's first hybrid car carrier, the *Emerald Ace*, which is equipped with a large-scale solar power generation system and batteries. The hydrogen hybrid PCC concept marks a further step from these projects, and the company is pursuing the possibility of introducing more extensive and more advanced technologies with the goal of zero emissions.

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e5 Lab has previously worked with Japanese tugboat operator Tokyo Kisen to jointly develop a concept design for the 'e5 Tug' hybrid electric harbour tugboat, with a high-capacity Li-ion battery system as the main power source and a hydrogen fuel cell and generator for auxiliary power [*FCB, November 2019, p15*].

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SMALL STATIONARY

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Onsite implementation is now under way, following successful completion of the tenders and the granting of €5 million (US$5.6 million) in funding from the Federal Ministry of Transport and Digital Infrastructure (BMVI), within the scope of the National Innovation Programme Hydrogen and Fuel Cell Technology (NIP2) [*FCB, January 2019, p11, and also see page 14*]. 'The research and development projects were successful – now the market-relevant phase of the fuel cell technology as a backup power supply is beginning,' explains Dr Henrik Colell, spokesman for the Clean Power Net (CPN) fuel cell network [*see the CPN feature in August 2012*].

Colell adds that the successful use of fuel cells in digital radio communications for public authorities proves how important financial support for market activation will remain in the future. 'Funding programmes are the preliminary stage to the market ramp-up,' he says. 'On the one hand, they support technically mature but not yet fully competitive products. On the other hand, they secure Germany's place in international competition for this technology of the future.' The CPN is aiming for a further call for BMVI funding for 2020.

Munich-based SFC Energy recently received a framework contract from cooperation partner adKor to deliver hydrogen fuel cells for emergency backup power for radio tower sites in several federal states [*December 2019, p5*].

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LARGE STATIONARY

# FCE progress at US Navy sub base, Tulare biogas project begins commercial operation

**Connecticut-based FuelCell Energy reports significant construction progress on the CMEEC (Connecticut Municipal Electric Energy Cooperative) Fuel Cell Micro-Grid Project at the US Naval Submarine Base in Groton. Construction is on track, with significant onsite work completed and power plant deliveries commencing. FCE has also announced the start of commercial operation of the 2.8 MW molten carbonate fuel cell project at Tulare's waste water treatment facility in California.**

The Fuel Cell Micro-Grid Project at the **Naval Submarine Base New London** in Groton – announced in May 2017 [*FCB, June 2017, p7 and November 2017, p7*] – includes the installation and commissioning of two FuelCell Energy SureSource™ 4000 power plants, which will provide 7.4 MW of continuous power generation. FuelCell Energy has now completed significant site work on the base, including excavation, wiring, and pouring of the concrete pads for siting the fuel cell units. The delivery of the MCFC modules and balance of plant began in the first week of January, with the first power plant expected to be commissioned in the spring.

Supported by the strength of the CMEEC project, the Connecticut Green Bank has agreed an incremental $3 million corporate loan. On the commercial operation date of the CMEEC project, the loan is expected to be converted into a project company term loan, secured by the consistent cashflow generation of the CMEEC project. Last spring FuelCell Energy signed a $23 million construction financing facility with Fifth Third Bank to finance the construction, installation, and commissioning of the power plant [*April 2019, p7*].

Meanwhile, FCE's 2.8 MW project at the waste water treatment facility for the city of **Tulare in California** has begun commercial operation. The SureSource 3000 power plant is fueled by the city's biogas, which is treated by the SureSource Treatment™ system, a cleanup technology optimised by FuelCell Energy's extensive experience with onsite biogas treatment [*July 2017, p6*]. Prior to the fuel cell's installation the methane-rich biogas was flared, which wasted energy and produced emissions. The FCE unit is now using that biogas and producing clean, renewable, carbon-neutral power. The MCFC system will also supply clean renewable heat to the wastewater facility's anaerobic digesters, further reducing carbon emissions.

Under California's Bioenergy Market Adjustment Tariff (BioMAT) programme, FuelCell Energy has executed a 20-year Power Purchase Agreement (PPA) with the local electric utility, Southern California Edison, to purchase the renewable and carbon-neutral power for supply to the California electric grid.

This installation builds on an earlier fuel cell project at the Tulare wastewater treatment plant, comprising four DFC300 systems generating a total of 1 MW [*January 2010, p6*].

FuelCell Energy: www.fuelcellenergy.com

Connecticut Municipal Electric Energy Cooperative: www.cmeec.com

Naval Submarine Base New London: www.cnic.navy.mil/newlondon

Connecticut Green Bank: www.ctgreenbank.com

City of Tulare, Wastewater Treatment: www.tulare.ca.gov/departments/public-works/wastewater

# Ballard, HDF Energy to develop multi-MW stationary systems, install Martinique unit

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HDF Energy's **Renewstable power plant** is a multi-MW baseload system enabling large-scale storage of intermittent renewable wind or solar energy in the form of hydrogen – through water electrolysis – as well as electricity generation using that hydrogen feedstock in a fuel cell system. This power plant can produce zero-emission power on a 24/7 basis from intermittent renewable energy, to support electrical grids.

The development agreement covers two phases of work. 'The first phase involves the design, build, and supply of two next-generation, MW-scale containerised stationary PEM fuel cell systems totaling 3 MW, based on our new high-durability LCS fuel cell stack,' says Dr Kevin Colbow, CTO at Ballard [*see also pages 3 and 11*]. 'Second, after HDF Energy incorporates these systems into their Renewstable power plant in an initial project, we plan to proceed with a technology transfer programme to enable HDF Energy to assemble these fuel cell systems for global market sales of their Renewstable power plants.'

In the initial HDF Energy project an installation is planned in French Guiana, in South America, under the Centrale Electricité de l'Ouest Guyanais (CEOG) project [*FCB, June 2018, p3*]. The project will involve 90 MWh of energy storage from hydrogen.

The collaboration also contemplates a future technology transfer of Ballard's new MW-scale containerised PEM fuel cell system to HDF Energy, with an exclusive royalty-bearing, non-transferable, multi-year global licence for the manufacture and sale of MW-scale fuel cell systems for Renewstable power plant systems. The collaboration will also see Ballard supplying LCS fuel cell stacks [*October 2018, p12*] for these systems based on an exclusive long-term supply agreement. HDF Energy plans to establish a manufacturing facility in Bordeaux.

Meanwhile, HDF Energy has inaugurated a Ballard 1 MW containerised fuel cell system in **Martinique**, to demonstrate the viability of MW-scale stationary fuel cell systems. Purified by-product hydrogen from the Société Anonyme de Raffinerie des Antilles (SARA) refinery on Martinique is being used as feedstock for the fuel cell system. The electricity generated by the system is then supplied to the island's electric grid, supporting an energy diversification strategy. The CLEARgen Demo project is partially funded by the EU-supported Fuel Cells and Hydrogen Joint Undertaking (FCH JU). The 1 MW system operating in Martinique was initially planned for deployment in Bordeaux [*August 2015, p4*].

The SARA refinery had previously installed a 1 MW PEM fuel cell power plant – using Nedstack fuel cells [*see also page 5*] – in 2016 [*February 2016, p5*], with operation starting the following year.

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FUELING

# Nel awarded orders for H2Station deployments in Europe, South Korea

**Denmark-based Nel Hydrogen has received several purchase orders for H2Station® hydrogen refueling stations, for deployment in several European locations as well as in South Korea.**

OrangeGas has ordered multiple H2Station units for fueling of mostly light-duty fuel cell electric vehicles in the **Netherlands**, for delivery this year. The contract, worth €3 million (US$3.3 million), also includes service and maintenance. The stations will expand Dutch fueling coverage for hydrogen powered light-duty (and in the future also heavy-duty) FCEVs.

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'The sites for producing renewable hydrogen will be capable of delivering 'green' hydrogen not only to Hyundai trucks, but also to a number of other applications like buses, cars, ferries, and fast ferries,' continues Løkke. 'The parties intend to establish the first production site just outside Oslo to serve the Oslo/Akershus region.'

Green H2 Norway is equally owned by the partners, and will be in dialogue with other potential partners as well as national authorities to initiate the first project in 2020, which will include exploring sector-coupling aspects of large-scale, electrolysis-based hydrogen production. The JV is intended to be the exclusive supplier of renewably produced hydrogen for Hyundai trucks in Norway.

South Korean automaker Hyundai Motor Company [*see also page 12, and the In Brief item on page 5*] unveiled its fuel cell truck design in autumn 2018, alongside plans to deploy the first truck fleet with $H_2$ Energy in Switzerland [*FCB, October 2018, p3*]. Last autumn Hyundai Hydrogen Mobility (HHM) – a joint venture between Hyundai and $H_2$ Energy – announced a partnership with Hydrospider – itself a joint venture of $H_2$ Energy, Alpiq and Linde – to accelerate a green hydrogen ecosystem in Switzerland and other European countries, including Norway [*October 2019, p9*].

Nel ASA: www.nelhydrogen.com

$H_2$ Energy: www.h2energy.ch/en

Greenstat: www.greenstat.com

Akershus Energi, Infrastruktur: https://akershusenergi.no/no/infrastruktur [in Norwegian]

Hyundai Commercial Vehicle: http://trucknbus.hyundai.com/global/en

# EMEC awards FCSL hydrogen refueling contract for HyFlyer

**The European Marine Energy Centre (EMEC) in Orkney, Scotland, UK has awarded a contract to Fuel Cell Systems Ltd (FCSL) for the supply of a mobile hydrogen refueling vehicle for the HyFlyer project.**

The HyFlyer project, funded by Innovate UK, aims to demonstrate hydrogen fuel cell powertrain technology for zero-emission aviation. The project will integrate a hydrogen fuel cell powertrain onboard a Piper M-class six-seater aircraft, and perform test flights from Cranfield and Orkney [*FCB, October 2019, p6*]. The project is led by California-based ZeroAvia, which is collaborating with UK fuel cell engineering company Intelligent Energy to optimise its PEM fuel cell technology for aviation applications.

The tender for the mobile refueling unit was issued by HyFlyer project partner EMEC Hydrogen, which is investigating the infrastructure required to supply renewably produced hydrogen for the flight tests in Orkney. The scope of work contracted to FCSL involves the design and development of a mobile refueling unit as a solution to supply hydrogen airside and fuel the aircraft for the test flights in Cranfield and Orkney.

FCSL designed and launched its HyTruck mobile hydrogen refueling vehicle in 2016, which has since supported a range of projects, including a trial of Suzuki fuel cell powered scooters with the Metropolitan Police in London [*September 2017, p3*], and for the testing of the HydroFLEX hydrogen fuel cell train [*July 2019, p4*]. FCSL will supply a new refueling vehicle for the HyFlyer project, based on this proven design.

Using Orkney's renewable energy resources to produce 'green' hydrogen [*see also page 10*], EMEC Hydrogen is a partner in a growing number of innovative energy systems and hydrogen demonstration projects [*e.g. June 2018, p8, and September 2019, p5*], and is driving the development of the local hydrogen economy alongside global stakeholders.

Fuel Cell Systems Ltd is the UK's leading fuel cell integrator, consultancy and distributor, and has developed a range of hydrogen refueling products to help address the infrastructure gap in the UK and support individual projects. These include the HySerVe hydrogen 'jerrycan' to provide an emergency fill for stranded vehicles, which is incorporated into the AA's first alternative fuels prototype vehicle in the UK [*October 2018, p10*].

EMEC Hydrogen: www.emec.org.uk/hydrogen

Fuel Cell Systems Ltd: www.fuelcellsystems.co.uk

HyFlyer project: www.hyflyer.co.uk

ZeroAvia: www.zeroavia.com

Intelligent Energy: www.intelligent-energy.com

**ENERGY STORAGE & P2G**

# Funding for two large-scale Power-to-X projects in Denmark

**The Danish Energy Agency has announced DKK128 million (US$19 million) in financial support for two large-scale electrolyser projects in Denmark, with a total installed capacity of 32 MW, for which Everfuel Europe A/S is the hydrogen partner.**

Everfuel [*see also pages 8 and 10*] has been awarded DKK48 million ($7.1 million) for the **HySynergy** project, which aims to establish a 20 MW electrolysis-based hydrogen production facility at the Shell refinery in Fredericia, Denmark [*FCB, December 2019, p9*]. This facility, which is planned to enter operation in 2022, will be the largest electrolyser installation in Europe.

Everfuel will own and operate the hydrogen production facility, while Shell will be the main off-taker of 'green' hydrogen from the electrolyser. Everfuel will also install hydrogen storage and trailer filling stations, and operate hydrogen trailers to supply hydrogen fuel in Denmark. The parties will continue to work on permits and agreements related to the project, and expect to provide further details by the summer. While the initial capacity of the electrolyser will be 20 MW, the Fredericia site will be prepared to accommodate a capacity increase to 1 GW by 2030.

In the other project, **GreenLab Skive** will lead a consortium that will create the world's first large-scale facility for production of green hydrogen and methanol, and has been awarded DKK80 million ($11.9 million). The consortium also includes Eurowind Energy, GreenHydrogen, Norlys Holding, RE:Integrate, Energinet Electricity System Operator, the Danish Gas Technology Centre, Everfuel, E.ON Danmark, DTU Energy, and EA Energy Analyses.

This versatile energy symbiosis project – called Power-to-X (PtX) – will include the establishment of a 12 MW electrolysis plant and a 10 MW methanol plant, with electric power coming from a local 80 MW hybrid wind and solar photovoltaic (PV) plant. Everfuel will install an integrated trailer filling station, and operate hydrogen trailers from the site. P2X production is expected to commence in 2022.

Everfuel: www.everfuel.com

GreenLab Skive: www.greenlab.dk

**Hyundai trucks, which are expected to be deployed later this year.**

'Our plan is to build several facilities for renewable hydrogen production across Norway, and serve the market with true zero-emission hydrogen,' says Jon André Løkke, CEO of Nel [*see also pages 4 and 8*]. 'Hyundai has indicated that they are looking into supplying hydrogen trucks already from 2020, and high numbers from 2021 and beyond. We believe the timing for this is correct, as we also see hydrogen trucks and buses becoming available in large numbers and car manufacturers scaling up the production volumes.'

'The sites for producing renewable hydrogen will be capable of delivering 'green' hydrogen not only to Hyundai trucks, but also to a number of other applications like buses, cars, ferries, and fast ferries,' continues Løkke. 'The parties intend to establish the first production site just outside Oslo to serve the Oslo/Akershus region.'

Green H2 Norway is equally owned by the partners, and will be in dialogue with other potential partners as well as national authorities to initiate the first project in 2020, which will include exploring sector-coupling aspects of large-scale, electrolysis-based hydrogen production. The JV is intended to be the exclusive supplier of renewably produced hydrogen for Hyundai trucks in Norway.

South Korean automaker Hyundai Motor Company [*see also page 12, and the In Brief item on page 5*] unveiled its fuel cell truck design in autumn 2018, alongside plans to deploy the first truck fleet with $H_2$ Energy in Switzerland [*FCB, October 2018, p3*]. Last autumn Hyundai Hydrogen Mobility (HHM) – a joint venture between Hyundai and $H_2$ Energy – announced a partnership with Hydrospider – itself a joint venture of $H_2$ Energy, Alpiq and Linde – to accelerate a green hydrogen ecosystem in Switzerland and other European countries, including Norway [*October 2019, p9*].

Nel ASA: www.nelhydrogen.com

$H_2$ Energy: www.h2energy.ch/en

Greenstat: www.greenstat.com

Akershus Energi, Infrastruktur: https://akershusenergi.no/no/infrastruktur [in Norwegian]

Hyundai Commercial Vehicle: http://trucknbus.hyundai.com/global/en

# EMEC awards FCSL hydrogen refueling contract for HyFlyer

**The European Marine Energy Centre (EMEC) in Orkney, Scotland, UK has awarded a contract to Fuel Cell Systems Ltd (FCSL) for the supply of a mobile hydrogen refueling vehicle for the HyFlyer project.**

The HyFlyer project, funded by Innovate UK, aims to demonstrate hydrogen fuel cell powertrain technology for zero-emission aviation. The project will integrate a hydrogen fuel cell powertrain onboard a Piper M-class six-seater aircraft, and perform test flights from Cranfield and Orkney [*FCB, October 2019, p6*]. The project is led by California-based ZeroAvia, which is collaborating with UK fuel cell engineering company Intelligent Energy to optimise its PEM fuel cell technology for aviation applications.

The tender for the mobile refueling unit was issued by HyFlyer project partner EMEC Hydrogen, which is investigating the infrastructure required to supply renewably produced hydrogen for the flight tests in Orkney. The scope of work contracted to FCSL involves the design and development of a mobile refueling unit as a solution to supply hydrogen airside and fuel the aircraft for the test flights in Cranfield and Orkney.

FCSL designed and launched its HyTruck mobile hydrogen refueling vehicle in 2016, which has since supported a range of projects, including a trial of Suzuki fuel cell powered scooters with the Metropolitan Police in London [*September 2017, p3*], and for the testing of the HydroFLEX hydrogen fuel cell train [*July 2019, p4*]. FCSL will supply a new refueling vehicle for the HyFlyer project, based on this proven design.

Using Orkney's renewable energy resources to produce 'green' hydrogen [*see also page 10*], EMEC Hydrogen is a partner in a growing number of innovative energy systems and hydrogen demonstration projects [*e.g. June 2018, p8, and September 2019, p5*], and is driving the development of the local hydrogen economy alongside global stakeholders.

Fuel Cell Systems Ltd is the UK's leading fuel cell integrator, consultancy and distributor, and has developed a range of hydrogen refueling products to help address the infrastructure gap in the UK and support individual projects. These include the HySerVe hydrogen 'jerrycan' to provide an emergency fill for stranded vehicles, which is incorporated into the AA's first alternative fuels prototype vehicle in the UK [*October 2018, p10*].

EMEC Hydrogen: www.emec.org.uk/hydrogen

Fuel Cell Systems Ltd: www.fuelcellsystems.co.uk

HyFlyer project: www.hyflyer.co.uk

ZeroAvia: www.zeroavia.com

Intelligent Energy: www.intelligent-energy.com

**ENERGY STORAGE & P2G**

# Funding for two large-scale Power-to-X projects in Denmark

**The Danish Energy Agency has announced DKK128 million (US$19 million) in financial support for two large-scale electrolyser projects in Denmark, with a total installed capacity of 32 MW, for which Everfuel Europe A/S is the hydrogen partner.**

Everfuel [*see also pages 8 and 10*] has been awarded DKK48 million ($7.1 million) for the **HySynergy** project, which aims to establish a 20 MW electrolysis-based hydrogen production facility at the Shell refinery in Fredericia, Denmark [*FCB, December 2019, p9*]. This facility, which is planned to enter operation in 2022, will be the largest electrolyser installation in Europe.

Everfuel will own and operate the hydrogen production facility, while Shell will be the main off-taker of 'green' hydrogen from the electrolyser. Everfuel will also install hydrogen storage and trailer filling stations, and operate hydrogen trailers to supply hydrogen fuel in Denmark. The parties will continue to work on permits and agreements related to the project, and expect to provide further details by the summer. While the initial capacity of the electrolyser will be 20 MW, the Fredericia site will be prepared to accommodate a capacity increase to 1 GW by 2030.

In the other project, **GreenLab Skive** will lead a consortium that will create the world's first large-scale facility for production of green hydrogen and methanol, and has been awarded DKK80 million ($11.9 million). The consortium also includes Eurowind Energy, GreenHydrogen, Norlys Holding, RE:Integrate, Energinet Electricity System Operator, the Danish Gas Technology Centre, Everfuel, E.ON Danmark, DTU Energy, and EA Energy Analyses.

This versatile energy symbiosis project – called Power-to-X (PtX) – will include the establishment of a 12 MW electrolysis plant and a 10 MW methanol plant, with electric power coming from a local 80 MW hybrid wind and solar photovoltaic (PV) plant. Everfuel will install an integrated trailer filling station, and operate hydrogen trailers from the site. P2X production is expected to commence in 2022.

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GreenLab Skive: www.greenlab.dk

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GREEN HYDROGEN

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The consortium – known as Hydrogen Hub Orkney (H2O) – sees OGTC collaborating with local environmental support specialist Aquatera, Cranfield University, Doosan Babock, EMEC Hydrogen [*see also page 9*], and NOV (National Oilwell Varco) to prove the feasibility of several options for decentralised hydrogen generation, storage and distribution that collectively provide a scalable offshore hydrogen production solution. If successful, this would enable bulk hydrogen production using offshore platforms, and could offset a portion of decommissioning costs currently estimated for all offshore assets and infrastructure.

The HOP Project aims to tackle the challenge of bulk hydrogen production by proposing viable environmental and economic technology solutions, and developing a new industrial hydrogen production test site to both prove the industrial benefits and aid commercialisation of emerging technologies. It will also produce and market the business case for the transformation of existing offshore infrastructure, repurposing assets and demonstrating the viability of decentralised generation of hydrogen.

The consortium was awarded £500 000 (US$650 000) in funding by the UK's Department for Business, Energy & Industrial Strategy (BEIS), under its £20 million ($26 million) Hydrogen Supply Competition. The first phase looked at the scenarios, concept design, and addressed the feasibility of offshore deployment, proposing viable technology options that could be fast-tracked for development. Phase 2 will create an industrial hydrogen test site and complete pilot studies, as well as FEED (front-end engineering design) of hydrogen systems and retrofitting of offshore systems. The consortium has submitted a proposal for BEIS funding for this second phase.

'It is often proposed that the solution to large-scale hydrogen production is large, centralised, onshore infrastructure; however, there is untapped potential in the use of offshore assets, many of which are decommissioned or approaching end-of-life,' explains Graeme Booth, Head of Research & Innovation at Doosan Babcock. 'Offshore wind farms – fixed and floating – offer a significant source of power, which strengthens the value proposition for offshore hydrogen generation.'

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# Ørsted-led consortium for renewable hydrogen using offshore wind

**The Danish Energy Agency's Energy Technology Development and Demonstration Programme (EUDP) is supporting the H2RES demonstration project in Denmark, in which a consortium of seven industrial partners will use power from an offshore wind farm to produce renewable hydrogen for road transport.**

Danish power company Ørsted (formerly DONG Energy) is the principal partner, working with Everfuel Europe [*see also page 9*], Nel Hydrogen [*see also page 8*], GreenHydrogen, DSV Panalpina, Hydrogen Denmark, and Energinet Elsystemansvar. The EUDP has issued DKK34.6 million (US$5.2 million) in funding to Ørsted for the construction of a 2 MW electrolysis plant with appropriate hydrogen storage. The plant will use electricity from Ørsted's two 3.6 MW offshore wind turbines at the Avedøre Power Station to produce 'green' hydrogen for use in buses, lorries, and potentially taxis. Electrolysis can be run flexibly, helping to utilise the fluctuating power production from the offshore wind turbines.

Hydrogen production is expected to total around 600 kg/day, enough to power 20–30 buses, while also making possible testing of its use in lorries and taxis. The funding awarded to the H2RES project is the largest among the 53 projects which have received funding from the EUDP in its second 2019 call for applications.

'The integration of energy from offshore wind into heavy transport is a main challenge in the green transformation,' comments Tejs Laustsen Jensen, CEO of Hydrogen Denmark. 'With H2RES, we'll have the possibility of testing how hydrogen and offshore wind can best complement each other.'

Ørsted is also participating in the UK's Gigastack feasibility study, led by ITM Power, which aims to demonstrate the delivery of bulk, low-cost, zero-carbon hydrogen through GW-scale PEM electrolysis using wind energy [*FCB, September 2019, p10*].

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The consortium is headed by Flakk Gruppen, in partnership with hydrogen storage supplier Hexagon Composites, hydrogen solutions integrator Hyon (a joint venture between Nel ASA, Hexagon Composites and PowerCell Sweden [*FCB, October 2017, p10*]), hydroelectric power supplier Tafjord, ship design and shipyard Fiskerstrand [*see the News Feature in January 2017*], safety and risk management services company Gexcon, the SINTEF research organisation, and Stranda Municipality.

GREEN HYDROGEN

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The project started its activities this month, and aims to deliver green hydrogen by 2023. The hydrogen will be produced by renewable surplus hydro power at Hellesylt, powering hydrogen fuel cell ferries operating on the Hellesylt–Geiranger route. Hydrogen will also be delivered to other vessels, trucks, buses and suitable vehicles in the region.

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The MEA purchase order, together with a fully operational fuel cell module factory, are expected to enable large-scale manufacturing of fuel cell products by the Weichai-Ballard JV in 2020. It builds on the agreement last summer to supply a mix of fuel cell products and components for the assembly of modules to power fuel cell commercial vehicles in China [*June 2019, p12*].

Once operational, the Weichai-Ballard JV production facility will begin the manufacture of next-generation LCS fuel cell stacks and LCS-based modules to power fuel cell electric vehicles for the Chinese market. The JV is expected to have an initial annual production capacity of 20 000 PEM fuel cell stacks, or 10 000 modules, based on two-shift operation.

'We have a simple shared vision with Weichai Power for our Weichai-Ballard JV – to create the leading fuel cell stack and module technology and manufacturing operation in China for buses, commercial trucks, and forklifts,' says Randy MacEwen, President and CEO of Ballard. 'In 2019, together with Weichai, we staffed up the JV, co-developed fuel cell products for the China market, substantially completed construction of the JV manufacturing facility, progressed on our manufacturing equipment, processes and automation, initiated localisation of the supply chain, and supported initial vehicle testing.'

Ballard supplied the fuel cell modules powering eight Van Hool fuel cell tram-buses in the Fébus project in Pau, in France [*see page 2*], and recently received another order from Van Hool for modules to power 20 buses in Groningen, the Netherlands [*see page 3*]. The company has also signed a Product Development Agreement with HDF Energy to develop and integrate a multi-MW scale fuel cell system into the latter's Renewstable® power plant for stationary power applications [*see page 7*].

Ballard Power Systems: www.ballard.com

Weichai Power: http://en.weichaipower.com

## PowerCell in phase 2 of Autostack Industrie project in Germany

**PowerCell Sweden has received approval from the German authorities for Phase 2 of the Autostack Industrie industrial project, which aims to develop a fuel cell stack for the German automotive industry, with commercial launch after 2022.**

PowerCell has previously participated in Phase 1 of the **Autostack Industrie** project, and has now received approval for the next phase. Autostack Industrie – partly funded by the German government – was launched to support the development of a fuel cell stack suitable for mass production, for the German automotive industry [*FCB, July 2017, p11 and July 2018, p15*]. The other project partners are Audi, BMW, Daimler, Reinz-Dichtungs GmbH (Dana), Ford-Werke GmbH, Freudenberg Performance Materials, Greenerity GmbH, Mercedes-Benz Fuel Cell GmbH, Umicore, Volkswagen, and the ZSW Center for Solar Energy and Hydrogen Research Baden-Württemberg [*see also page 15*].

PowerCell is responsible for stack design, and developing suitable production methodology. The approval frees up grant funding possibilities for PowerCell, up to a maximum of €4.85 million (US$5.4 million), for work it carries out within the project. The funding is within the scope of the German National Innovation Programme Hydrogen and Fuel Cell Technology (NIP), coordinated by NOW GmbH.

In other news, **Midroc New Technology** has acquired 2.1 million shares in PowerCell, representing 4.1% of votes and capital, from the Belgian investment company Finindus, which has approximately halved its ownership stake. Finindus – owned by ArcelorMittal and the Flemish region – has been a major owner in PowerCell since it was spun out of the Volvo Group in 2008, but has gradually reduced its stake over the last couple of years. Midroc New Technology is a venture capital company within Stockholm-based Midroc Europe, and was an owner in PowerCell until it sold all of its holding to Robert Bosch GmbH in November [*December 2019, p13*].

PowerCell Sweden: www.powercell.se

National Innovation Programme Hydrogen and Fuel Cell Technology: http://tinyurl.com/nip-h2fc-tech

Midroc Europe: www.midroc.se/en

Finindus: www.finindus.be

## Hyundai deal for SGL Carbon components, Impact Coatings MOU

**South Korean conglomerate Hyundai Motor Group and SGL Carbon in Germany have agreed on an early extension to their existing supply agreement for fuel cell components. The new long-term contract will enable a substantial ramp-up of current production and delivery volumes, to support Hyundai's objectives in fuel cell drive systems. And automaker affiliate Hyundai Motor Company has signed a Memorandum of Understanding with Impact Coatings in Sweden, furthering their cooperation in the development of fuel cell coatings and hydrogen energy technology.**

The new long-term agreement between **Hyundai and SGL Carbon** provides for a substantial ramp-up of current production and delivery volumes of Sigracet® gas diffusion layers for the Hyundai NEXO fuel cell electric vehicle [*FCB, May 2018, p15*]. The investment required to fulfill this contract will not increase the overall capital expenditure budget of SGL Carbon in the next two years, as the company has reprioritised its investment projects.

In the medium term, SGL Carbon plans to grow its fuel cell components business by a factor of five, to annual sales of €100 million (US$111 million). The company supplies around 200 customers around the world with GDLs for use in fuel cells. As a result of the growing demand, the company has gradually stepped up production capacity at its plant in Meitingen. Its technological expertise and experience mean that it can manufacture high-quality components for fuel cells on an industrial scale. To further accelerate commercialisation, the GDL business was recently transferred from the company's Central Innovation R&D department to the Graphite Materials & Systems (GMS) business unit.

Meanwhile, the MOU between **Hyundai and Impact Coatings** will further their cooperation in developing fuel cell coatings and hydrogen energy technology. The MOU, which is non-binding and has no defined economic value, follows a Joint Development Agreement announced in October [*November 2019, p13*]. The signing ceremony took place during the recent visit to Seoul by the Swedish Prime Minister Stefan Löfven and the Minister for Foreign Trade Anna Hallberg, together with a large delegation of Swedish business leaders.

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'We have a simple shared vision with Weichai Power for our Weichai-Ballard JV – to create the leading fuel cell stack and module technology and manufacturing operation in China for buses, commercial trucks, and forklifts,' says Randy MacEwen, President and CEO of Ballard. 'In 2019, together with Weichai, we staffed up the JV, co-developed fuel cell products for the China market, substantially completed construction of the JV manufacturing facility, progressed on our manufacturing equipment, processes and automation, initiated localisation of the supply chain, and supported initial vehicle testing.'

Ballard supplied the fuel cell modules powering eight Van Hool fuel cell tram-buses in the Fébus project in Pau, in France [*see page 2*], and recently received another order from Van Hool for modules to power 20 buses in Groningen, the Netherlands [*see page 3*]. The company has also signed a Product Development Agreement with HDF Energy to develop and integrate a multi-MW scale fuel cell system into the latter's Renewstable® power plant for stationary power applications [*see page 7*].

Ballard Power Systems: www.ballard.com

Weichai Power: http://en.weichaipower.com

## PowerCell in phase 2 of Autostack Industrie project in Germany

**PowerCell Sweden has received approval from the German authorities for Phase 2 of the Autostack Industrie industrial project, which aims to develop a fuel cell stack for the German automotive industry, with commercial launch after 2022.**

PowerCell has previously participated in Phase 1 of the **Autostack Industrie** project, and has now received approval for the next phase. Autostack Industrie – partly funded by the German government – was launched to support the development of a fuel cell stack suitable for mass production, for the German automotive industry [*FCB, July 2017, p11 and July 2018, p15*]. The other project partners are Audi, BMW, Daimler, Reinz-Dichtungs GmbH (Dana), Ford-Werke GmbH, Freudenberg Performance Materials, Greenerity GmbH, Mercedes-Benz Fuel Cell GmbH, Umicore, Volkswagen, and the ZSW Center for Solar Energy and Hydrogen Research Baden-Württemberg [*see also page 15*].

PowerCell is responsible for stack design, and developing suitable production methodology. The approval frees up grant funding possibilities for PowerCell, up to a maximum of €4.85 million (US$5.4 million), for work it carries out within the project. The funding is within the scope of the German National Innovation Programme Hydrogen and Fuel Cell Technology (NIP), coordinated by NOW GmbH.

In other news, **Midroc New Technology** has acquired 2.1 million shares in PowerCell, representing 4.1% of votes and capital, from the Belgian investment company Finindus, which has approximately halved its ownership stake. Finindus – owned by ArcelorMittal and the Flemish region – has been a major owner in PowerCell since it was spun out of the Volvo Group in 2008, but has gradually reduced its stake over the last couple of years. Midroc New Technology is a venture capital company within Stockholm-based Midroc Europe, and was an owner in PowerCell until it sold all of its holding to Robert Bosch GmbH in November [*December 2019, p13*].

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National Innovation Programme Hydrogen and Fuel Cell Technology: http://tinyurl.com/nip-h2fc-tech

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## Hyundai deal for SGL Carbon components, Impact Coatings MOU

**South Korean conglomerate Hyundai Motor Group and SGL Carbon in Germany have agreed on an early extension to their existing supply agreement for fuel cell components. The new long-term contract will enable a substantial ramp-up of current production and delivery volumes, to support Hyundai's objectives in fuel cell drive systems. And automaker affiliate Hyundai Motor Company has signed a Memorandum of Understanding with Impact Coatings in Sweden, furthering their cooperation in the development of fuel cell coatings and hydrogen energy technology.**

The new long-term agreement between **Hyundai and SGL Carbon** provides for a substantial ramp-up of current production and delivery volumes of Sigracet® gas diffusion layers for the Hyundai NEXO fuel cell electric vehicle [*FCB, May 2018, p15*]. The investment required to fulfill this contract will not increase the overall capital expenditure budget of SGL Carbon in the next two years, as the company has reprioritised its investment projects.

In the medium term, SGL Carbon plans to grow its fuel cell components business by a factor of five, to annual sales of €100 million (US$111 million). The company supplies around 200 customers around the world with GDLs for use in fuel cells. As a result of the growing demand, the company has gradually stepped up production capacity at its plant in Meitingen. Its technological expertise and experience mean that it can manufacture high-quality components for fuel cells on an industrial scale. To further accelerate commercialisation, the GDL business was recently transferred from the company's Central Innovation R&D department to the Graphite Materials & Systems (GMS) business unit.

Meanwhile, the MOU between **Hyundai and Impact Coatings** will further their cooperation in developing fuel cell coatings and hydrogen energy technology. The MOU, which is non-binding and has no defined economic value, follows a Joint Development Agreement announced in October [*November 2019, p13*]. The signing ceremony took place during the recent visit to Seoul by the Swedish Prime Minister Stefan Löfven and the Minister for Foreign Trade Anna Hallberg, together with a large delegation of Swedish business leaders.

**venture in China, valued at US$19.2 million, to be delivered in 2020 under a long-term MEA supply agreement.**

Weichai Power is an investor in, and strategic partner with, Ballard [*FCB, September 2018, p10*]. Under terms of a strategic collaboration agreed in November 2018, Weichai holds a 51% ownership position and Ballard a 49% ownership position in the Weichai-Ballard JV [*December 2018, p13*]. The Weichai-Ballard JV production facility, located in Shandong Province, China, is expected to be commissioned and operational in the first half of 2020.

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**French hydrogen mobility company Symbio will begin construction of its new fuel cell factory in March, with a ceremony to lay the cornerstone. The company plans to produce 200 000 StackPack units per annum by 2030, in line with its ambition to become a world leader in fuel cell systems for the global hydrogen mobility market.**

Symbio says that the new factory will be the largest production plant for hydrogen systems in Europe, with a manufacturing capacity of 200 000 StackPack units per annum [*FCB, October 2019, p12*]. The StackPack comprises a hydrogen PEM fuel cell and key components to prolong its lifetime and optimise both compactness and integration into vehicles.

The factory project is supported by the Lyon Metropolis and the Auvergne-Rhône-Alpes Region, in particular through their respective development agencies Aderly and Auvergne-Rhône-Alpes-Entreprises. 'Beyond financial aid, their teams have demonstrated real expertise in setting up businesses,' says Fabio Ferrari, Executive Chairman of Symbio.

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## Proton Motor order from Fincantieri, signs LOI with APEX

**Proton Motor Power Systems Plc – the new name for Proton Power Systems Plc, the UK-based parent company of Proton Motor Fuel Cell GmbH in Germany – is supplying a 38 kW fuel cell to Italian shipbuilding giant Fincantieri, so that it can be validated in a pilot project for one of its vessels. Proton Motor has also signed a Letter of Intent with APEX Energy Teterow GmbH in Germany, further to the receipt of an order announced in May.**

The **Fincantieri** order, for a fourth-generation PEM fuel cell, includes a feasibility study for integration into the first ship, as well as other potential collaborations. 'With Proton having been the world's first fuel cell system provider that has powered a ferry in Hamburg for six years between 2009 and 2014 with a 50 kW fuel cell system [*FCB, October 2008, p4*], this is a great opportunity to enter the maritime market at the shipbuilding stage,' says Dr Faiz Nahab, CEO of Proton Motor.

Proton Motor has also signed a Letter of Intent with **APEX Energy**, based in Rostock-Laage in northeastern Germany. The company, which specialises in the production and distribution of modular renewable energy storage solutions, placed a €630 000 (US$700 000) order for a 150 kW fuel cell system last May, although it was not identified as the customer at that time [*June 2019, p14*]. The LOI envisages concluding a framework agreement with a consortium, to provide 10 fuel cell containers with up to 150 kW fuel cell systems within a two-year period commencing in 2020. The LOI also includes the intention, at an appropriate point in the future, to offer licensing agreements, whereby the licensees will produce Proton Fuel Cell containers with a capacity of up to 500 kW.

Proton Motor has more than 20 years' experience in industrial fuel cells and hybrid systems [*see the feature in May 2015*]. The company offers complete fuel cell and hybrid systems, from development and production to implementation of customised solutions, in automotive, maritime, and stationary applications.

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## Nuvera breaks ground on automated fuel cell production site in China

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'China is leading the world in the adoption of fuel cell electric vehicles, and we are excited to be at ground zero of this transformation,' says Lucien Robroek, CEO of Nuvera. 'The new manufacturing site establishes Nuvera as a major fuel cell provider both in China and in the entire Asian region.'

Nuvera expects the combined market for fuel cell powered forklifts, passenger vehicles, and commercial vehicles in China to reach nearly 50 000 units per annum in 2025, and 400 000 units per annum by 2030. The company's new production site incorporates equipment for the automated manufacture of up to 5000 fuel cell stacks per annum for vehicle applications, and additional capacity can be added if demand grows sufficiently.

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Symbio designs hydrogen fuel cell kits that can be incorporated into various types of electric vehicles (e.g. utility vehicles, buses, heavy goods vehicles) [*July 2018, p3*], and associated with a range of services (e.g. remote vehicle repairs, fleet management). There are several hundred of these vehicles on the road in France and across Europe, mostly light utility vehicles (vans) such as the Renault Kangoo ZE H2 [*July 2015, p2*].

Symbio: www.symbio.one/en

Aderly, Lyon: www.aderly.com/index.html

Auvergne-Rhône-Alpes-Entreprises: www.auvergnerhonealpes-entreprises.fr [in French]

## Proton Motor order from Fincantieri, signs LOI with APEX

**Proton Motor Power Systems Plc – the new name for Proton Power Systems Plc, the UK-based parent company of Proton Motor Fuel Cell GmbH in Germany – is supplying a 38 kW fuel cell to Italian shipbuilding giant Fincantieri, so that it can be validated in a pilot project for one of its vessels. Proton Motor has also signed a Letter of Intent with APEX Energy Teterow GmbH in Germany, further to the receipt of an order announced in May.**

The **Fincantieri** order, for a fourth-generation PEM fuel cell, includes a feasibility study for integration into the first ship, as well as other potential collaborations. 'With Proton having been the world's first fuel cell system provider that has powered a ferry in Hamburg for six years between 2009 and 2014 with a 50 kW fuel cell system [*FCB, October 2008, p4*], this is a great opportunity to enter the maritime market at the shipbuilding stage,' says Dr Faiz Nahab, CEO of Proton Motor.

Proton Motor has also signed a Letter of Intent with **APEX Energy**, based in Rostock-Laage in northeastern Germany. The company, which specialises in the production and distribution of modular renewable energy storage solutions, placed a €630 000 (US$700 000) order for a 150 kW fuel cell system last May, although it was not identified as the customer at that time [*June 2019, p14*]. The LOI envisages concluding a framework agreement with a consortium, to provide 10 fuel cell containers with up to 150 kW fuel cell systems within a two-year period commencing in 2020. The LOI also includes the intention, at an appropriate point in the future, to offer licensing agreements, whereby the licensees will produce Proton Fuel Cell containers with a capacity of up to 500 kW.

Proton Motor has more than 20 years' experience in industrial fuel cells and hybrid systems [*see the feature in May 2015*]. The company offers complete fuel cell and hybrid systems, from development and production to implementation of customised solutions, in automotive, maritime, and stationary applications.

Proton Motor Fuel Cell GmbH: www.proton-motor.de/gb

Fincantieri: www.fincantieri.com

APEX Energy Teterow GmbH: www.apex-group.de/en

## Nuvera breaks ground on automated fuel cell production site in China

**US-based Nuvera Fuel Cells has begun construction of a fuel cell stack production line in China, with a ground-breaking ceremony in mid-December in the Fuyang District of Hangzhou City, Zhejiang Province, south of Shanghai.**

Nuvera signed a cooperation agreement with the Fuyang government in December 2018, to enable the local manufacture of Nuvera® PEM fuel cell stacks [*FCB, January 2019, p14*]. The agreement provided incentives to Nuvera for the establishment of its production facility. The fuel cells will power heavy-duty vehicles such as delivery vans and transit buses.

'China is leading the world in the adoption of fuel cell electric vehicles, and we are excited to be at ground zero of this transformation,' says Lucien Robroek, CEO of Nuvera. 'The new manufacturing site establishes Nuvera as a major fuel cell provider both in China and in the entire Asian region.'

Nuvera expects the combined market for fuel cell powered forklifts, passenger vehicles, and commercial vehicles in China to reach nearly 50 000 units per annum in 2025, and 400 000 units per annum by 2030. The company's new production site incorporates equipment for the automated manufacture of up to 5000 fuel cell stacks per annum for vehicle applications, and additional capacity can be added if demand grows sufficiently.

Nuvera Fuel Cells: www.nuvera.com

## Winkelmann invests in Hydrogenious

**German hydrogen storage company Hydrogenious LOHC Technologies GmbH has successfully concluded its present fundraising round, with a €3.5 million (US$3.9 million) investment by the metal-forming specialist Winkelmann Group.**

The Winkelmann investment adds to the €17 million ($18.9 million) secured from several strategic investors last summer [*FCB, August 2019, p10*], led by tank storage company Royal Vopak, along with Japanese trading giant Mitsubishi Corporation, polymer supplier Covestro in Germany, and

Hyundai is also supplying fuel cell powered trucks for deployment in Norway, utilising renewable hydrogen production [*see the item on page 8*], and its Indian subsidiary is evaluating the feasibility of bringing FCEVs to India [*see the In Brief item on page 5*].

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

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

SGL Carbon: www.sglcarbon.com/en

Impact Coatings: www.impactcoatings.com

## Symbio progress on its new fuel cell factory

**French hydrogen mobility company Symbio will begin construction of its new fuel cell factory in March, with a ceremony to lay the cornerstone. The company plans to produce 200 000 StackPack units per annum by 2030, in line with its ambition to become a world leader in fuel cell systems for the global hydrogen mobility market.**

Symbio says that the new factory will be the largest production plant for hydrogen systems in Europe, with a manufacturing capacity of 200 000 StackPack units per annum [*FCB, October 2019, p12*]. The StackPack comprises a hydrogen PEM fuel cell and key components to prolong its lifetime and optimise both compactness and integration into vehicles.

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## Ionomr financing aids commercialisation of membrane technology

**Canadian-based Ionomr Innovations, which is developing ion-exchange membrane and polymer solutions for use in zero-emission power sources for vehicles and energy storage for renewable power generation, has raised an additional C$3 million (US$2.3 million) in seed financing to advance the development, production, and market expansion of its membranes and polymer products.**

The Vancouver, British Columbia-based company was founded in 2017 to commercialise a major performance breakthrough from polymer research undertaken at Simon Fraser University. It has subsequently pioneered and advanced the development and production of environmentally friendly membranes and polymer products for use in advanced fuel cells, hydrogen production, batteries, and renewable energy generation and storage systems. Ionomr says that its membranes and polymers will assist product developers to overcome cost, performance and environmental constraints by increasing performance and durability while eliminating the use of expensive precious metals and fluorinated compounds, which can adversely affect the environment.

'This new funding, which was led by BC-based seed fund Pallasite Ventures, will help us move rapidly and expand our work with internationally recognised companies and product developers in the emerging clean energy economy,' comments Bill Haberlin, CEO of Ionomr.

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Pallasite Ventures: www.pallasiteventures.com

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The Hydrogen Council has already identified more than 20 hydrogen projects as examples of initiatives that are ready to be scaled up, and this agreement will guide and support investments in clean, efficient, and profitable solutions based on hydrogen and ultimately accelerate the transition to a carbon-neutral economy.

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on the use of hydrogen powered cars, buses and waste collection vehicles in Bremen and Oldenburg. The Metropolitan Region Rhine-Neckar (around Mannheim, Ludwigshafen and Heidelberg) in Baden-Württemberg has the €61 million ($68 million) $H_2$Rivers project, focused on the sustainability, local and integrated generation aspects of diverse mobile fuel cell applications. And the €45 million ($50 million) HyBayern initiative in the Landshut Region in Bavaria (with the Districts of Munich and Ebersberg) plans to implement a closed cycle of 'green' hydrogen generation, distribution, and use in hydrogen vehicle fleets.

HyLand – Hydrogen Regions in Germany: https://tinyurl.com/now-hyland

NOW GmbH: www.now-gmbh.de

National Innovation Programme Hydrogen and Fuel Cell Technology: http://tinyurl.com/nip-h2fc-tech

**RESEARCH**

# German project on use of fuel cells in trucks

**The Esslingen University of Applied Sciences (*Hochschule Esslingen*) in Germany has been awarded a contract by the Baden-Württemberg Ministry of the Environment [*see also the next item*] to lead the Reallabor Hylix-B research project, which will study whether fuel cell technology is suitable for everyday goods transport in trucks.**

The project team plans to equip a prototype 26 tonne electric truck with a fuel cell drivetrain, which will be tested in the Stuttgart area, to identify and hopefully remove obstacles to wider deployment. The researchers will look at both the technical and organisational challenges in practice.

'Electrical operation with hydrogen technology is ideal for heavy commercial vehicles or larger buses,' says project manager Professor Dr Ralf Wörner, Head of the Institute for Sustainable Energy Technology and Mobility (INEM) at Hochschule Esslingen. 'The greater the load and the further the distance, the more it is worth using hydrogen. Otherwise the battery would have to be oversized.'

The two-year project, with a budget of some €840 000 (US$930 000), comprises the construction of the truck, which will take around 18 months, and an operational phase lasting six months. The research consortium plans to bring in other experts to build a user- and market-oriented vehicle, with the various forms of participation acting as a 'practical laboratory' (*Reallabor*). Several partners are involved in the project, including the local utility Stadtwerke Esslingen and the Electrify-BW electromobility association.

Hochschule Esslingen, Institute for Sustainable Energy Technology and Mobility: https://tinyurl.com/esslingen-inem

Stadtwerke Esslingen: www.swe.de [in German]

Electrify-BW: www.electrify-bw.de [in German]

# ZSW, Fraunhofer in HyFab project to scale up fuel cell production

**In Germany, the Baden-Württemberg Ministry of the Environment [*see also the above item*] is funding the 'HyFab-Baden-Württemberg – Research Factory for Fuel Cells and Hydrogen' project, to support the scaling-up of fuel cell production for hydrogen mobility.**

Scientists at the Center for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW) and the Fraunhofer Institute for Solar Energy Systems ISE are developing and testing automated manufacturing and quality assurance processes for fuel cells, in collaboration with industry and research partners. The ministry is providing €7.9 million (US$8.8 million) in funding: ZSW in Stuttgart will receive €4.9 million ($5.5 million), with €3 million ($3.3 million) going to Fraunhofer ISE in Freiburg.

The HyFab project will prepare for scaling-up to fuel cell mass production, with production-focused research and support for market participants in their production development. The aim is to set up a platform for production research from components to complete stacks, offering the fuel cell industry and machine and plant manufacturers opportunities for coordinated and collaborative research on series production, including quality assurance.

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Center for Solar Energy and Hydrogen Research Baden-Württemberg: www.zsw-bw.de/en

Fraunhofer ISE, Hydrogen Technologies and Electrical Energy Storage: http://tinyurl.com/ise-h2fuelcell

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### Arup reviews case for UK hydrogen trains

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Alongside electrified rail and battery powered trains, the deployment of hydrogen powered trains offers a lower-carbon alternative to diesel. Working closely with manufacturers, regulators, rolling stock owners and train operators, Arup's work will inform the specific design solutions of hydrogen powered trains, factoring in operational and safety risks. The study, which is due to finish in February, will also determine what level of standardisation is needed across the UK's railway system.

Last summer Vivarail announced a collaboration with Arcola Energy to develop a fuel cell-battery hybrid train [*FCB, June 2019, p5*], and Porterbrook is partnering with the University of Birmingham's Centre for Railway Research and Education to test the UK's first hydrogen train, called HydroFLEX, on the mainline railway following a successful proof-of-concept [*July 2019, p4*].

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Fuel cells are also addressed in the *ABS Advisory on Hybrid Electric Power Systems*, published in 2017 (https://tinyurl.com/abs-hybrid-electric), which takes a measured approach to evaluating the potential advantages and disadvantages, challenges, and level of readiness for the primary hybrid electric power systems and components that are most suited for marine and offshore applications.

on the use of hydrogen powered cars, buses and waste collection vehicles in Bremen and Oldenburg. The Metropolitan Region Rhine-Neckar (around Mannheim, Ludwigshafen and Heidelberg) in Baden-Württemberg has the €61 million ($68 million) $H_2$Rivers project, focused on the sustainability, local and integrated generation aspects of diverse mobile fuel cell applications. And the €45 million ($50 million) HyBayern initiative in the Landshut Region in Bavaria (with the Districts of Munich and Ebersberg) plans to implement a closed cycle of 'green' hydrogen generation, distribution, and use in hydrogen vehicle fleets.

HyLand – Hydrogen Regions in Germany: https://tinyurl.com/now-hyland

NOW GmbH: www.now-gmbh.de

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RESEARCH

# German project on use of fuel cells in trucks

**The Esslingen University of Applied Sciences (*Hochschule Esslingen*) in Germany has been awarded a contract by the Baden-Württemberg Ministry of the Environment [*see also the next item*] to lead the Reallabor Hylix-B research project, which will study whether fuel cell technology is suitable for everyday goods transport in trucks.**

The project team plans to equip a prototype 26 tonne electric truck with a fuel cell drivetrain, which will be tested in the Stuttgart area, to identify and hopefully remove obstacles to wider deployment. The researchers will look at both the technical and organisational challenges in practice.

'Electrical operation with hydrogen technology is ideal for heavy commercial vehicles or larger buses,' says project manager Professor Dr Ralf Wörner, Head of the Institute for Sustainable Energy Technology and Mobility (INEM) at Hochschule Esslingen. 'The greater the load and the further the distance, the more it is worth using hydrogen. Otherwise the battery would have to be oversized.'

The two-year project, with a budget of some €840 000 (US$930 000), comprises the construction of the truck, which will take around 18 months, and an operational phase lasting six months. The research consortium plans to bring in other experts to build a user- and market-oriented vehicle, with the various forms of participation acting as a 'practical laboratory' (*Reallabor*). Several partners are involved in the project, including the local utility Stadtwerke Esslingen and the Electrify-BW electromobility association.

Hochschule Esslingen, Institute for Sustainable Energy Technology and Mobility: https://tinyurl.com/esslingen-inem

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