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H2 international

THE E-JOURNAL ON HYDROGEN AND FUEL CELLS

→ GREAT FUEL CELL POTENTIAL IN RAIL AND CARGO TRANSPORTATION

→ SWITZERLAND TO SET UP HYDROGEN INFRASTRUCTURE

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Cover image Fuel Cell Train by Alstom [Source: Alstom]

Theme: Trade Shows & Conferences | **Author:** Sven Geitmann

STUTTGART – THE ELECTRIC INDUSTRY'S MEETING POINT

EVS30, f-cell and Battery+Storage

One of the biggest electric transportation conferences in the world will open its doors from Oct. 9 through 11 in the German state capital of Baden-Württemberg, Stuttgart. In 2017, the city's show grounds will see three events run in parallel – the Electric Vehicle Symposium & Exhibition, or EVS for short, the f-cell and the Battery+Storage. One day before the start of those, Stuttgart will have its Electric Transportation Day, AtEm.

This year, one ticket will give attendees access to three conferences – EVS30, f-cell and Battery+Storage – and free choice between all their sessions. The trio will offer the latest research findings, best practice examples, technology advancements and hands-on experience from projects on vehicles and transport means, electric engines and applications, components, charging and refueling infrastructures, commercialization and marketing strategies, energy and environmental analyses, and transportation designs. Discussions will also revolve around the technological and political developments at German, European and international level.

With the EVS turning 30, the bar has been set higher than ever. All 650 conference submissions have had to pass with flying colors when presented to the EVS30 Scientific Program Committee consisting of 250 experts from all around the world.

POLITICAL DISCOURSE Considering the starting date, exactly two weeks after Germany's general election, the event will certainly reflect the political mood in possible negotiations about a governing coalition. The election may have considerable impact not only on the development in the hydrogen and fuel cell industry, but also on energy storage and electric transportation. When listening to past speeches kicking off the f-cell, one would think it seems only natural that someone such as Franz Untersteller, Baden-Württemberg's environment minister from the Greens, would have a more favorable outlook on the industry than some of his colleagues in parliament.

30TH ANNIVERSARY
The hosts of EVS's thirtieth installment are the World Electric Vehicle Association and the European Association for Electromobility. After the opening remarks, the floor will be given to Espen Hauge, WEVA's president, Winfried Kretschmann, the head of Baden-Württemberg's state government, and Maroš ŠefcoviĐ, the European Commission's vice president for energy union.

The state's economy minister, Nicole Hoffmeister-Kraut, did admit to nemo, a local Swabian magazine, that we "are experiencing a paradigm shift from the car as a product to transportation as a service." However, before Stuttgart's groundbreaking court decision, she had been doubtful as to whether

Fig. 1: Thomas Walter, Messe Stuttgart, and Franz Loogen, e-mobil BW

"there really will be any bans on driving." She said: "I, myself, have called for great leniency, for providing exceptions in the case of commercial operations and residents impacted by such bans. I would like to see an end to the oft-experienced diesel bashing. That doesn't help our community." She didn't see any parallels between Stuttgart's situation and the one in Detroit, where the three largest American carmakers – GM, Ford and Chrysler – had to deal with drastic cuts that almost led to a complete breakdown in production ten years ago. "First, the Stuttgart region has a much more diversified economy than Detroit. Second, the American city had started to miss out on important trends," she said.

Thomas Walter from Messe Stuttgart had a different opinion: "Fossil fuels are past their peak. We believe that electric transportation will fundamentally change the way we travel. But for this to happen, the technology needs to be available on the mass market."

FREE TICKETS
As in past years, Hydrogeit Verlag is offering free admission to the event. Readers of H2-international can use the EVS30_Hzwei code to register for a free ticket covering the entire three days:
→ http://bit.ly/2vAzguX

THE CAPITAL CITY OF ELECTRIC TRANSPORTATION The main items on this year's f-cell agenda will be the intelligent sector integration of heat, power and transport; stationary renewable storage in hydrogen, batteries and fuel cells; installing electric engines on ships and airplanes; and the use of electricity-powered trains. A second important topic will be the potential benefit to suppliers and OEMs that decide to switch to battery and hydrogen-electric vehicles, whether these businesses are thinking of setting up a clean, smart and demand-responsive infrastructure or sustainable energy, technology and process value chains.

Both fields will have sessions dedicated to them in parallel on Oct. 10 and 11 at the International Congress Center. The discussions on electric transportation will already start a day earlier, just as the joint exhibition in hall 1 (in the L-Bank Forum), networking opportunities, the poster session, catering and outdoor activities. And the day before, on 8 October, people can participate in the Electric Transportation Day in Stuttgart on Marktplatz and Karlsplatz. Titled "Stuttgart, the global capital of electric transportation," the inner-city event will provide details on the program at the show grounds to road users and potential customers, a chance to Ride & Drive, an electric car rally, and an extensive Q&A on infrastructure and transportation offerings.

The exhibition – at which more than 250 organizations are expected to showcase their technology and services – will provide a platform for manufacturers, users and decision makers to get an up-to-date overview of all forms of electric transportation, new trends and applications for electric drive systems. One exhibitor on the 20,000 square meters will be 3M, a technology supplier whose Advanced Materials Division intends to illustrate together with the company's Dyneon subsidiary how the fluoropolymers developed in-house can increase a fuel cell's or battery's performance and life (booth 1G14 in hall 1). The organizers of the entire three-day show are Messe Stuttgart, the federal Solar Mobility Association, Baden-Württemberg International, e-mobil BW, Peter Sauber Agentur and Stuttgart Region Economic Development Corporation. They will be supported by local businesses from the automotive industry and its suppliers. Wolf-Henning Scheider, chair of Mahle's management board, said: "Mahle considers Stuttgart's EVS30 to be an important event sending the clear message that drive systems will continue to be developed in the region where the automobile was born." ||

→ www.evs30.org, www.elect-expo.com, www.f-cell.de

2018 OUTLOOK
What comes after EVS30? Next year's location is Kobe, Japan. But what about Stuttgart? The state's show grounds intend to organize an on-premise electric transportation fair called "elect!" from Oct. 8 through 10 next year. Conversely, Peter Sauber told H2-international that he wanted to go "back to the roots" and plan for another f-cell in the House of the Economy in Stuttgart. His colleague, Silke Frank, explained that the objective was to solidify the position of this already established event, which has been held every year since 1997, as a meeting place for the industry in fall and redesign its program with help from hydrogen and fuel cell stakeholders.

Theme: Energy Storage | **Author:** Dr. Ulrich Zuberbühler

CARBON-FILLED AIR AS RAW MATERIAL SOURCE

CO_2 Capture to Produce Plastics and Fuels

Carbon dioxide may be a greenhouse gas, but it can also be a raw material source in industries such as plastics processing and renewable energy generation, where it could gradually replace natural gas and crude oil. Capturing carbon dioxide directly from air provides several advantages for combatting climate change. While limiting the atmospheric concentration of CO_2, it offers new opportunities in the chemical industry and in transportation and could dramatically lower harmful emissions by cutting into fossil fuel demand. The aim of a new German project, CORAL, is to use a demonstration system for researching and analyzing the viability of individual carbon capture methods. Coordinated by ZSW, the Center for Solar Energy and Hydrogen Research Baden-Württemberg, it has been joined by the University of Stuttgart's Institute of Polymer Chemistry and Heidelberg's Institute for Energy and Environmental Research.

So far, the raw materials for most chemical products – be they plastics, gasoline, diesel or kerosene – have been crude oil and natural gas. To meet international climate targets, fossil fuels will need to be replaced by renewables as soon as possible. One option is to employ power-to-gas or P2G®. Through electrolysis, it creates hydrogen that can later be used in combination with CO_2 to synthesize hydrocarbons.

Please note that P2G® has been trademarked by ZSW.

As much as it may be a surprise, one future raw material source is carbon dioxide, whose environmental exposure we aim to limit, and air is a virtually inexhaustible resource. The latter we intend to tap into as part of the three-year CORAL project launched last fall. Its objective is to show power plant operators who have no access to concentrated CO_2 sources that they do have an economically feasible and environmentally sensible solution at their disposal.

SEARCH FOR THE MOST EFFICIENT SOLUTION There have already been several methods available to extract carbon dioxide from air and use it to synthesize raw materials. The aim of CORAL is to determine the most efficient and inexpensive technique. The next step would be to build a demonstration system and test the selected method, showing that key chemical compounds, such as methanol, dimethyl ether and propylene, could be created based on nothing but renewable resources in the future.

Air capture will be of particular interest to energy suppliers at remote locations. To give an example, wind power plants on Chile's coastline could convert electricity directly into hydrogen and methane through on-site power-to-gas systems. The carbon dioxide for methanation could be extracted from the surrounding air and would no longer have to come from sites a few thousand kilometers away. There would be no need for any power lines either, since electricity is put into chemical storage. To create carbon dioxide, one could recover the waste heat from electrolysis and synthesis and reduce the overall energy consumption throughout those processes – another focus area of CORAL.

FROM CO_2 SUPPLY TO WASTE HEAT RECOVERY The last point also serves to distinguish air capture from similar, but very energy-consuming methods for extracting CO_2. It is their power demand that won't allow them to leave the R&D stage. ZSW's experience with cost-benefit analyses dates to 2009, when a pilot plant was built to demonstrate successfully that concentrated CO_2 can be extracted from air to produce methane using electric energy as part of our P2G® process. However, it was a very power-hungry system, creating a drawback that we aim to overcome by setting up a new demonstration plant. The key to improved efficiency will be power-to-x (P2X) generating a considerable amount of waste heat.

Producing a hydrocarbon (in the simplest case, methane) requires around two kilowatt-hours of renewable power for one kilowatt-hour of chemical calorific value. Air capture with the old pilot system added another kilowatt-hour to the process. The new method is intended to replace much of the electricity consumption with waste heat from P2X and make the system more energy-efficient.

Fig. 1: ZSW scientists prepare a thermogravimetric analysis to determine the CO_2 capture capacity

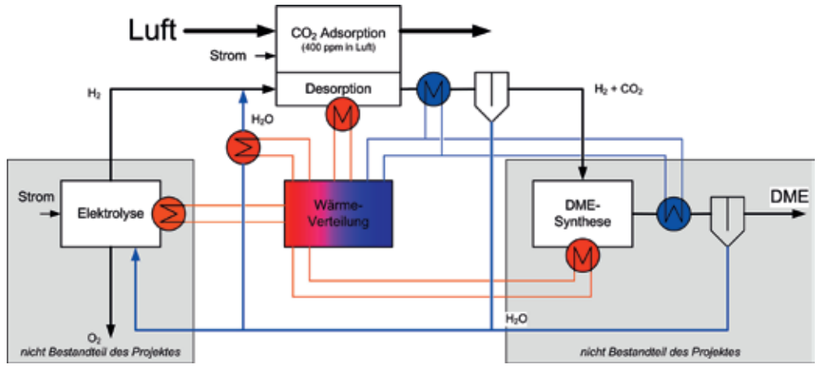

Fig. 2: Capture

RENEWABLE TRANSPORTATION BY P2X The first stage of all P2X methods is water electrolysis, as hydrogen is used as the raw material source for all subsequent stages. Converting this hydrogen into CNG, LNG or another renewable, carbon-based energy carrier primarily requires carbon dioxide.

The use of P2X will make it possible to refuel FCVs and supply methane for natural gas vehicles, kerosene for airplanes, liquified gas for marine vessels and base compounds for the chemical industry – in a sustainable and environmentally friendly way through renewable power. P2X also provides the option to store electricity from volatile sources, a task that is becoming an increasingly urgent matter to resolve due to the German energy transformation and the expansion of the renewable infrastructure. Ideally, the project will illustrate what little energy the new method would need to provide CO_2 and how much carbon dioxide it would save during production and use compared to fossil fuels. ||

This project is being supported with EUR 755,000 by Germany's federal education ministry as part of the CO2Plus program.

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Thema: Energy Storage | **Autoren:** Sven Geitmann

HYDROGEN TO REPLACE COAL

H_2 Pilot System at Steelmaker

Now, there's another installation to add to the growing list of hydrogen production systems: H2Future in Linz, Austria. Supported by the European commission, it is managed by a consortium aiming to produce "green" hydrogen in large quantities to bring the energy and industrial sector closer together.

Bart Biebuyck

On Feb. 7, 2017, the consortium partners – APG, Siemens, VERBUND and voestalpine – were awarded the contract for setting up a 6-megawatt pilot between the furnaces at voestalpine in Linz. By their own account, the objective was to construct one of the world's largest PEM electrolysis systems for producing green hydrogen and determine whether it could be deployed as a load-following power plant and whether the hydrogen itself could be used in industry. Their efforts will be supported by the Fuel Cells and Hydrogen Joint Undertaking with around EUR 12 million in funds from the EU's Horizon 2020 program.

More precisely, the EUR 18 million project will have hydrogen produced by an on-site Siemens electrolyzer feed directly into the in-house grid for use in steelmaking, while the required power will be supplied by Austria's largest utility, VERBUND. Dutch-based ECN is said to conduct the related research throughout the four-and-a-half years, for example, if and how the process could be adapted for other industries. Additionally, APG will test the comparatively "flexible" PEM system for its feasibility in the load-following power plant market.

Bart Biebuyck, executive director of the Fuel Cells and Hydrogen Joint Undertaking, explained at the start of H2Future: "We at FCH JU are proud to see this highly innovative project being launched. H2Future is based on a constructive partnership that will play a decisive role in bringing green energy to manufacturing businesses and increase the use of renewables."

It's the steel industry's first test run to see whether hydrogen could gradually replace coal in all kinds of applications. Projects such as this one could help meet Austria's target of 40 percent decarbonization by 2030, believes Wolfgang Anzengruber, CEO of VERBUND. *Wolfgang Eder, CEO of voestalpine, agrees*: "The system will help us get a feeling for whether we can or can't use hydrogen in combination with our technology in the long term. Our expectations today are that it will be possible. It's more a question of how, not if."

According to the latest information, the system is planned to go online in 2021. ||

Theme: Research & Development | **Author:** Dr. Alexander Trattner, Stefan Brandstätter, Michael Striednig

FUEL CELLS PUT TO THE TEST

Highly Integrated and Versatile Engineering Environment

The automotive industry is working in high gear on the mass-market introduction of hydrogen and fuel cell technologies. To support their efforts, AVL List partnered with HyCentA Research to develop and build test equipment for researching polymer electrolyte membrane or PEM systems. The result has been a unique research setup that makes it possible to analyze fuel cell systems by simulating the vehicle, driver, drive cycle, powertrain and other car components, such as battery, electric motor and gear, in real time. The stand can be used for applied science projects on energy and thermal management, calibration and integration at vehicle and subsystem level, and investigations into component behavior, cold starts and material aging under real-life ambient and operating conditions.

FCEVs' range and refueling time (three to five minutes) are similar to conventional cars powered by diesel or gasoline. A fuel cell's significantly higher energy density compared to a battery lowers powertrain weight and costs, making hydrogen a particularly recommendable option in scenarios requiring high power output and large amounts of energy (heavy loads, high mileage).

Hydrogen-powered PEM fuel cell systems have proved to be the most promising technology in use today. They offer a great many benefits (e.g., zero emissions locally, high efficiencies, great volume-based and gravimetric energy densities) and the potential for low manufacturing costs. Individual cells containing the bipolar plates, the gas diffusion layers, and the electrode and polymer membrane are already as thin as 1 to 1.2 millimeters throughout. The catalyst is typically made of platinum compounds and the ion-carrying membranes are superacids that need fine-tuned water management to transport those ions. The resulting stacks are compact, high-performance components. Even today, their specific output is 3 to 3.5 kilowatts per liter when installed in mass-market vehicles.

At the system level, the question of how to supply individual cells with a medium has often proved challenging. The medium must be provided independently of operating points in a narrow pressure, temperature, humidity and mass flow range, which imposes stricter requirements on regulating, measuring, controlling and running fuel cell systems. It also calls for a closer link of cell, stack and secondary unit advances in the future, making it necessary to create new kinds of highly integrated research and engineering environments.

RESEARCH INFRASTRUCTURE The above, coupled with a subsequent increase in research and development potential, has generated demand for various test stand uses. One important application is the analysis of degradation causes and their impact on a system's lifetime. Crucial research needs to be done into what materials are suitable for stacks and what impact BoP – balance of plant – elements and operating conditions have on declining performance.

An important point is cutting the cost of fuel cells and BoP components to develop competitive systems and encourage broad market introduction. Other aims are to improve dynamic properties, ensure proper cold starts and realize substantial efficiency gains.

All these research objectives can only be achieved through creating a setting that will approximate real-life conditions as much as possible. Case studies in automotive have established criteria for system operation and many different stop-start and load cycles, and a wide variety of environmental factors, such as temperatures, humidity levels, frost, vibrations and pollution, have added particularly high requirements for finding a suitable testing environment.

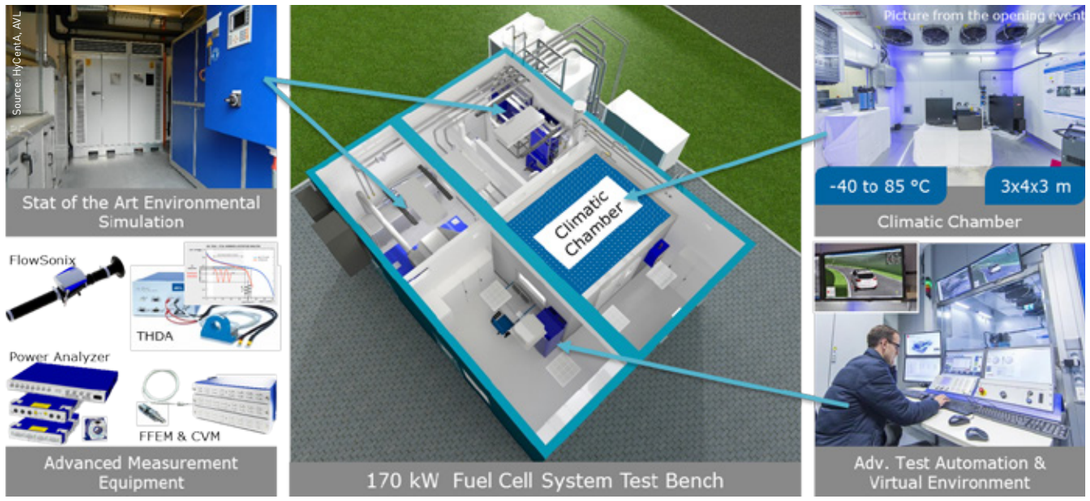

Fig. 1: HIFAI test stand

These prerequisites and activities can be met and implemented with the use of the innovative Highly Integrated Fuel Cell Analysis Infrastructure. The test stand, which received financial support from the Austrian Research Promotion Agency – FFG and the Federal Ministry of Science, Research and Economy – BMWFW was developed in partnership between HyCentA Research and AVL List and set up by the former at the Graz University of Technology. It marks a milestone in the design of test stands for PEM fuel cell systems.

Real-life conditions have been made possible by a climate chamber offering temperatures between minus 40 °C and plus 85 °C to simulate extreme ambient operating temperatures to the fuel cell and BoP elements, for example, as would be the case near the arctic circle or in Death Valley. These tests additionally use the hardware-in-the-loop method to include a feed-in of all media, such as air, hydrogen and cooling fluids, based on a typical operating scenario. Driver, vehicle and drive cycle data and BoP and powertrain information can be changed and transmitted as virtual parameters to the fuel cell system in real time.

R&D ACTIVITIES One field in which HIFAI research activities are concentrated is the investigation of aging phenomena under real-life ambient and operating conditions. Automotive applications require a lifecycle expectancy of 5,000 to 8,000 hours at 10 percent performance degradation and highly variable power output, while stationary systems need to be up and running for up to 40,000 hours.

To meet these targets, it is essential to understand what kind of damage could be caused by the selected operation mode (stop-start, transient, etc.). National and international research projects have been able to identify several types of aging. An inspection of single cells can already help with a rough categorization of the process or processes present in combination with a certain membrane electrode unit, a specific type of stack component (flow field, seal) and a subset of operating parameters. However, quantitative predictions of material aging and the transfer of results to the system level do have their limitations at present, creating a need for load cycles to produce those results based on accelerated aging tests undergone by the system.

Power output	2.5 to 170 kW
Voltage range	8 to 800 V
Current range	–600 to +600 A
Maximum thermal power	200 kW
Climate chamber temperatures	-40 °C to +85 °C
Cathode	0 to 580 kg / hour –40 °C to +85 °C 5 to 95 percent relative humidity
Anode	0 to 12 kg / hour –40 °C to +85 °C 5 to 15 bars

Table 1: Properties and key figures of HIFAI test stand equipment

Another focus of HIFAI is to identify and enhance system responsiveness. Response times of automotive fuel cell units available on the market range from around 0.5 to 0.7 seconds. HIFAI's highly configurable properties make it possible to test and analyze fully or partly developed fuel cell systems under real-life load conditions, with instrumentation and control equipment tailored to individual requirements. The stand has likewise been used to research highly responsive warm-up systems for reactive gases.

Operating this kind of equipment requires the just-in-time supply of hydrogen and air based on predefined, configurable settings and high-precision flow metering. A new supply system satisfies these needs by offering a greatly variable setup of mass flows, relative humidity levels, temperatures and system pressures. These thermodynamic properties influence each other, presenting challenges especially if operating parameters do not remain constant. Thanks to a non-linear multi-parameter control system, they can be provided in a suitable manner.

The HIFAI test stand also facilitates the design of novel operating strategies and PEM fuel cell calibration, as especially the complex interactions between BoP elements and stack come with their own set of difficulties.

At present, the control devices integrated into fuel cell systems and vehicles must be calibrated by hand or semi-automated. However, a calibration of several thousand parameters complicates things considerably. The HIFAI test stand solves this problem of multi-variable optimization with the help of software that processes such tasks by means of a real-time capable, model-like approach based on design of experiments methods. It increases the potential for enhancements and improves the efficiency of new advances and the rate at which they occur.

Further R&D activities can be found in the field of component and system integration. Models capable of real-time simulation can be used for a great number of powertrain components to investigate application and integration scenarios. Besides targeting only certain uses for enhancement, it is also possible to have the test stand equipment replace individual BoP elements and let developers optimize at an early stage. This will accelerate product creation by opening up the possibility of modular fuel cell system structures and simultaneous stack and component development.

IDEAL ENGINEERING TOOL HyCentA is an independent, non-university research organization whose innovative idea offers R&D departments at system suppliers and OEMs a valuable tool to speed up in-house processes. In close collaboration with universities and engineering companies, it has been working tirelessly to improve HIFAI and expand it in modules based on requirements from industry and research. The test stand as an integrated development tool will be key to efficient zero-emission transportation in the future. ‖

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Theme: Research & Development | **Author:** Bernd Oberschachtsiek, Joachim Jungsbluth

NEW ZBT HYDROGEN TEST FIELD

15-Year Anniversary in Duisburg

Fig. 1: Model of planned H_2 test array, as showcased at Hannover Messe in 2017

ZBT based in Duisburg in the German state of North Rhine-Westphalia has just received approval for four individual publicly funded projects that will make it possible to set up a unique hydrogen array and develop new inspection and testing methods for hydrogen infrastructures. These projects will expand the technology portfolio of an organization which has just celebrated its 15th anniversary and enable it to establish partnership initiatives focused on user and infrastructure scenarios.

ZBT is now planning to set up the field on its premises within the next two years to provide opportunities for exploring hydrogen infrastructure potential in industry-research partnerships. The testing and inspection platform that is being developed could soon be used in collaborative efforts between manufacturers, suppliers and research institutes to advance the aim of safe and secure, nationwide and, above all, inexpensive hydrogen supply.

CARBON2CHEM Subproject L1 of Carbon2Chem, which has received financial support from the Federal Ministry of Education and Research, offers a thorough investigation of systems (alkaline, membrane and solid oxide electrolysis) and stacks under highly variable operating conditions. It has two main purposes, with the first being the provision of operational data to identify material aging factors. The second is to use this data to arrive at simulation models for the design of optimal operation profiles ensuring technological durability in industrial settings. The entire project was launched on June 1, 2016, and will run for four years.

H_2TESTOPT The objective of H_2TestOpt, supported by the Federal Ministry for Economic Affairs and Energy, is to construct a test stand consisting of a compressor, storage space for 500 and 850 bars, an H_2 dispenser for 350, 500 and 700 bars, cooling units and an inspection and control room. Together, these individual units comprise a refueling station that could be used to test both components and a station's subsystems. The outstanding features will be its extensive metering and analysis functionality and the option to recover hydrogen after refueling, coupled with a high degree of flexibility when simulating the most varied fill-ups. Equal weight will be put on considering economic feasibility, energy consumption, technological issues, safety concerns and component and subsystem efficiency. The station will additionally offer an extended range of analytical functions to determine inspection intervals and methods. The test stand is expected to be available for research projects on hydrogen infrastructures by spring 2018.

MOBFUELH$_2$ This venture aims at designing a mobile refueling unit for decentralized, stationary and non-stationary storage up to 700 bars. It has received funds from the Ministry for Environment, Agriculture, Conservation and Consumer Protection of the state of North Rhine-Westphalia as part of HydrogenHighway NRW. The design base is a truck with a maximum weight of 7.5 tons and enough room for the storage tank, the compressor, dispensing systems and the necessary control and safety equipment. One use of the mobile unit will involve the supply of locations that are difficult to reach, such as remote cell towers. The vehicle is planned to be operational in twelve months' time and will then undergo a series of tests based on real-life conditions. It will also be available to support research and demonstration projects. MobFuelH$_2$ started on May 1, 2017, and is planned to run for two years in cooperation with Anleg based in Wesel, Germany.

HYLAB The fourth endeavor will deal with ensuring proper hydrogen quality at filling stations. Supported by the Federal Ministry of Transport and Digital Infrastructure as part of the second National Innovation Program Hydrogen and Fuel Cell Technology – NIP 2, it has the primary aim of developing technologies and methods for an inexpensive, standardized analysis of hydrogen fuel quality. Together with the ZSW Center for Solar Energy and Hydrogen Research in Ulm in the state of Baden-Württemberg, ZBT will identify suitable methods for analysis and sample-taking, conduct a series of measurements at filling stations and rate the quality of the hydrogen samples. Combined with the above-mentioned projects, ZBT offers excellent opportunities for extensive testing and the subsequent improvement of new solutions in research and development. HyLab was also launched on May 1 and will run for two-and-a-half years. ||

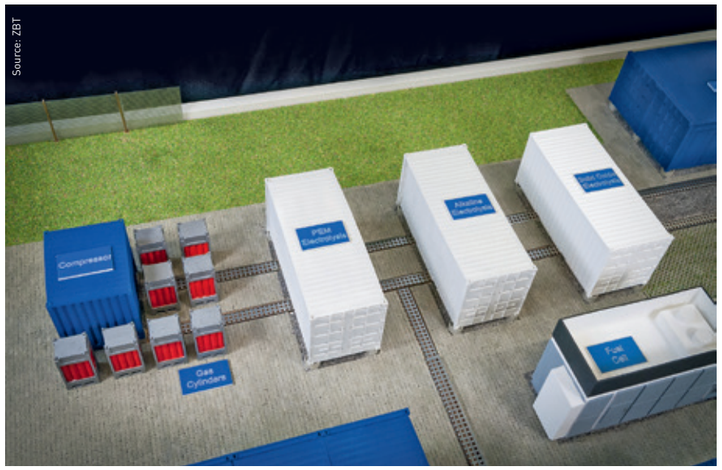

Fig. 2: Electrolyzer container with compressor and H_2 storage – Carbon2Chem

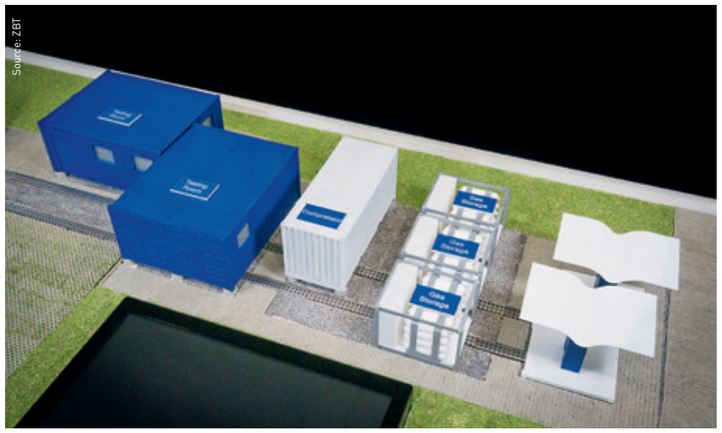

Fig. 3: Test rooms, compressor, gas storage and refueling station – H2TestOpt

15 YEARS OF ZBT

ZBT celebrated its 15-year anniversary on June 29, 2017. As part of the JRF On-Site event series by Johannes Rau Forschungsgemeinschaft, Angelika Heinzel, ZBT's managing director, presented the research institute and its accomplishments over past years. Other speakers included North Rhine-Westphalia's education minister, Svenja Schulze, Reinhold Achatz from thyssenkrupp and Jorgo Chatzimarkakis, secretary general of Hydrogen Europe (see interview in August 2017 issue of H2-international). All of them stressed the importance that hydrogen technology has in this German state.

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RESEARCH & DEVELOPMENT

H2-international 02 | 17

Theme: Electric Transportation | **Author:** Sven Geitmann

RIDE ON A FUEL CELL TRAIN

Alstom: Uncontested No. 1 for Railroad and Commercial Vehicles

The zero-emission future of the transportation sector has prompted an increasing number of energy policy debates on railroad electrification. At Hannover Messe, it was Alstom's new fuel cell train that garnered much attention. After having been developed in less than two years, it had its first run in March and will reportedly be used to transport passengers starting in 2018.

The attention of fuel cell stakeholders is slowly but gradually shifting away from personal transport and turning to railroad and commercial operations. Whereas European automakers are pulling out all the roadblocks when it comes to fuel cell development, it seems that everyone else is beginning to view hydrogen as a plus for heavier vehicles (buses, trucks and trains) to extend their range way beyond what batteries would be capable of on their own. Hydrogen-powered trains and fuel cell trucks could soon be outmaneuvering H_2 cars.

RIGHT ON SCHEDULE Up to now, everything has been right on schedule. On May 27, 2015, Alstom Transport signed an exclusive agreement with Hydrogenics, a technology supplier from Canada (see October 2015 issue of H2-international). Valued at over EUR 50 million, it has provided the grounds for a ten-year collaboration between both businesses and the prospect of at least 200 drive systems based on the HD series by the Canadian-based business. Last year, Alstom received the first fuel cell system based on this agreement and presented it to the public as part of the Coradia LINT prototype at InnoTrans 2016. It said that the March test trip was the first of a low-floor fuel cell passenger train at 80 kph (50 mph). The train didn't leave the company's own track system in Salzgitter, and the next scheduled tests at up to 140 kph (87 mph) will be done in Velim in the Czech Republic. But in 2018 – just around three years after the agreement was signed – the train will make its first regular run from Buxtehude to Bremervörde and Bremerhaven to Cuxhaven (see November 2016 issue of H2-international).

INNOVATIVE TECHNOLOGIES With EUR 8 million in support from the National Innovation Program Hydrogen and Fuel Cell Technology, Alstom converted a diesel model from the Coradia LINT family into a fuel cell version. Two units offer enough room for 300 passengers (150 seats) and have been equipped with an entirely new smart energy grid supplying power on demand to all components of the train.

Energy is stored in in-roof hydrogen tanks manufactured by Xperion and installed by Wystrach. The roof is also the place where the Hydrogenics fuel cell system is located. The lithium-ion batteries were placed between the train wheels, where they can additionally be used to recover braking energy.

LOWER SAXONY BACKS FUEL CELL NETWORK EXPANSION There was even an entire podium discussion dedicated to fuel cell trains at the Public Forum of the joint H_2 and fuel cell booth at Hannover Messe. Jens Sprotte, director of urban transport & systems at Alstom Transport Deutschland, was pleased to announce that "zero-emission commuter rail will come – as early as the end of this year."

Lower Saxony's economy minister, Olaf Lies, who was visibly proud of the fact that these railcars will be both run in the state and be manufactured in one of its cities, Salzgitter, added: "We are talking about really substantial figures here. […] My colleagues from other states quickly jumped on the bandwagon, so

Source: Alstom

to speak. […] This means an actual, big roll-out over the coming years and consequently, a chance to bring a technology that is in heavy use at home to the global market." Alstom's statement that it had already signed letters of intent for 60 railcars with Lower Saxony, North Rhine-Westphalia, Baden-Württemberg and Rhein-Main-Verkehrsverbund in Hesse fitted right in.

Sprotte stressed that it had been important to Alstom not to end up in the same situation as the automotive industry, an allusion to the chicken-and-egg dilemma in hydrogen supply. "If we want to grow the segment, we need to offer a complete package. We will look for a reliable business partner to supply the hydrogen," he said. It is the reason for Alstom investing in not only train development and maintenance, but also in an H_2 infrastructure. Sprotte said that an all-in-one approach would make it "possible to drive down costs and outcompete diesel engines." He added: "There's no option that can match a fuel cell's viability in heavy duty applications and commuter rail."

FROM "GRAY" TO GREEN HYDROGEN In the beginning, 70 percent of the hydrogen required for the new train system is said to come from the chemical industry. This byproduct of chemical reactions called "gray hydrogen" will later be supplanted by gas produced through electrolysis, meaning "green hydrogen." However, Sprotte added

Fig. 2: Sprotte, Lies and Bonhoff having an expert discussion on fuel cell trains

that the big problem was the cost of electricity. "The renewable energy surcharge adds eight to ten cents to the price tag. It is our hope that the next years will see changes in this policy, so that we can make large-scale use of electrolyzers." The only reply Klaus Bonhoff, chair of NOW, could give was that the issue was "being debated intensively" and that there had already been many people who had "realized that there is great potential."

Olaf Lies immediately followed up by saying: "We need to double our efforts to install a decentralized H_2 infrastructure – be it for passenger cars, trucks, buses or trains. This expansion will require an increase in the use of electrolysis." ||

Some German states have already started requesting bids for zero-emission commuter rail, putting Alstom in competition with other businesses, for example, from the battery industry. GP Joule's managing director, Ove Petersen, has said that his company was currently bidding on a project to adapt diesel train tracks for fuel cell use. This one project alone would require 20 megawatts of electrolysis capacity, he said.

THREE H_2 FILLING STATIONS IN GERMANY'S SOUTH

Germany is experiencing a further ramp-up of hydrogen filling stations. On July 31, two new ones started serving customers in Sindelfingen at the A81 freeway and in Pforzheim at the A8. The former, a Shell station southwest of Stuttgart, is in direct vicinity of the Daimler factory that houses the carmaker's R&D facilities on fuel cell technologies. Stijn van Els, chair of the German Shell companies, said: "Hydrogen is a promising technological field. We expect this alternative engine fuel to play an increasingly stronger role in markets such as Germany, the Benelux countries, the UK and the US from the 2020s on."

There is also a new multi-energy Total station, which was brought online on Sept. 6 in Karlsruhe. In contrast to comparable stations, it uses a Sunfire electrolyzer running on solar energy to produce hydrogen on-site. ||


Source: Daimler
Fig. 1: H_2 refueling station in Sindelfingen

Theme: Electric Transportation | **Author:** Sven Geitmann

FIRST H_2 TRUCK IS A GO

Switzerland Opens New Chapter in H_2 Development

As early as last November, Switzerland saw the opening of its first public hydrogen station. But soon, it will create a whole new chapter with a fleet of hydrogen trucks to be brought into operation. A prototype has already been in use in the Zurich area.

In the beginning, the endeavor seemed to go on and off track. Shortly after Axpo, a big Swiss-based renewable energy producer, and the Coop retail chain launched a joint project on hydrogen transportation, the former announced its exit (see October 2015 and June 2016 issue of H2-international). H_2 Energy, a Swiss-based project management business in which Coop has a minority interest, was there to fill the void.

The initial objective was to produce hydrogen through a 2-megawatt system at Axpo's Eglisau-Glattfelden power plant near Zweidlen at the German-Swiss border and transport it to a Coop station in the Zurich area. This station's yearly demand from a planned commercial fleet of fuel cell vehicles was projected to be 200 tons.

TWENTY TONS OF H_2 FOR 170 PASSENGER CARS Now, plans have changed. The electricity will come from IBAarau's hydropower plant instead. The Proton OnSite C30 PEM electrolyzer installed on the premises includes one of Diamond Lite's pressure swing adsorption dryers and will be run by H_2 Energy if there is surplus power available, meaning when it can't be used for other purposes. Overall, the unit consumes 2 percent of the electricity generated on-site – 20 tons at 30 bars or 435 psi of outlet pressure – a share that is enough to supply 170 passenger cars or four trucks a year.

The gaseous hydrogen will be directed through a Sera-brand compressor to end up at 200 bars or 2,900 psi and will be transported in ten steel tanks holding 338 kilograms each to Switzerland's first public H_2 refueling station, which had likewise been set up as part of this project. Once the hydrogen arrives, it will be pumped into a stationary tank at 50 bars or 725 psi, and an ionic compressor by Linde will ensure supply ranging up to 950 bars or nearly 14,000 psi for the quick refueling of trucks and buses at 350 (5,000 psi) and passenger cars at 700 (10,000 psi).

The primary objective of building the public Coop Pronto gas station in Hunzenschwil was to supply the fuel cell truck prototype and twelve Hyundai fuel cell cars, type ix35 Fuel Cell, all of which are in use by the retail chain's distribution center in Schafisheim. However, as Hansjörg Vock, vice president of H_2 Energy's board of directors and managing director of Diamond Lite, stressed when talking to H2-international: "Passenger cars aren't the target market; the truck industry is."

Switzerland's first non-public H_2 station is located at the Empa material research facility in Dübendorf and the supply pressure was upgraded from 350 to 700 bars last October.

FUEL CELL TRUCK IN 18-TON CATEGORY This puts the MAN-brand truck squarely at the heart of the project. The refrigeration vehicle is an automatic equipped with a high-power electric engine and a fuel cell unit developed by Swiss Hydrogen and installed by Esoro. The latter has 455 individual cells and features an integrated 100-kilowatt S3 PEM stack manufactured by PowerCell in Sweden. A CALB lithium-ion battery (2 x 60 kilowatt-hours) is used as temporary storage to recover braking energy and supply power at peak demand.

The hydrogen is stored directly behind the driver's cab in seven 350-bar high-pressure tanks (see fig. 2). These composite pressure vessels hold up to 35 kilograms, enough to get as far as 400 kilometers or 249 miles. The fuel cell system is additionally used to supply power to peripheral systems (cooling).

The 18-wheeler, the first fuel cell vehicle in the 35-ton category – 19 tons plus 16-ton trailer, with renewable-powered trucks being permitted to weigh a ton above the limit – has been part of Coop's logistics chain since May 31, 2017. From Schafisheim, it supplies stores across Switzerland's entire northwest region. Initially, after the public gas station opening on Nov. 4, 2016, it had been used only during test drives and received a new stack before being integrated in day-to-day operations. Rolf Huber, chair of H_2 Energy's management board, told H2-international: "It was important to all stakeholders to avoid any risk of downtime. The critical routes were first completed with artificial weights in the back. This has led to enhanced waste heat management, water separation, and retarder, gear and fuel cell fine-tuning." Max Senn, the Coop employee driving the vehicle throughout the test stage, was satisfied with the outcomes and recommended the truck for regular use. It was said that even thirty percent inclination at 32 tons proved to be easily overcome. After 3,500 kilometers or 2,175 miles with a company license plate, the truck finally received its official road permit in early June.

Huber said that Coop would like to add more of those trucks over the coming months. But that would require negotiations with OEMs. If the test truck has a successful run, the retail chain would be willing to replace most of its fleet vehicles with fuel cell versions by 2023 and help grow the gas station infrastructure. In that case, the target would be ten trucks per station. Several Swiss-based forwarders and production companies had already shown interest in the technology. But Huber added: "Unfortunately, European truck manufacturers haven't been as involved as the ones in Asia."

Fig. 1: Truck fuel cell system

CHICKEN AND EGG Joos Sutter, CEO of Coop, said during an interview with the Blick newspaper: "In 2008, we created a vision for our company, namely to have carbon-neutral operations by 2023. To reach our objective, one half of our efforts has been put into reducing carbon dioxide emissions; the other half has been directed into external projects. The operating range we need for the use of trucks and light commercial vehicles is up to 90 kilometers or 56 miles around a site. We've already put five battery-electric trucks into operation – and hydrogen versions are admittedly an intriguing proposition." Asked about the expansion of the H_2 grid in Switzerland, he replied: "Fortunately for us, we provided both the chicken and the egg, as the new hydrogen station is in direct vicinity of our large distribution center in Schafisheim. […] If we succeed in getting the permit, we could bring another two stations online early next year." ||

Source of both images: Coop

Fig. 2: Hydrogen storage behind driver's cab

The Hunzenschwil station also offers customers to pay by credit card (see also editorial in May 2017 issue of H2-international).

Theme: Electric Transportation | **Author:** Sven Geitmann

TOYOTA TRUCK FOR L.A.

Electric Transportation

Soon, Toyota may not only be known for its fuel cell cars and buses, but for trucks as well. A new initiative called Project Portal aims to build a 36-ton truck equipped with two fuel cell stacks originally designed for the Mirai. They will be supported by a 12-kilowatt-hour battery to provide 500 kilowatts of output and 1,800 Nm of torque at a range of 320 kilometers (199 miles). Tests were reported to start this summer at the Port of Los Angeles in close cooperation with the California Air Resources Board and the California Energy Commission.

When the truck was unveiled, Bob Carter, executive vice president sales at Toyota Motor North America, said: "From creating one of the world's first mass-market fuel cell vehicles to introducing fuel cell buses in Japan, Toyota is a leader in expanding the use of versatile and scalable zero-emission technology. With Project Portal, we're proud to help explore the societal benefits of a true zero-emission heavy-duty truck platform." ||

Source: Toyota Motor North America

Fig. 1: Fuel cell truck equipped with H_2 tanks behind driver's cab

Theme: Electric Transportation | **Author:** Sven Geitmann

ON COURSE FOR LOW-CARBON SOCIETY

The German H_2 infrastructure is growing steadily. Early this year, Linde expanded its offering around Munich by turning the Linde Hydrogen Center in Unterschleißheim into a public refueling station. What had previously been the industrial gas supplier's hydrogen R&D facility has been used since Jan. 12 to fill up fuel cell cars such as the ones owned by Linde's subsidiary BeeZero.

As part of the Clean Energy Partnership, Air Liquide has so far opened one filling station in Kamen, Limburg an der Lahn and Mülheim in 2017 (see page 3). All three received over EUR 800,000 each by the federal transportation ministry. Their daily capacity of 200 kilograms is enough to refuel up to 40 cars.

The first one was inaugurated on Jan. 18, 2017, on Schattweg at the interchange near Kamen in North Rhine-Westphalia and went online four weeks later. The system in the state of Hesse, on Brüsseler Strasse near the A3 freeway, was completed on Jan. 26 and opened in mid-March. The one in Mülheim, where a joint project with Orlen Deutschland saw it integrated with a Star gas station, was inaugurated on May 23. Antoine Mazas, managing director of Air Liquide Advanced Technologies, explained: "Hydrogen will be key for progressing toward a low-carbon society."

A few days earlier – on May 19 – H_2 Mobility brought one of its first units online, bestowing the Total gas station in Rostock with the honor of being the first public multi-energy supply location in the state of Mecklenburg-Vorpommern. It offers both hydrogen and electricity besides fossil fuels. On June 14, Norbert Barthle, parliamentary state secretary at the BMVI, inaugurated the Shell station on Hanauer Landstrasse in Frankfurt am Main. On the same day, there was also the opening of the location on Borsigstrasse in Wiesbaden-Nordenstadt, Hesse.

Bremen seems to be next in line: The gas pressure vessel at the Shell station on Osterholzer Heerstrasse in the city state had already been set up to prepare for the unveiling of the GLC F-Cell – a car planned to be manufactured by Mercedes in Bremen's Sebaldsbrück suburb – at the International Motor Show in September. A Daimler spokesperson, however, told the local Weser Kurier newspaper: "It certainly isn't a mass-market product yet. But it's a good option for the future."

Other refueling stations will reportedly come online in Pentling, Nuremberg, Bad Rappenau, Wolfsburg, Düsseldorf and Cologne-Bonn. But some states, namely Brandenburg, Saxony, Saxony-Anhalt, Thuringia, Schleswig-Holstein and Saarland, still have much catching up to do.

In Austria, the fourth OMV station came online in late March. Partly funded with support from the European COHRS or Connecting Hydrogen Refueling Stations program and located in Graz-Liebenau, directly at the A2 interstate, it is situated at one of the most crucial traffic corridors across Europe. Wilfried Gepp, manager at OMV, said: "It's the first time that drivers of hydrogen cars have been able to travel all around Austria – from north to south, west to east and vice versa." And in the middle of this year, Wiener Neudorf was said to get its own refueling station. ||

Source: CEP

Fig. 1: G. Horzetzky, state secretary in North Rhine-Westphalia, T. Herbert, NOW, A. Mazas, Air Liquide, U. Scholten, Mülheim's mayor, P.-E. Franc, Air Liquide, W. Milkiewicz, Orlen (from left)

NEW EMOVE360° PROGRAM

Source: BYD

Fig. 1: The latest Chinese technology at eMove360° in Bavaria.

A look at this year's calendar will reveal the absence of three trade shows previously held in Munich, Germany: eCarTec, Materialica and sMove. They're not gone, but have been integrated into the eMove360° Europe, which takes place from Oct. 17 through 19. Robert Metzger, CEO of Munich Expo, said that the change in program had already paid off. This April, the number of exhibitors had already surpassed last year's figure by 45 percent. Overall, 356 organizations from 28 countries came to Bavaria's state capital in 2016.

More than 40 businesses from China alone have confirmed that they would attend this second International Trade Fair for Mobility 4.0 – electric – connected – autonomous in 2017. Said Metzger: "No other country is seeing urbanization advance at such a rate. A 43 percent share in the global production of electric vehicles and sales of over half a million – that shows you how important the market is to China. Every fourth battery cell and every third electric engine comes from the People's Republic. It is home to the world's biggest electric carmaker, BYD, and has become a leading supplier of automotive networking technology and components for autonomous driving. The eMove360° offers Chinese companies a great opportunity to exchange ideas and tap into international markets." Exhibition space rented by Chinese-based businesses will reportedly total 1,000 square meters or 10,764 square feet.

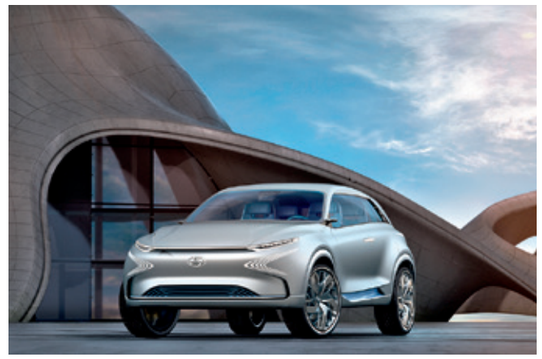
Other organizations to exhibit at eMove360° will include Bals, Delta Energy Systems, EBG compleo, Harting, Huber+Suhner, innogy, Lapp Cables, Otto Dunkel, SEW Eurodrive and Walther Werke. The focus may be on electric transportation, but there will be other topics up for discussion, such as connected and autonomous driving, future-proof and sustainable transportation concepts, lightweight construction and innovative materials, and urban and non-stationary use.

The organizers have said that the spotlight would be on storage and engine technologies. Battery prices may have dropped faster than expected, but the EUR 130 target per kilowatt-hour is still far out of reach, making innovative designs more important than ever. Metzger: "Putting these [technologies] to the forefront will be one of our main objectives this year. They will also have their own category when we present the new eMove360° awards for electric transportation and autonomous driving. The World Mobility Summit that runs in parallel will even have two whole days dedicated to the main components of electric vehicles." ||

www.emove360.com

HYUNDAI'S NEW FUEL CELL CAR READY IN 2018

Not only has the second generation of Hyundai's fuel cell car been unveiled earlier than expected, the price has already been set as well. The first event featuring the Next-Gen Fuel Cell was moved up half a year and took place in mid-August in South Korea's capital, Seoul. The car scheduled to hit the market in early 2018 will cost EUR 54,000 (USD 62,712) outside South Korea, where incentives will push it down to EUR 29,000 (USD 33,596). That's 20 percent below the price tag of the previous model, ix35 Fuel Cell. Improvements include an extended range of 800 kilometers or 497 miles on one tank and increases in efficiency (60 percent) and power output.



Next-Gen Fuel Cell SUV

The five-seat FCEV offers a 100-kilowatt fuel cell (electric engine: 120 kilowatts), a 2-kilowatt-hour lithium-ion battery, an automated parking assist and the latest version of Hyundai's driver assistance. Expectations are that Hyundai will use the Olympic Winter Games in Pyeongchang to market the vehicle, of which the carmaker intends to produce an initial 3,600 in its factory in Chungju. One thousand units of its predecessor have so far been sold in 17 countries.

A second model that is said to get its own fuel cell option is the Genesis. A first concept study had already been showcased at the International Auto Show in New York earlier this year. The next fuel cell vehicle, the GV80, is planned for 2019. And Hyundai's subsidiary Kia is reportedly working on its own FCV. Equipped with fuel cell technology by Hyundai, it could be ready for the market in 2020 or 2021. ||

Theme: Global Market | **Author:** Alexandra Huss

CAR OF THE FUTURE TO ARRIVE – SOON

Netherlands: Talks to Form Government Delay Energy Projects

After the parliamentary election in the Netherlands this March, it quickly became clear that the previous coalition partners could no longer hope for a majority. Talks about forming a new government have yet to yield any results. One reason for the breakdown in mid-May negotiations between the parties most inclined to join forces – VVD, Christian Democratic Appeal, Democrats 66 and GreenLeft – was their disagreement on environmental policy. Of course, this offers little planning security in climate protection, energy supply and clean transportation, and subsequently hydrogen and fuel cells, but has so far kept the country on the course it charted in 2007, when the aim was to set up a "green transportation sector."

In 2013, the Netherlands passed a national energy agreement, Energieakkoord voor duurzame groei, for sustainable growth. It had been drafted following numerous discussions between Dutch politicians, employees, unions, environmental organizations, civic institutions and the financial industry. The agreement stipulates a yearly reduction in the energy used in transportation of 15 to 20 petajoules (around 5 terawatt-hours) by 2020 compared to 2012. Emissions in 2030 must not exceed 25 megatons of CO_2 equivalents, a 17 percent drop compared to 1990. In 2035, the transportation sector is to emit only 60 percent of what it had in 1990 (tank-to-wheel).

These targets have made hydrogen an even more crucial part of the Dutch transportation market, next to biofuels and electricity. The Netherlands has been a supporter of exploring the gas's potential for about 20 years – long before it announced its Energy Strategy 2013. The country intends to become a world leader in this field and for good reason, as several factors point to a very favorable environment for expanding the market.

Some of these are a high population and, consequently, market density (around 17 million people on 41,500 square kilometers or 16,023 square miles), a high GDP along with an equally great purchasing power per capita (USD 41,711) and large H_2 production capacities (around 10 million normal cubic meters) already available today. The Netherlands is likewise well connected to its neighbors, Belgium, Denmark, Germany, France and the UK, all of which pursue similar avenues for expanding their hydrogen infrastructures. A European leader in the deployment and use of innovative, clean vehicle technologies, it has the highest share of hybrid cars and the greatest market penetration of plug-in vehicles across Europe.

DUTCH PROGRAMS Consequently, clean transportation has become the focus of H_2 and fuel cell technology advances throughout the country. The government, namely the Ministry for Infrastructure and the Environment, Rijkswaterstaat, is encouraging those efforts, mainly by funding research activities and demonstration projects. Additionally, it offers tax rebates and incentives and supports public-private partnerships.

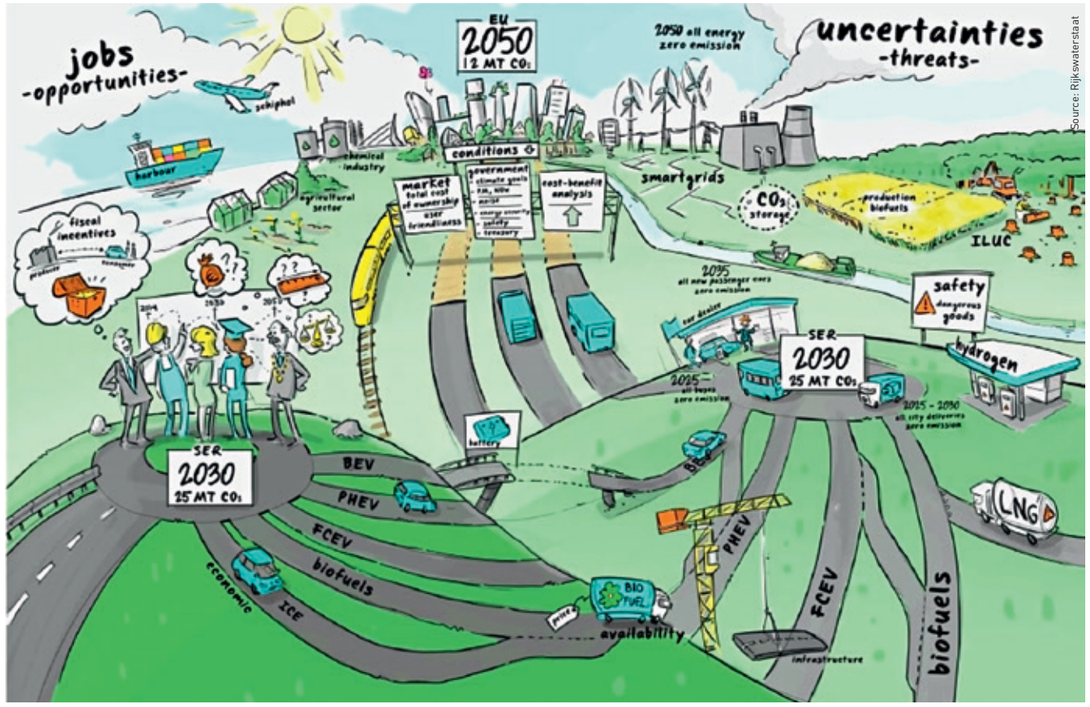


Fig. 1: Illustration depicting the Dutch path toward clean fuels until 2050

The largest and most important subsidy program on transportation is called De auto van de toekomst gaat rijden, which roughly translates as: "The car of the future will arrive." Its objective is to accelerate the market introduction of promising technologies, turning the Netherlands into a test lab for sustainable transportation ideas. Questions to which the project intends to find answers include how vehicles are classified, what "green" vehicle taxation and leasing contracts may look like, for which applications hydrogen could be used as an alternative fuel, and how to set up smart grids and multi-vector transportation value chains.

Today, the most prevalent method to demonstrate H_2 and fuel cell potential in transportation is the deployment of buses in mass transit. These national activities have been closely intertwined with the ones at EU level.

GREEN DEALS Last April, the infrastructure ministry made an agreement with mass transit operators in the country as part of the government's Green Deal Initiative. It will ensure that only zero-emission buses will be added from 2025 at the latest and that all of them are emission-free by 2030 (today, there are about 5,000 buses in operation in the Netherlands), while the entire public system also needs to be renewable-only by that time.

Eindhoven has already had two fuel cell buses in use. In August, another two were added to the fleet in Rotterdam. More are planned to be deployed in Groningen and Arnhem at the end of the year and together with the Benelux countries, the Netherlands has joined FCH JU's JIVE project, which intends to bring (a minimum of) 50 buses to three or four regions. Currently employed models also include battery-electric versions, such as the 18 vehicles (with overnight charging) in use on several Dutch islands. And the Eindhoven region is planning to add another 42 with opportunity charging.

NATIONAL H2NL HYDROGEN PLATFORM As a public-private partnership, there is the national H2NL project, which was established in cooperation with the Dutch hydrogen and fuel cell association – Nederlandse Waterstof en Brandstofcel Associatie. It is thought to provide a platform for an exchange of ideas between politics, industry and research to advance H_2 developments. It is also intended to ensure that the government can deliver on the 2025 hydrogen targets, namely 20 new H_2 refueling stations, 1,500 to 2,000 fuel cell cars and 100 buses (including the relevant opportunities to fill up their tanks), up to 500 delivery vans and 20 trucks for zero-emission logistics in urban areas. When the platform can begin its work, however, will entirely depend on the successful formation of a new government and official approval.

A subsidy program to support the installation of a nationwide refueling infrastructure has likewise been delayed by the long search for a new political coalition. This program aims to set up filling stations in cities and regions that promise a certain number of potential hydrogen users and vehicles. To date, the country has had three operational H_2 stations in place. Two, one in Arnhem and one near Rotterdam, are accessible to the public; the one in Helmond, where the Dutch bus industry has its R&D center for electric transportation, isn't.

POWER TO FLEX Power to Flex is a Dutch-German cooperation project during which businesses, research organizations and government agencies from the north of the Netherlands and northwest Germany will develop demonstration systems for renewable storage. There will be individual tasks to design storage solutions in building engineering – both for single-family houses and large residential complexes and commercial premises – and in transportation. The project started last December. ||

IPHE MEETING
The Netherlands will host the 28th Steering Committee Meeting of the International Partnership for Hydrogen and Fuel Cells in the Economy this November.

EVENTS 2018

22ND WHEC
June 17th to 22nd, 2018
in Rio de Janeiro, Brazil
www.whec2018.com

11TH ENERGY STORAGE WORLD FORUM
organized by Dufresne
May 16th to 18th, 2018, in Berlin, Germany
www.energystorageforum.com

THE BATTERY SHOW
May 15th to 17th, 2018
in Hanover, Germany
www.thebatteryshow.eu

5TH RESIDENTIAL ENERGY STORAGE FORUM
organized by Dufresne
May 14th to 15th, 2018, in Berlin, Germany
www.energystorageforum.com

EV EXPO
INTERNATIONAL EV INDUSTRIAL ECOLOGY CHAIN EXPOSITION & GLOBAL ELECTRIC VEHICLE LEADERSHIP SUMMIT
May 9th to 11th, 2018, in Guangzhou International Sourcing Center, China
www.evexpovip.com

EUROPEAN HYDROGEN ENERGY CONFERENCE (EHEC)
March 14th to 16th, 2018
in Málaga, Spain
www.ehec.info

HYDROGEN & FUEL CELLS ENERGY SUMMIT
January 24th to 25th, 2018
in Brussels, Belgium
www.wplgroup.com

EVENTS 2017

FUEL CELL SEMINAR & ENERGY EXPOSITION
November 7th to 9th, 2017, in Long Beach Convention Center, Long Beach, California, USA
www.fuelcellseminar.com

IBEROAMERICAN CONGRESS ON HYDROGEN AND FUEL CELLS – IBERCONAPPICE
Parque Tecnológico Walqa, Ctra. Zaragoza-Huesca, 22197 Cuarte
October 17th to 20th, 2017, in Huesca, Spain
www.appice.es/web/iberconappice2017/

EMOVE 360° EUROPE
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October 17th to 19th, 2017, in Munich
www.emove360.com

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October 9th to 11th, 2017, on the Stuttgart Fair Ground
www.world-of-energy-solutions.de

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iGas energy GmbH, Cockerillstr. 100, 52222 Stolberg, Germany, Phone +49-(0)2402-9791600, Fax -7094864, *www.iGas-energy.de*

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ENERGY STORAGE

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EVENT ORGANIZERS

24rd Group Exhibit Hydrogen + Fuel Cells + Batteries, HANNOVER MESSE 2018, April 23 – 27, Tobias Renz FAIR, Tobias Renz, *tobias@h2fc-fair.com*, *www.h2fc-fair.com*

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OMB Saleri SpA, Via Rose di Sotto 38/c – 25126 Brescia, Italy, *hydrogen@omb-saleri.it*, *www.omb-saleri.it*

PTEC – Pressure Technology GmbH, pipelines, screw connections, filters, valves, regulators, TPRD, Linde 11, 51399 Burscheid, Germany, Phone +49-2174-748-722, mail@ptec.eu, *www.ptec.eu*

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SerEnergy A/S, Reformed Methanol fuel cell systems for stationary and e-mobility, Lyngvej 8, 9000 Aalborg, Denmark, Phone +45-8880-7040, *www.serenergy.com*

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Borit NV, Bipolar plates and interconnects, Lammerdries 18e, 2440 Geel, Belgium, Phone +32-(0)14-25090-0, Fax -9, contact@borit.be, *www.borit.be*

ElectroChem Inc., 400 W Cummings Park, Woburn, MA 01801, USA, Phone +1-781-9385300, *www.fuelcell.com*

HIAT gGmbH, Schwerin, Germany, CCMs / MEAs / GDEs for PEFC, DMFC & PEM-Electrolysis, *www.hiat.de*

Kerafol Keramische Folien GmbH, Koppe-Platz 1, 92676 Eschenbach, Germany, Phone +49-(0)9645-884-30, Fax -90, *www.kerafol.com/sofc*

WEKA AG, Schuerlistr. 8, 8344 Baeretswil, Switzerland, Phone +41-(0)43-833434-3, Fax -9, info@weka-ag.ch, *www.weka-ag.ch*

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