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AND FUEL CELLS

H₂ international



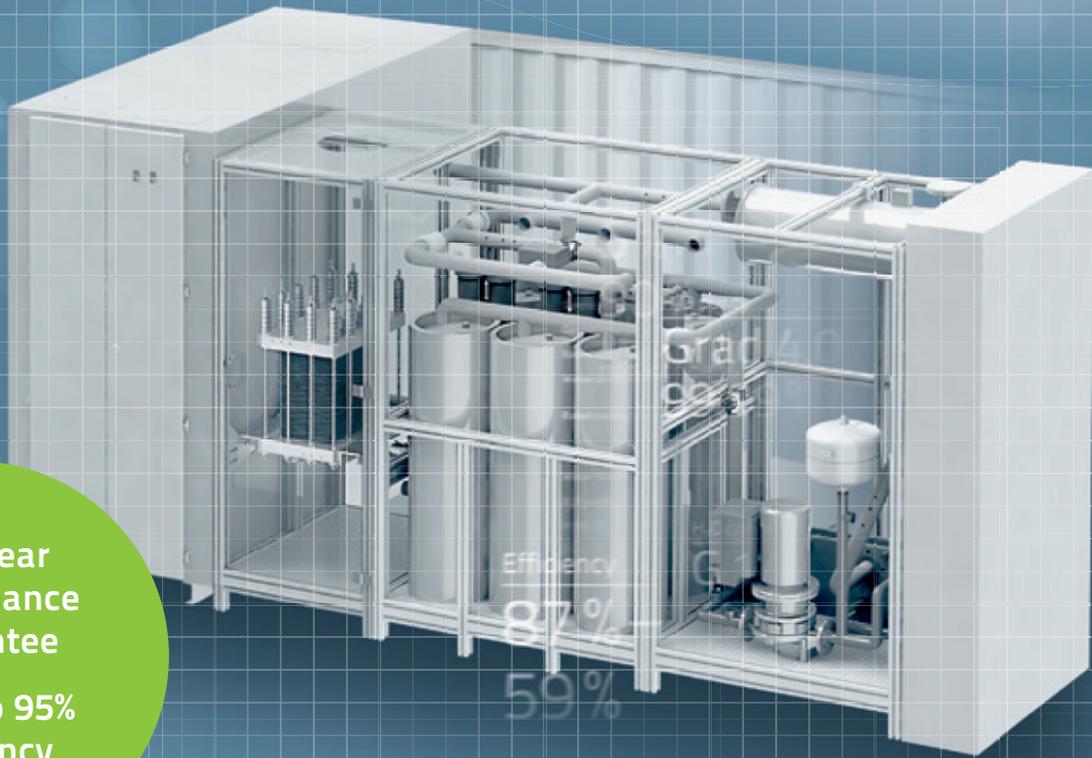
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PEM FUEL CELLS' (OLD AND) NEW COMPETITION

Alkaline Fuel Cell Solutions by AFC Energy and GenCell



Fig. 1: KORE fuel cell module in Stade, Germany

For a long time, it seemed as if alkaline fuel cells, or AFCs for short, no longer had a chance on the market. But now, some developers are set on reviving this “old” technology. GenCell, a cash-rich business from Israel, has optimized these cells to a point where they can be offered as part of a commercially available backup power system. And a successful trial run in Stade has encouraged AFC Energy to push onto the German market with its own solutions. Currently, it is planning to set up a 1-megawatt system in the Covestro Industrial Park in Brunsbüttel.

AFC Energy, which was founded in the UK in 2006, started getting involved in alkaline fuel cell development in Germany in April 2013. As part of the EU’s Power-Up support program, it set up two stationary KORE fuel cell modules with a total nominal capacity of 500 kilowatts at DowDuPont in Stade (see fig. 1). The first one of these modules, a 240-kilowatt installation, began producing electricity in July 2015. Its three tiers comprised of 8 fuel cell cartridges were up and running by the end of January 2016, a bit later than expected. Together, they have since been feeding power into the public grid of the municipality’s energy utility. Each of the 24 cart-

ridges in this installation consists of 101 individual cells and initially showed 7.5 kilowatts of output, a value close to the lower performance threshold.

All tiers are operated at low pressure and moderate temperatures, i.e., 0.02 bars and 70 °C, respectively, and each has its own gas pressure regulator for hydrogen and nitrogen, blower with electrolyte tank and pump, and carbon dioxide scrubber. The hydrogen is supplied by plant operator Air Products, or more precisely by DowDuPont’s electrolyzers. The project is said to have cost EUR 11.5 million, which includes EU subsidies of EUR 6.1 million.

BRITISH BUSINESS BUILDS IN BRUNSBÜTTEL Now, AFC Energy is reported to be planning another installation, a 1-megawatt system in Brunsbüttel. The new system is said to receive hydrogen from the pipeline network of Covestro Germany, the management company of the Covestro Industrial Park in the city. One of the business divisions of the pipeline operator, which was known until 2015 as Bayer Material-Science, is chloralkali electrolysis. The hydrogen produced by this industrial method and distributed through the company’s H₂ network is planned to be utilized for an alkaline fuel cell

Source: GenCell



Fig. 2: GenCell unit

in the foreseeable future. According to AFC Energy, construction at the river Elbe had begun in May 2017. The manufacturer, which is headquartered south of London, hopes that the project will provide it with easier access to the German market. It is the reason why it also intensified the partnership with plantIng, a German engineering company, in early 2016.

Meanwhile, the Brexit vote has raised doubts about whether work can be completed at all. In May, however, it was announced that construction would proceed as planned. A spokesperson for AFC Energy told H2-international that “in partnership with plantIng and Covestro Germany, our Brunsbüttel project is making progress.”

In April, the British company entered into a cooperation agreement with Italian supplier De Nora to speed up AFC market deployment. Through collaborative efforts, they intend to reach the multi-megawatt range by 2020.

GENCELL At the same time, GenCell based in Petach Tikva, Israel, has been trying to improve the fuel cell’s image from the ground up. This June, it published a white paper titled “The Big Deal With Fuel Cells,” which describes fuel cell operation, hydrogen properties and the differences between several types of cells. The authors of the paper also give a detailed explanation of the advantages of AFC technology, since GenCell manufactures alkaline fuel cells for backup power solutions.

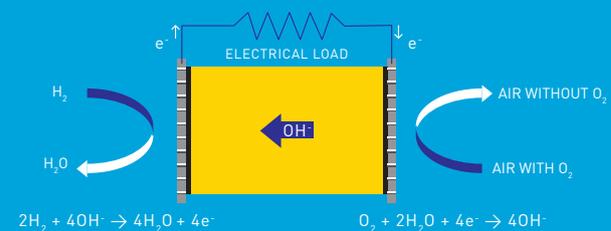
In particular, the supplier has been touting the efficiency and reliability of stationary fuel cells in UPS application. By its own account, the AFC’s biggest advantage was a platinum-free and thus inexpensive catalyst. Additionally, hydrogen supply didn’t have to show the ultra-high purity that was needed for operating PEM fuel cells. Michael Tausch, who used to work for H₂ PowerTech, formerly IdaTech, and Hoppecke before joining GenCell in June 2017 and becoming its director of sales and business development on Sept. 4, told H2-international that normal 3.5 hydrogen at 99.95 percent purity was good enough. The required oxygen would be extracted from the air. He added that his company possessed a technology which could filter out any CO₂ amounts that might prove disruptive to fuel cell operation.

Rami Reshef, CEO of GenCell, explained, “Thanks to patented AFC technology, we’ve achieved cost breakthroughs

that make our solutions affordable for mainstream consumers. Our 5-kilowatt backup power systems overcome the significant weaknesses of other clean technologies, such as solar and wind, and they’re the perfect option to replace outdated technologies, such as batteries and diesel generators.”

The Israeli company offers two products, GenCell G5 for uninterruptible power supply, for example, in the telecom-

ALKALINE FUEL CELLS



Alkaline fuel cells had been employed as early as the 1960s, during NASA’s mission to the moon, and were likewise used in Europe’s Ariane spaceflight program. They were regarded as comparatively durable and could produce both power and heat as well as water.

The alkaline fuel cell was the first type of fuel cell to have been fully developed and used as a low-temperature unit in non-stationary applications, for example, in spaceflight and the submarine industry. Its electrolyte is a caustic potassium hydroxide solution. The charge carriers, that is OH⁻ ions, migrate from the cathode to the anode, where they release electrons while becoming water molecules.

In contrast to other types of fuel cells, this type of cell can be designed with catalyst materials that are more cost-effective than platinum. Its operating temperature is below 100 °C.

So far, there has been only moderate interest in AFC development despite the promise of relatively high efficiency. Parts of the AFC’s chemical process chain involve relatively slow reaction rates and the system doesn’t have a very long life. Neither ammonia nor CO₂ may be allowed to enter the cell; otherwise, the electrolyte would be crystallized. On top of this, a separate loop is needed for the aqueous electrolyte solution.

munications industry, and GenCell G5rx, which comes with a special encasing, e.g., to complement battery-based backup power systems. Their overall efficiency is said to be 55 percent, while operating temperatures are said to range from minus 40 °C to plus 45 °C.

One G5 unit has already made it to Brazil. In early 2016, it was installed at telecommunications provider Claro in Rio de Janeiro, where it is being tested and validated. GenCell said that the system cost the same as a fully installed ISO14001-compliant diesel generator. “We’ve really put the GenCell G5 to the test. We performed a variety of power outage simulations that considered factors such as the duration and type of blackout, with outstanding results,” Luis Galindo, operations manager at Claro, said. He added that it required less space than a diesel generator and was a “100 percent clean” solution, which emitted no CO₂. Additional systems were installed in the Galil Elion Municipality in Israel in November last year and at a power plant substation in the United States. ||

FUEL CELL STACK OVERVIEW

During a first market analysis several years ago, Professor Birgit Scheppat from RheinMain University conducted extensive tests and evaluations of fuel cell stacks available at the time (see October 2010 issue of German-language magazine HZwei). On behalf of Hessen Agentur and in collaboration with the H2BZ initiative, she examined which challenges customers face when they intend to replace a battery or another unit supplying electrical energy with a fuel cell stack. The analysis also involved the purchase of stacks in the 1-kilowatt category. The research team contacted 33 businesses; however, only six could deliver a unit. Tests were performed with three modules from Europe, two from Canada and one from China. The net price for these systems ranged between EUR 3,500 and EUR 8,500.

The new market overview compiled by H2-international lists fuel cell stacks that have a polymer electrolyte membrane and between 1 kilowatt and 100 kilowatts of output. We only included units that are supplied with pure hydrogen and can be operated either at around 80 °C (low-temperature PEMs) or between 120 and 160 °C (high-temperature PEMs). Direct methanol versions were not considered.

We wrote to 30 organizations altogether, including some wholesalers and some businesses which have since discontinued their fuel cell activities. Eight of them replied, although one did not return any usable data, so we only had seven stacks to compare in total. For this reason, our list is not to be regarded as exhaustive. ||

RISING FUEL CELL DEMAND

H2-international has recently asked manufacturers of fuel cell stacks not only about their systems' technical specifications, but also about their opinion of current market developments. As only seven companies participated in the survey, the results may not be very indicative of where the entire market is heading. However, you can discern a few trends. For example, six of seven suppliers agreed or strongly agreed with the statement that demand for fuel cells will increase considerably before 2020. These six also wished for more financial support for R&D activities and market introduction, although they seem to put more emphasis on the latter, which received broader agreement than the former when comparing the answers to both questions (see chart).

Three of the respondents were mostly satisfied – one was even very satisfied – with how the NIP 1 and NIP 2 subsidy programs had turned out. Unfortunately, the others did not comment on the subject. One supplier praised NIP 2's Market Activation Support in particular. Another hoped that the current program stage would lead to increased fuel cell deployment in Germany. A third wished for separate basic research budgets, coupled with the requirement that the results of this research would be made available to the public.

When asked about the market most likely to see sustainable growth first, six of the respondents chose utility vehicles, making it the clear favorite. Industrial trucks were available as an option, but none of the respondents checked the field. However, some of the questionnaires showed forklift trucks and materials handling below Other – both descriptions which match that option. Buses were mentioned as well. ||

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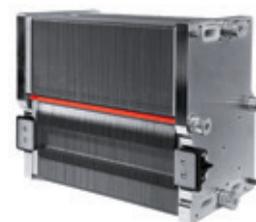
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Website www.f-cell.de

MARKET OVERVIEW FUEL CELL STACKS



| | | | | |
|---------------------------------|--------|---|--------------------------|-----------------|
| COMPANY | | Ballard Power Systems Inc. | Hydrogenics Corp. | Plug Power Inc. |
| PRODUCT | | FCvelocity-9SSL | HyPM-HD 30 Power Modules | ProGen |
| STATE OF DEVELOPEMENT | | commercial | commercial | commercial |
| MAIN APPLICATION | | mobile | mobile | mobile |
| NOMINAL OUTPUT (KW) | min. | 4 | | 1,5 |
| | max. | 21 | 31 | 30 |
| NUMBER OF CELLS | min. | 20 | | |
| | max. | 110 | | |
| OUTPUT VOLTAGE (V) | | 12,8-70,2 | 60-120 | |
| OUTPUT CURRENT (A) | | 300 | 0-500 | |
| WORKING TEMPERATURE (°C) | min. | -25 | -10 | -30 |
| | max. | 75 | 55 | 70 |
| COOLING TECHNOLOGY | | de-ionized water and/or ethylene glycol mix | water | air, water |
| BIPOLAR PLATES | | graphene | graphene | metal, graphene |
| STACK DIMENSIONS (CM) | height | 6 | 26,1 | varies |
| | width | 76 | 40,6 | |
| | depth | 9,2-30,2 | 71,9 | |
| STACK DIMENSIONS (KG) | | 7,1-17 | 72 | varies |
| LIST PRICE | | on request | | on request |

Source: manufacturer's instructions



| | | | |
|----------------------|---|---|--|
| PowerCell Sweden AB | Proton Motor Fuel Cell GmbH | Zentrum für Brennstoffzellen Technik GmbH | Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg |
| PowerCell S1, S2, S3 | PM 400 | Outdoor UPS Stack | Stack BZ-100 |
| commercial | commercial | prototype | prototype |
| mobile, stationär | mobile, stationary | UPS | research tool |
| 1 | | 3,3 | 0,1 |
| 100 | 25,6 | | 4,8 |
| | | 54 | 3 |
| | 96 | | 80 |
| | 118 | 35 | 1,8-48 |
| | 500 | 100 | 100 |
| -30 | -40 | -10 | |
| 70 | 70 | 55 | |
| water | water | air | water |
| metal | graphene | metal | graphite composite |
| 19,1-56,5 | 19,5 | 37,5 | 14 |
| 24,0-48,0 | 40 | 32,2 | 12 |
| 14,8-15,6 | 41,9 | 10,6 | depending on cell count |
| 7,9-33,1 | 40,1 | 11 | depending on cell count |
| | no pure stack sale; only available as system | | depending on cell count |

FUEL CELL MASS PRODUCTION IN GERMANY

AutoStack CORE Successfully Completed

Fuel cell stacks continue to show a critical gap in power density development along the European automotive value chain. Filling it was the objective of two EU projects, Auto-Stack (FCH-JU GA 245142) and AutoStack CORE (FCH-JU GA 325335), which received financial support from the Fuel Cells and Hydrogen Joint Undertaking. The collaboration between European carmakers, suppliers and renown research organizations has now succeeded in establishing core specifications and a technology platform for fuel cell stacks powering vehicles. These stacks meet the most stringent global standards on power density, lifetime, efficiency and cost.

The initial aim was to identify performance and space requirements to create baseline specifications for a scalable stack platform delivering between 10 kilowatts and 95 kilowatts of output. This stack was intended for vehicles from several manufacturers, for buses and for the energy industry.

Based on an iterative approach, specifications were created through an analysis of power requirements for medium-size vehicles built by the participating automakers and the room available for stack installation. This data was subsequently used to arrive at geometric boundaries and target specifications for power density and operating conditions. An added limitation was the request for an exclusive deploy-

| | Unit of Measure | Target | Evolution 1 | Evolution 2 |
|---|--|--------|-------------|-------------|
| Power | Continuous [kW] | 95 | 94 | 97 |
| | Peak (30 sec) [kW] | 118 | 99 | 114 |
| Volume | [l] | < 35 | 34,3 | 27,7 |
| Wight | [kg] | < 44 | 46,3 | 33,1 |
| Power density | Continuous [kW/l] | 2,8 | 2,7 | 3,5 |
| | Peak [kW/l] | 3,4 | 2,9 | 4 |
| Power density (continuous) | [W/cm ²] @ 1.5 A/cm ² | 1,0 | 0,947 | 0,987 |
| Cell height | [mm] | 1,5 | 1,2 | 1 |
| Degredation rate | [μV/h] | < 2 | -27 | < 20 |
| Freeze startup | Von ... °C | -25 | -20 | -25 |
| Total cost per stack (gross) ¹ | [€/kW] | < 40 | 47,83 | 36,81 |

Table 1: Target specifications and project outcomes



Fig. 2: Test stand for Evolution 1 stack

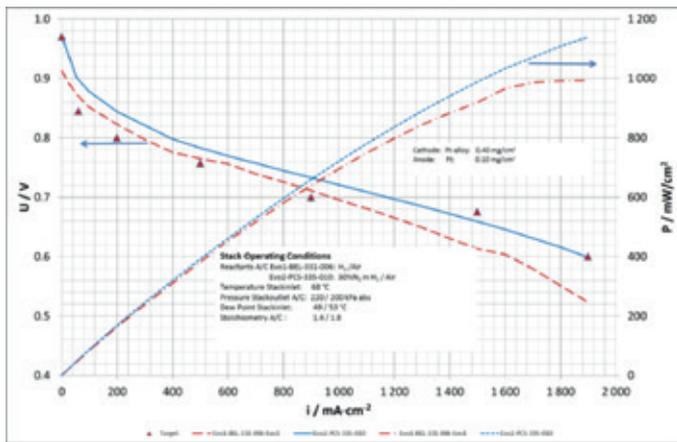


Fig. 2: Comparing polarization and power density curves of Evolution 1 and 2 (identical MEAs)

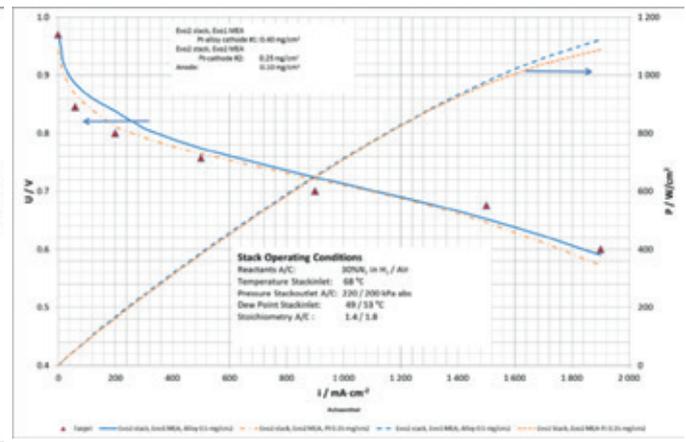


Fig. 3: Comparison between two MEAs in compact stack versions: Despite the reduction in precious metal loading, there was little difference in output.

ment of industrial components. These factors laid the foundation for the design of bipolar plates and gaskets and set the requirements for membrane electrode assemblies or MEAs.

Development was supported by benchmark studies to compare work results with the current state of technology around the globe and by a study from an independent service provider to determine costs based on automotive industry standards. Extensive testing was conducted to confirm the performance, lifetime and functional capabilities of the stack. It also provided the basis for recommendations on developing future stack generations.

Two stacks in different stages of development were designed, built and tested in a total of 51 months. The first stack is called Evolution 1, which the industry considers to be a prototype. Evolution 2 corresponds to an A sample in automotive engineering. Additionally, design guidelines were created for developing a third-stage unit, a B sample in automotive terms.

Most of the specification targets could be achieved or exceeded (see table 1). A peak load comparison of power densities between AutoStack CORE (4 kW/L) and figures given by carmakers Nissan (2.5 kW/L), Honda (3.1 kW/L) and Toyota (3.1 kW/L) shows that the project has been successful in meeting the ambitious aim of creating the “best-of-its-class automotive stack technology.”

What needs to be stressed is that the new stack design can meet the cost targets by the U.S. Department of Energy at a production of 30,000 stacks a year, which no other developer has been able to achieve.

| AutoStack CORE consortium members | Car manufacturers Component and system suppliers | Research organizations |
|-----------------------------------|--|-------------------------|
| BMW | Belenos/Swiss | CEA |
| Volvo | Hydrogen | Fraunhofer ISE |
| VW | DANA | RC/Institute for Energy |
| | Freudenberg | Paul-Scherrer-Institute |
| | Powercell | ZSW |
| | Solvicore/Greenerity | |
| | SymbioFCcell | |

Comparing full-length Evolution 1 and 2 stacks (see fig. 2) will clearly show the higher output of the latter, which is solely the result of improved bipolar plate design. Additionally, the projects led to the testing and enhancement of several types of MEAs. Figure 3 compares the performance of two shortened stacks of different precious metal loading. The figures in the table indicate that the shortened stack manufactured with a low platinum catalyst load is comparable to the high-load alloy version across all relevant output categories. The adaptation of operating conditions offers yet more potential to improve stack performance.

The deciding factor for the project’s success was the open-minded attitude and the commitment of all partners to the collaborative effort. It not only encouraged answers to critical questions on stack development. The direct interaction between automotive manufacturers, component suppliers and research organizations also helped to identify and tap potential for improvement.

Progress reports and stack design samples were presented at several conferences and trade shows and have piqued the interest of many. A number of A samples have already been delivered for testing and demonstration. More are available on request.

NEW RESEARCH VENTURE TO FOLLOW This May, AutoStack Industry, a new endeavor with a planned duration of 4 years, was established as part of the federal transportation ministry’s National Innovation Program Hydrogen and Fuel Cell Technology. Succeeding the two projects mentioned above, it is a joint initiative by businesses from the German automotive industry, with the intent to advance the newly developed stacks toward full-scale production. It also aims to develop and validate the methods required for manufacturing 30,000 stacks a year and establish a foundation for the timely mass production of stacks after its end. ||

□ [1] Based on DoE/SA methods: Brian D. James, Jennie M. Moton, Whitney G. Colella. Mass Production Cost Estimation of Direct H₂ PEM Fuel Cell Systems for Transport Applications 2015 Update. Strategic Analysis Inc., Arlington, VA

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NORTHERN GERMANY'S PATH TO ENERGY INDEPENDENCE

How to Bring Hydrogen and Wind Power Closer Together

Northern Germany is well on its way to becoming a power-to-gas El Dorado. The past years have seen citizens' initiatives and businesses initiate projects to explore new avenues in this wind-rich region. Most of their activities have yet to hit the mainstream news and some weren't even known to many professionals in the industry. But recently, an increasing number of publications have been focusing on ongoing projects, so we thought it was time to take a closer look at what's happening.

Schleswig-Holstein and Lower Saxony are among the German states with the most wind power plants. In some parts of both, the generation of locally sourced renewable power is already enough to meet the entire electricity demand at certain times of the year. Expectations are that by 2030, Schleswig-Holstein will theoretically be able to produce as much as 300 percent of the power required in this northernmost state in Germany.

Companies such as GP Joule, with its years-long investment of time and resources, have been trying to make efficient use of these large, locally generated amounts without having to transport it far away. André Steinau, assistant to GP Joule's management board, explained, "We need to add value to these energy amounts in nearby facilities. The use of electrolysis to split water into hydrogen and oxygen is perfect for doing that."

As part of a collaborative project in northern Friesland, GP Joule is currently planning to install a total of five power-to-gas plants, each including a 200-kilowatt PEM electrolysis system. The hydrogen produced by these systems is intended to be used, for example, to refuel two public H₂ buses that make regular runs in Husum and Niebüll, south of the Danish border (around 300 kilometers or 186 miles per day). Additionally, it could be sold in the region or fed into the natural gas

network. A spokesperson for GP said, "This is how northern Germany will gradually get to cost-effective and economical zero-emission mass transit." She added, "Niebüll is the starting point for the train to the island of Sylt. Its diesel engine could be converted with little effort to run on renewably sourced hydrogen." GP Joule had already conducted a study to determine the feasibility of such a project (see May 2017 issue of H₂-international), with encouraging results. The company said that the endeavor had now reached the planning stage.

POWER-TO-GAS IN BRUNSBÜTTEL A similar project has been underway in Brunsbüttel, 3 kilometers or nearly 2 miles north of the decommissioned power plant on the Northern Elbe riverside. Based on a bid request instigated by NEW 4.0, northern Germany's innovation alliance (see box), plans are to install a wind-to-gas system and a battery storage unit next to the biomass heat power plant on Bioenergie Contracting's factory premises. Both installations are said to be supplied with renewable electricity from Ostermoor, which has five wind power stations totaling 15 megawatts of capacity. The operator will be Wind to Gas Südermarsch, which early this year received a grant approval letter promising funds of EUR 2 million for the project worth EUR 7 million overall. The PEM electrolyzer (HyLYZER-400-30, 30 bars output pressure, 2.4 MW_{peak}; see figure 2) will come from Canadian manufacturer Hydrogenics, which won the contract for it in March. Installation is reported to start this fall.

Tim Brandt, managing director of Wind to Gas Südermarsch, explained, "Hydrogenics not only offered a compelling technological solution but also unmatched experience – underscored by over 500 reference sites in the past 20 years."

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Fig. 1: Collaborative project planned in northern Friesland

NEW 4.0 – NORTHERN GERMANY'S ENERGY TRANSFORMATION

The objective of NEW 4.0 is to show to stakeholders from Germany, as well as Europe, that the energy market can indeed be transformed. By 2035, the project is planned to lead to a wide-ranging network of systems supplying safe, inexpensive, eco-friendly and socially accepted energy to meet the entire demand of the 4.5 million population living in Schleswig-Holstein and Hamburg. CO₂ emissions are to be cut by up to 70 percent during the same period. Germany's federal economic ministry has provided more than EUR 40 million to implement the measures needed to achieve those targets. Professor Werner Beba, the project's manager from HAW Hamburg, said, "The outcomes of this project will help us succeed in transforming our entire energy supply grid, something we definitely need to advance."

NEW 4.0 is one of five Smart Energy Showcases on the Digital Energy Transformation Agenda. The program is supported with EUR 200 million in government funding.

He added, “We believe Brunsbüttel has huge potential, especially for industrial solutions.” The city is also home to the egeb Wirtschaftsförderung consulting company, which for years has been trying to raise public awareness of renewable energies and alternative fuels. Volker Jahnke, deputy director at egeb, said, “We want to create a showcase for Germany’s energy market transformation and this project is proof of how serious we are about that.”

QUARREE100 TO TEST OUT NEW TECHNOLOGIES In Heide, a bit farther up north, one can find a venture not unlike the above but at an earlier stage of planning. The initial aim of the regional economic development agency was to set up an international campus focused on power-to-X technologies and grid balancing options. Formerly known as IN-ENTREE100, the program has meanwhile grown in scope and was renamed QUARREE100. Its new objective is to design forward-thinking energy technologies and to turn one of Heide’s neighborhoods into a sustainable community.

Part of this project coordinated by Bremen University’s interdisciplinary Institute for Advanced Energy Systems is the installation of a “future-proof refueling station” together with the Center for Solar Energy and Hydrogen Research Baden-Württemberg. The station is thought to provide alternative vehicle power sources in the form of renewable hydrogen as well as methane and electricity. The planned “resilient, integrated and grid-supportive energy supply system” is said to be subsidized with EUR 25 million overall.

Stefan Gößling-Reisemann, Professor of Resilient Energy Systems at Bremen University, told H2-international that “QUARREE100 concentrates on providing urban areas with electricity, heat and fuel from regenerative sources. Hydrogen and other renewable gases and liquids will have an important role to play in reaching our objective. We aim to advance those technologies and see to their implementation as part the project.” In addition, he was looking forward to being able to put “ideas for sustainable and resilient grid design into practice. Thanks to generous public funding, we will be able to test highly innovative energy technologies in Rüsdorfer Kamp [one of Heide’s residential areas]. We’re bridging the gap between research and practical application, which brings us a good deal closer to transforming the energy market. It’s not just our students who will benefit from this.”

H₂ GAS STATION IN FLENSBURG Farthest up north, hydrogen has likewise been a hot topic for years. Now, Schleswig-Holstein is said to be seeing its first H₂ filling station built in Flensburg. The idea is believed to have originated with a 2015 project of Reinhard Christiansen’s. The aim two years ago was to set up an installation in Risum-Lindholm in partnership with several energy companies to produce hydrogen from electricity and use it in FCEVs. Christiansen, who was born in the region, is not only managing director of Energie des Nordens based in Ellhöft but also the head of several wind

farm cooperatives. As such, he has a valuable network of contacts throughout the area. In cooperation with 45 businesses, he originally intended to build an H₂ refueling station, including an electrolyzer, on the outskirts of Niebüll.

But the idea never came to pass. Instead, the hydrogen station may now be set up in Flensburg. The reason for the change in plans could have had something to do with Christiansen’s collaboration with the Erneuerbare Energie und Speicher association based in the city and its bid on an H2 Mobility project, during which it was among the last three standing, but lost to Halle.

The association’s president, Peter Helms, described what happened next as follows:

“Our commitment and the way leading officials from Flensburg and the state advocated for H₂ technology in Schleswig-Holstein had made such an impression on the decision makers in Berlin that we met face to face to talk about a potential second avenue to receive funding. Then, everything happened quite fast: On July 6, they came from the capital to attend a first meeting at the IHK Flensburg. Our city’s mayor, Simone Lange, was there, as well as members of the board of Erneuerbare Energie und Speicher and stakeholders from business. They had the choice between four to five locations. In the end, the preliminary vote on where to set up a new hydrogen filling station favored the Handewitt Shell station, near the Scandinavian Park shopping mall. A final decision will be reached this fall.”

Helms also called for other regional projects, for example, regarding vehicles, trains and buses to follow the current one. When asked by H2-international, Nikolas Iwan, managing director of H2 Mobility, said that “Flensburg is one of over 20 new locations we’re evaluating for their implementation potential in 2018. I think after the next two to three months, we will have a better idea which of the stations under review we can set up.” ||

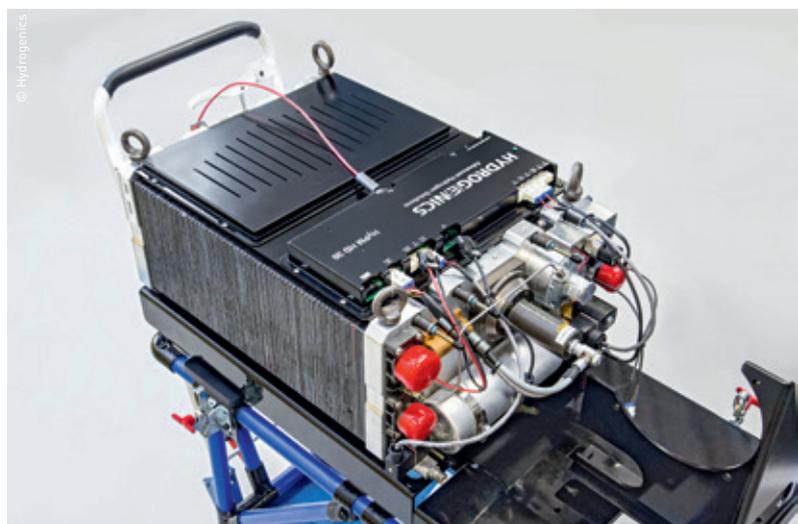


Fig. 2: HyLYZER® 400-30 electrolyzer

COMBINED CHANGE IN ENERGY AND TRANSPORTATION

BEVs and FCEVs in the German Energy Grid

Meeting the German federal government’s ambitious climate target, that is, a 95 percent reduction in GHG emissions until 2050 compared to a 1990 baseline, will require a decarbonized transportation sector. Cars powered by conventional engines must be replaced by low-emission versions. The two most promising substitutes are battery-electric vehicles or BEVs and fuel cell vehicles or FCEVs. Of course, their zero-emission refueling requires power, either directly for BEV charging or indirectly when hydrogen is generated through electrolysis. An increase in the market penetration of these technologies will likewise generate more demand for electrical energy, which could then put constraints on the national energy grid.

A study by the Reiner Lemoine Institute examined the impact of zero-emission passenger transportation on a system supplied exclusively with renewable energy sources. Four scenarios were used to create optimized grids that need to cover today’s power consumption in Germany and meet additional demand from zero-emission transportation. These scenarios differ in their level of market penetration and the number of BEV charging options. To analyze simulation results, a comparison was drawn to an optimal energy grid that shows no power consumption from transportation (base scenario).

BEV OR FCEV It is not yet clear how successful these technologies will be on the market. Studies by Reiner Lemoine Institute see a combination of both as the best opportunity for establishing a future-proof energy grid. BEVs are most suited for frequent short-distance travel, as they need less energy per mile. FCEVs, on the other hand, are the better option for long-distance routes because of their higher range and shorter refueling times. These assumptions have been confirmed by findings from a vehicle analysis during the PIONeER project. A simulation of Enertrag’s fleet cars showed that BEVs prove insufficient for 60 percent of the driving profiles in the 3.5-ton vehicle category, making FCEVs a necessity [1]. However, a contrasting opinion states that advantages in efficiency and expected technical advancements will be the reason why the transportation sector of the future will consist exclusively of BEVs. The following paragraphs will explicate the issue based on scenarios that have BEV and FCEV market penetration ratios at 50:50 and 100:0.

METHODS At present, it cannot be said with certainty how BEVs can be integrated into a future energy grid. If charging times are primarily linked to grid load, road users may find it more difficult to adapt. For this reason, we examined two types of charging. In the table below, “No flexibility” means that BEVs need to be fully charged after use. In contrast, “High flexibility” will allow drivers to charge their BEVs at any given time as long as the battery level is high enough to start driving again. A scenario providing a high degree of flexibility also allows for bidirectional energy flows between BEVs and power grids (vehicle-to-grid), so that battery-electric vehicles can be used as electricity storage.

We employed an open source simulation framework called oemof to determine what impact the scenarios shown in the table have on Germany’s energy grid [2]. This tool optimizes the entire energy network comprised of renewable power and storage systems to keep costs as low as possible throughout the economy. Simulated data is displayed by the hour over the period of one year. Power grid restrictions did not factor into the calculation (the “copper plate approach”).

In these scenarios, renewable energies comprise PV and wind power systems, hydropower plants and geothermal and biogas power stations. Storage includes batteries and pump storage systems as well as power-to-gas technologies. An increase in renewable energy use and in the number of pump storage systems was limited to the relevant technical potential (see fig. 1).

FINDINGS Passenger transportation at 100 percent BEV market penetration will have power demand rise by 90 terawatt-hours per year, a 17 percent increase compared to power consumption in the base scenario, where there is no zero-emission transport of people. If, however, the ratio of BEVs to FCEVs is on par, power demand increases by 169 terawatt-hours per year, which translates into a 33 percent jump compared to the base scenario. The higher demand in the second scenario is a result of efficiency losses resulting from electrolysis and fuel cell use. Still, the energy required by added renewable capacities is not necessarily proportional to rising demand.

Offering an annual 90 terawatt-hours in energy supply for BEVs at no charging flexibility requires 106 terawatt-hours per year within the energy network, i.e., 18 percent more generating capacity. Figure 2 shows that the mixed-use scenario needs

| | BEV / FCEV SHARE | BEV CHARGING FLEXIBILITY |
|---------------|---|--------------------------|
| BASE SCENARIO | 0 % / 0 % (no zero-emission transportation) | — |
| SCENARIO 1 | 100 % / 0 % (BEV scenario) | No |
| SCENARIO 2 | 100 % / 0 % (BEV scenario) | High (vehicle-to-grid) |
| SCENARIO 3 | 50 % / 50 % (mixed-use scenario) | No |
| SCENARIO 4 | 50 % / 50 % (mixed-use scenario) | High (vehicle-to-grid) |

Table 1: List of the four scenarios in the focus of this article

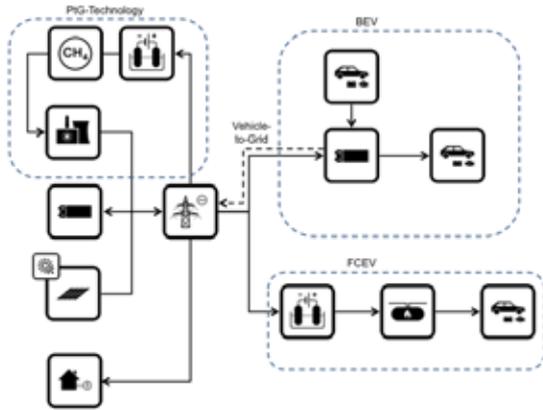


Fig. 1: Diagram of simulated components

169 terawatt-hours each year, but only 134 terawatt-hours, i.e., 21 percent less, must be additionally generated during the same period. Thus, FCEVs are more efficient in utilizing available energy amounts. The scenarios which provide a high degree of charging flexibility will reverse this trend and a BEV-only scenario will create as little as 48 terawatt-hours in added demand per year. This means that the surplus energy available throughout the system is 47 percent less than the energy required above baseline. The mixed-use scenario, on the other hand, has production at 103 terawatt-hours above baseline level, 39 percent less than what is required by the vehicles. FCEVs can certainly reduce surplus energy because of the storage capabilities of hydrogen. If BEV-only scenarios are compared to mixed-use models, the above results will lead to a surplus reduction of 26 percent in a scenario with no charging flexibility and of 13 percent in one with a high degree of it.

The influence of FCEVs on creating the best possible energy network setup depends on BEVs' charging flexibility. Figure 3 shows that additional demand in scenarios that provide no charging flexibility is met through an increase in PV and wind power systems. The FCEV scenario slightly raises the need for renewables, but storage capacities decrease. A high degree of charging flexibility will lead to considerable growth in PV installations, but will reduce the number of new wind power units. In contrast to scenarios that provide no charging flexibility, FCEV shares in passenger transportation will result in increased demand for storage compared to BEV-only settings.

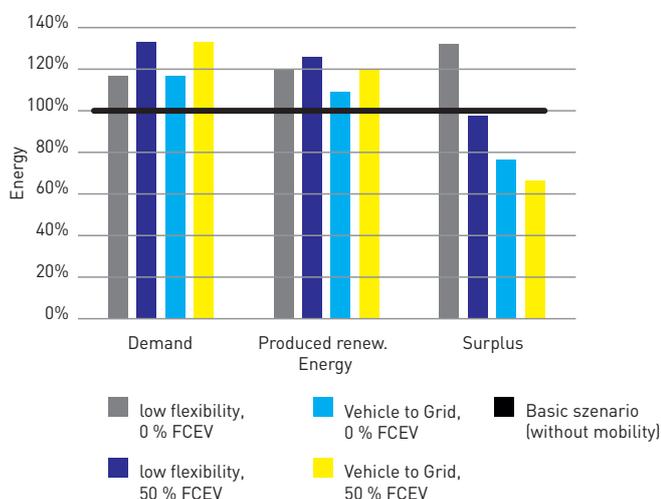


Fig. 2: Annual energy balance figures compared to a baseline grid that does not include the transportation sector. The bars show the respective figures for energy demand above the base scenario.

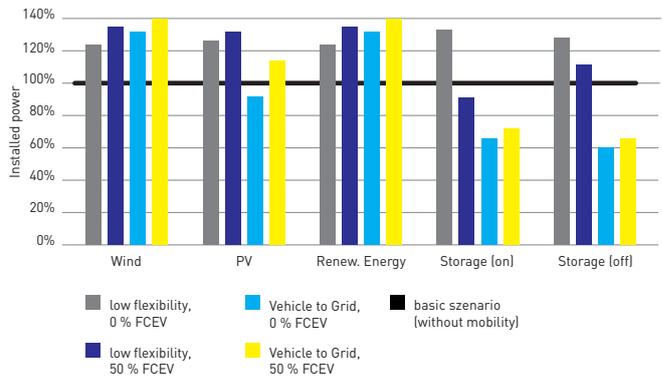


Fig. 3: Installed nominal capacity of renewables and storage compared to baseline energy network (which does not include transportation)

CONCLUSION These findings show that the degree of flexibility provided by hydrogen production and BEV charging will lower surplus energy amounts and lead to a better utilization of volatile renewables. Likewise, demand for storage will decrease. In conclusion, a future zero-emission energy grid needs some flexibility, which the new BEV and FCEV technologies can provide in addition to stationary storage.

Highly flexible BEV charging poses a great challenge and places severe limitations on road users' schedules. At present, it remains unclear which type of incentive model could be suggested and whether most users would accept it. Conversely, the flexibility that FCEVs provide in fuel production does not result in any undue limitations. Even today, hydrogen can be produced for grid balancing and combined with other renewables. Thus, it seems as if FCEVs could easily be incorporated into the German energy network and a meaningful market penetration rate would decrease stationary storage requirements.

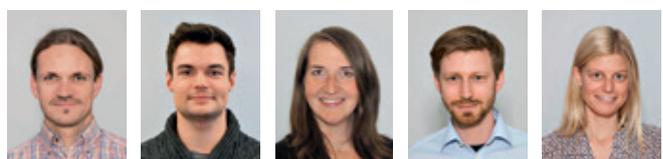
The demand for and the importance of grid balancing across the energy grid will grow together with the expected increase in renewable energy use. FCEVs offer the opportunity to meet part of this demand. An improved FCEV market ramp-up could raise the degree of flexibility in transportation alongside an increase in the use of renewables. ||

References(s)

- [1] Reiner Lemoine Institute. PIONeER Abschlussbericht. [Online] July 2017. http://reiner-lemoine-institut.de/wp-content/uploads/2017/07/PIONeER_Abschlussbericht_final.pdf.
- [2] oemof Developer Group. *Open Energy Modelling Framework (oemof) - A modular open source framework to model energy supply systems*. 2017. Version v0.0.9.

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FROM STORAGE TO DISTRIBUTION

HYPOS – New H₂ Infrastructures

One of the objectives of HYPOS, the Hydrogen Power Storage & Solutions East Germany initiative founded in 2013, is to establish a renewable hydrogen economy in middle and east Germany. The initiative identified the setup and expansion of the associated infrastructure as an essential prerequisite to achieve that aim. The region offers already available structures throughout (e.g., pipelines, underground caverns) and great renewable energy potential. According to HYPOS' roadmap, the first salt cavern is intended to start storing hydrogen for grid balancing in 2026. Energy is to be supplied by water electrolysis. Currently, 12 research projects have been dedicated to the topic; the number is expected to rise to 24 by mid-2018. These projects cover the entire value chain, from production and transport to storage and utilization. The pipeline network is thought to be the main link between them.

Within HYPOS, four projects are conducting research on pipeline networks. H₂-PIMS examines the use of hydrogen-rich gases in existing natural gas pipelines. A closely associated endeavor is H₂-MEM, whose aim is to allow for a cost-effective separation of hydrogen-natural gas mixtures at exit points of a network. H₂-Netz, on the other hand, researches polymeric materials for use in an energy distribution grid across the Bitterfeld-Wolfen region should it become necessary to build new hydrogen-only lines. During this project, a network connect to Linde's hydrogen pipeline was created to offer several linkages for energy-consuming applications. And H₂-Home is working on a fuel cell CHP unit that is to be connected to this trial network for a first demonstration of capabilities.

H₂-NETZ: NEW DISTRIBUTION GRID DESIGN DBI GUT, TÜV Süd, Mitnetz Gas, Rehau and HTWK Leipzig have established a collaboration with the intent to design an innovative H₂ distribution infrastructure that could become the basis for setting up and expanding a low-cost but wide-ranging pipeline hydrogen supply network. The joint project was launched last November and has a total budget of EUR 3.8 million. The overall objective is to demonstrate and test a distribution grid consisting primarily of polymer pipelines. Several materials will be used throughout the network to test their feasibility in a real-life environment.

Meanwhile, the consortium has created its first technical draft listing materials, pressure levels and design options. The materials will be examined at pressures of up to 22 bars across the distribution grid. Residential connections and installations inside buildings will be tested at up to 500 millibars. This will make it possible to meet the demand of innovative device technologies, such as fuel cells. Plans are to analyze polymer multilayer composite pipes that include permeation barriers made of metal and a copolymer (ethylene vinyl alcohol), high-pressure polyethylene versions with a protective polyethylene film and pipes made from PE100 RC. The pipes will be connected through mechanical components made of metal and polymers as well as electrowelding fittings.

| TARGET PRESSURE (MAX) | Materials | Installation |
|-----------------------|---|--|
| 22 bars | PE-Xa with aluminum barrier | Pipe bridge and soil displacement hammer |
| 10 bars | PE-Xa with EVOH or protective PE film, PE100 RC | Boring (drilling fluid used), soil displacement hammer, trench (no sand) |
| 500 millibars | PE100 RC, PE-Xa | Trench (no sand) |

Table 1: Materials and operating pressures (current planning base)

The chosen polymer materials have already been tested in the laboratory for their suitability to transport hydrogen. After passing at the laboratory scale, the materials are now being tested in the form of metal-plastic multilayer composite pipes in a higher-pressure, real-world setting. Underground installation is preferred, which is why the researchers involved in the project are looking into several soil displacement methods (see table 1). To rate environmental factors, particularly the impact of heat and UV radiation, individual pipelines are placed on support structures for pipe bridges.

During the project, TÜV will also test the technical feasibility of suggested design ideas. It will, for example, confirm the certification of pipeline materials, test pressure resistance and rate permeation properties based on the results from the previous test stage. A first day-to-day operation of the hydrogen pipeline structure is scheduled for late 2018.

H₂-HOME: HOW TO DESIGN A CHP FUEL CELL SYSTEM As part of this project, a consortium consisting of inhouse engineering, TU Freiberg, Enasys, Fraunhofer IMWS and DBI GUT is developing a residential 4.8 kW_{el} CHP system equipped with a PEM fuel cell. The aim is to increase electrical efficiency to above 50 percent and total efficiency to more than 95 percent. The consortium is not only designing the CHP installation, but evaluating its economic feasibility and market potential in building energy supply. Both Fraunhofer IMWS and TU Freiberg have already been able to provide preliminary findings and a safety certificate.

TU Freiberg used TRNSYS® to simulate a four-story multifamily property and determine the first benchmark values for economically feasible installation (see fig. 1). The analysis differentiates between grey hydrogen from fossil fuel steam reforming and green hydrogen from wind-powered water electrolysis. The stated costs stem from findings in the literature and include the identification of the median and the lower and upper quartiles.

According to the simulation, hydrogen supply offers a cost advantage of less than 10 cents per kilowatt-hour compared to other heating systems, such as gas engine CHP, wood pellet boilers, heat pumps and gas boilers combined with a solar thermal system. For there to be any benefit, the on-site consumption of generated electrical energy must exceed 80 percent at 5,500 full-load hours or more. Transport costs were kept constant, assuming a connection to a pipeline. The preliminary findings underline that hydrogen can be an economically sensible solution in the building sector, given the right circumstances. More research and analyses are underway [1].

HYPOS FORUM

The latest findings from H2-Home, H2-Netz and H2-PIMS were presented in detail at the HYPOS Forum. It took place on Nov. 2. and 3, 2017, in the BMW factory in Leipzig. See www.hypos-eastgermany.de

H2-PIMS: TOWARD AN H₂ ECONOMY The Pipeline Integrity Management System research project, or PIMS for short, is looking at the safety of natural gas grids operated with hydrogen-rich mixtures. The focus of the project is the identification of possible hydrogen-induced damage. Taking into account an installation's pipeline materials, typical types of preexisting damage and current operating conditions, the project partners perform comprehensive tests, e.g., for degradation resistance, on selected critical materials. The results obtained from those tests will be used to devise new evaluation methods to safeguard against operational failures. An additional objective is to draft a roadmap detailing how to make parts of the existing natural gas grid suitable for transporting hydrogen-rich gases as well as pure hydrogen.

The partners in this collaboration – DBI GUT, TÜV Süd, Ontras, Dr. Veenker Ingenieurgesellschaft, Fraunhofer IWM and Salzgitter Mannesmann – are currently analyzing and classifying existing pipelines. They have created an extensive trial program that closely approximates expected operating conditions and allows them to analyze the suitability of the existing infrastructure for gas mixtures and pure hydrogen.

H₂-MEM: HOW TO SEPARATE CH₄-H₂ MIXTURES This project to develop carbon-based membranes for separating hydrogen-natural gas mixtures has reached its first milestone. Scientists from the Fraunhofer Institute for Ceramic Technologies and Systems have succeeded in designing several samples that show an ideal H₂/CH₄ permselectivity of up to 225. The researchers had set the bar at 200.

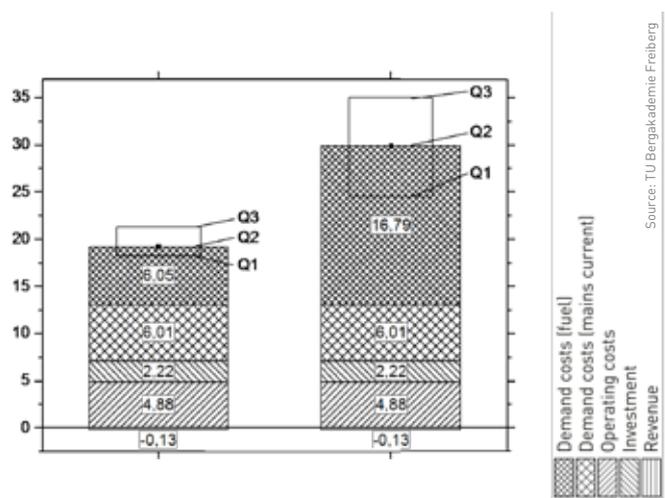


Fig. 1: Total energy supply cost [€/m²a] of several H₂ production pathways – grey (left) and green hydrogen (right) in a CHP system

Likewise, changes in pyrolysis methods have expanded the range of production options, making it possible to manufacture a greater number of units and membrane geometries. Now, membranes can be used to limit the hydrogen content in natural gas to 10 percent by volume. At present, it can be below 2 percent by volume, which meets the requirements of CNG stations. In cooperation with DBI GUT, the project partners will further optimize the membrane and increase its surface area over the coming months. At the same time, the membrane will be tested with real gases at varying percentages. The aim is to gradually modify natural gas grids to support hydrogen. ||

Information on the individual collaborations was derived from the objectives and most recent findings provided by the relevant project group.

REFERENCE(S)

[1] Hermann et al., Cost-efficiency of a CHP hydrogen fuel cell, 6. European PEFC and Electrolyzer Forum, TU Freiberg, 2017

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Theme: Energy News | Author: Sven Geitmann |

POWER STATION GETS H₂ UPGRADE

Natural gas and hydrogen have much in common, but can a gas power station be adapted for hydrogen use? One organization that has been trying to answer this question since the summer is the Vattenfall energy corporation. In partnership with Gasunie, a Dutch gas infrastructure services business, and Statoil, a Norwegian oil company, it aims to examine whether a retrofit is technically feasible. The objective is to convert one of the three blocks at the Magnum gas power plant into a hydrogen-based energy generator by 2023. The

design of Magnum, a 440-megawatt installation in Eemshaven, Netherlands, is already suited to accommodate various types of fuel sources.

Statoil will be in charge of converting the natural gas from Norway into hydrogen and carbon dioxide; the CO₂ will then be stored in an underground facility off the Norwegian coast. Gasunie will be responsible for transporting and storing the hydrogen, while Vattenfall is going to generate the electricity jointly with its Nuon subsidiary. ||

FUEL CELL INCENTIVE AT 40 PERCENT ...

... But Few Vehicles on the Road



Fig. 1: Hyundai ix35 Fuel Cell – less expensive than you may have thought

18

“Fuel cell cars are too expensive – and there’s no refueling infrastructure either.” You may hear a sentence like this one many times over. Both German-language magazine HZwei and H2-international have reported regularly about new hydrogen filling stations (e.g., October 2017 issue of H2-international). So, let’s look at the price, which might be much lower than many Germans believe. If you factor in available incentives, an FCV such as the Honda Clarity Fuel Cell would cost only around EUR 42,000 instead of EUR 57,000 – that is if it were offered on the domestic market. But NOW confirmed that “this Honda model is currently unavailable in Germany.”

Hydrogen cars make up a negligible percentage of new vehicle registrations in the country today, as indicated by a total of only three people applying for a fuel cell incentive between July 1, 2016, and March 31, 2017. Conversely, the German Office for Economic Affairs and Export Control received 8,655 applications for battery-electric and 6,690 for plug-in hybrid vehicles – more than half of them from commercial buyers.

A short reminder: The economic incentive grants EUR 2,000 in federal subsidies and a further price reduction of the same amount is given by the car manufacturer, which means that customers can cross EUR 4,000 off their bill. For example, it reduces the price tag of a Toyota Mirai (EUR 78,600) by 5 percent. But much more is possible: A relatively new project can help buyers recover two-fifths of the added cost for buying an FCV.

FORTY PERCENT OFF THE PRICE DIFFERENCE On March 1, the government introduced the Funding Guideline for Market Activation Measures as part of Phase II of the National Innovation Program Hydrogen and Fuel Cell Technology. The guidance, which will be in effect until the end of 2019, is part of a government program designed to prepare competitive hydrogen and fuel cell products for market introduction. It makes it possible to offer subsidies in the form of non-repayable grants if the relevant project involves at least three fuel cell vehicles.

To be more precise, it covers up to 40 percent of the price difference between fuel cell and conventional vehicle technology. As NOW said, “Submissions must include quotes for both fuel cell and conventional models.” For example, Toyota’s Mirai counterpart is the Avensis, sold at a list price of EUR 24,790. Eligible for grants are public and private corporations and individuals engaged in business or commerce. Especially German-based SMEs have been encouraged to apply. However, the grant cannot be combined with the economic incentive for electric vehicles.

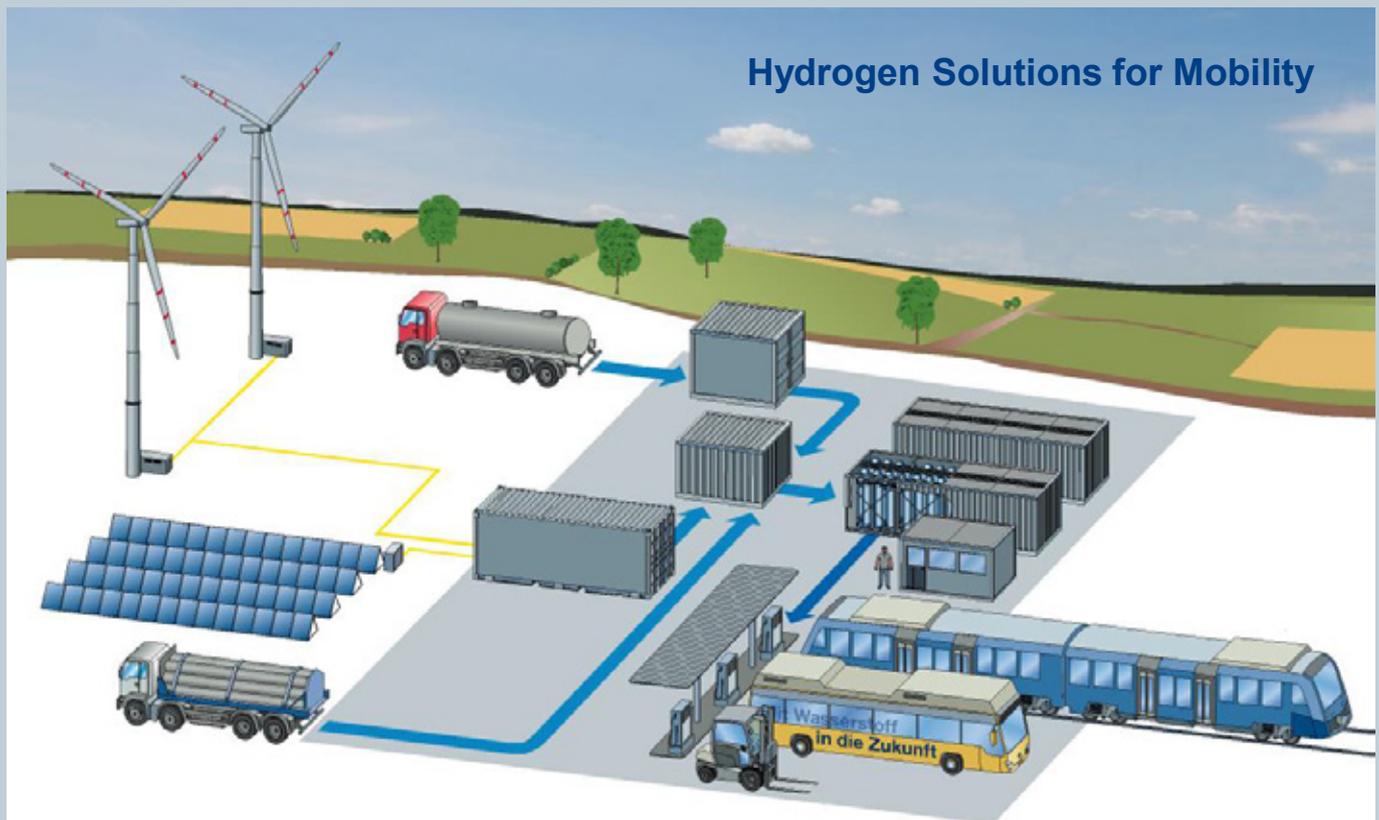
CALCULATION EXAMPLES At least, that’s the theory, because the calculation examples shown in the table will only be of use if a fuel cell car is available on the German market. So far, carmakers have manufactured only a few thousand units (see Hyundai in October 2017 issue of H2-international). They are primarily offered in Japan and California, while relatively few make it onto German roads most of the time. The domestic market saw merely two of the FCX Clarity, Honda’s first generation of fuel cell cars, delivered and both remained in the company’s possession. Asked about the automaker’s most recent model, Thomas Brachmann from Honda R&D Europe Germany replied, “The latest Clarity Fuel Cell is not sold in Europe.” In the States, it can be leased for USD 59,365. ||

| Model | Hyundai ix35 Fuel Cell | Toyota Mirai |
|--------------------------|------------------------|----------------------|
| Price (new) | EUR 65,450 | EUR 78,600 (leased) |
| Price (comparable model) | EUR 22,740 – Tucson | EUR 24,790 – Avensis |
| Added cost | EUR 42,710 | EUR 53,810 |
| Grant (40 %) | EUR 17,084 | EUR 21,524 |
| Total (incentivized) | EUR 48,366 | EUR 57,076 |

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THE FUTURE OF RACING



Fig. 1: Forze VII

By now, it should be glaringly obvious that times are changing: Mercedes-Benz is exiting the German Touring Car Championship and entering the Formula E in 2019, alongside Audi, BMW and Porsche. Electricity is also increasingly driving Formula 1. The fossil fuel to electric power transition is in full throttle. Technologies that used to be visions (see also Eco-marathon in October 2017 issue of H2-international) are becoming reality.

August 6 saw the first-ever race of the Forze, developed by TU Delft and currently in its 7th generation (see September 2016 issue of H2-international), during the Gamma Racing Day in Assen, Netherlands. Never has a hydrogen-powered electric car (max power: 190 kW; top speed: 210 km/h or 130 mph; two electric motors) participated in this event, which used to be the domain of fossil fuelers. Actually, the Forze Hydrogen Racing Team Delft had been trying to get into the

2016 race, so they had even more reason to be happy that everything worked out this year. The result, a spot in the middle, wasn't what really counted that day. The important thing was that they had broken new ground. "It's been a really great experience – just incredible," Mats Dirkwager, the team's manager, told motorsport.com.

The same trend can be seen for long-distance races. Jean Todt, who used to head Ferrari's Formula 1 team and has been president of the international FIA motor sport association since 2009, announced that the World Endurance Championship would see fuel cell cars among its vehicles. As manager of this marathon of motor sport racing, Todt said, "The fuel cell is probably the decisive technology. FCVs have a range of 600 kilometers and can be filled up to the brim within three minutes." He intends to have this technology established at the series by 2021. ||

4 TIMES THE VOLTAGE

The latest technology making the rounds in the automotive world is a 48-volt system. This quadrupling of the onboard voltage from the earlier 12 volts reduces the current required for a given amount of power by a factor of 4 ($P = U \times I$). A smaller current makes thinner cables possible. Considering the length and number of wires installed in today's vehicles, the new approach results in a notable reduction in weight and thus fuel consumption.

A so-called mild-hybrid car will combine the technology with a newly developed, extremely efficient starter. In contrast to a traditional alternator bolted to an engine block, the latter can be integrated into new generations of motors and offer not only starter functionality, but also a start-stop system and a boost mode. In addition, it recovers energy from braking and coasting and stores it temporarily in a 48-volt battery. This kind of integrated solution makes the most sense in the luxury segment, whereas belt alternator starters could make it relatively easy to retrofit smaller vehicles. ||

DOUBLE FEATURE IN HANOVER

Following its successful launch in Sindelfingen near Stuttgart this April, a new German dual exhibition will find itself in Hanover in the next. From May 15 through May 17, 2018, it will be featured at Hanover's show grounds in halls 19 and 20. The joint debut of the Battery Show Europe, whose organizers have termed it the continent's premiere show on the latest in battery manufacturing and product development, and its sister event, the Electric & Hybrid Vehicle Technology Expo, attracted around 4,000 professionals and 200 exhibitors. James Reader, CEO of British event organizer Smarter Shows, said that he would now move the show to "the heart of Lower Saxony – a core location for the worldwide automotive industry, in the direct vicinity of companies like the world's biggest car producer Volkswagen, automotive supplier Continental, battery manufacturer Johnson Controls, vehicle system manufacturer Wabco and construction machinery manufacturer Komatsu Hanomag." There is no entrance fee for either event, but both require registration. Conference attendance, on the other hand, does have a cost, and subscribers to HZwei and H2-international can get a 10 percent discount on tickets. ||

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Collaborations Across Europe

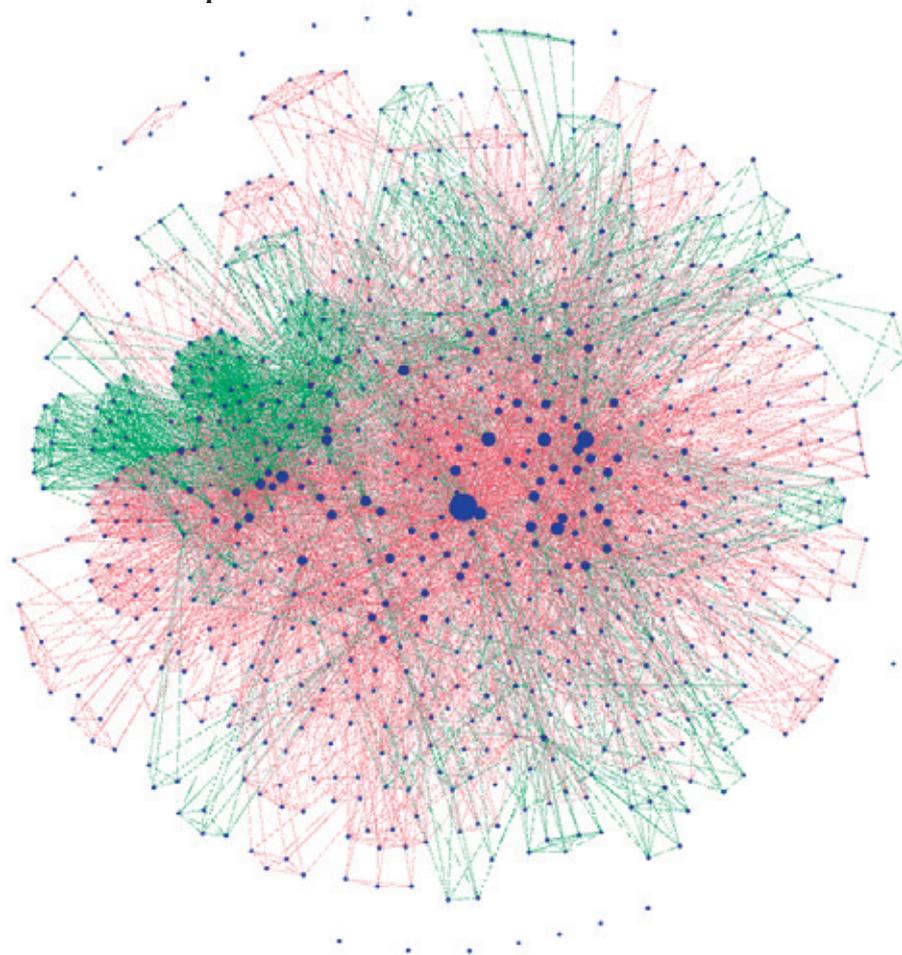


Fig. 1: Partnership network within EU projects: FP7 (red) and H2020 (green)

The European Commission publishes metadata about all funding approved as part of the 7th Framework Program (FP7) and Horizon 2020, with the latter still in effect to date. Analytical tools can be used to process and sift through this data to gain valuable information, for example, about the competitive environment. This article will show which organizations have entered into collaboration as part of European support programs and what their collaborative networks look like.

This analysis is based on data from 39,251 FP7 and H2020 projects, of which 238 or as little as 0.6 percent involved fuel cells to a greater degree. However, the small percentage is a result of including only those which received grant approval in the end. The number of applications was much higher.

Many of the fuel cell projects were or are a collaboration of more than two partners. Of course, an increase in the number of project partners means an increase in the amount of generated data. One method to create an easy-to-understand overview of this large bulk of information is utilization of a network diagram based on a forces model. Such a model gives more weight to stakeholders that collaborated with a greater number of organizations.

Since the H2020 program is still in effect and projects are added to it regularly, only metadata before June 1, 2017, was considered. Information was filtered by FCH (fuel cell hydrogen) and Fuel Cell to ensure the exclusion of projects which conduct basic research on catalysts or are concerned with battery development.

COMPETITIVE ANALYSIS Figure 1 clearly shows that FP7 focused primarily on one stakeholder and, at lower priority, on a few other organizations. The principal receiver of funds was the *French Alternative Energies and Atomic Energy Commission*, followed by the German Aerospace Center. It is not uncommon for R&D support programs to concentrate on research institutions. Both are collaborating or have collaborated with around 240 partners on 78 projects. They have also been the coordinating organization in about one-third of their projects, i.e., they shared in the success of project applications. In all, the number of institutions and companies involved in fuel cell and hydrogen R&D is greater than one would expect when reading the news. The total stood at 747, which suggests a broad range of expertise. The majority, however, was only part of one single EU project (see fig. 3). Even large companies had not initiated more than a handful each during the period analyzed in this article.

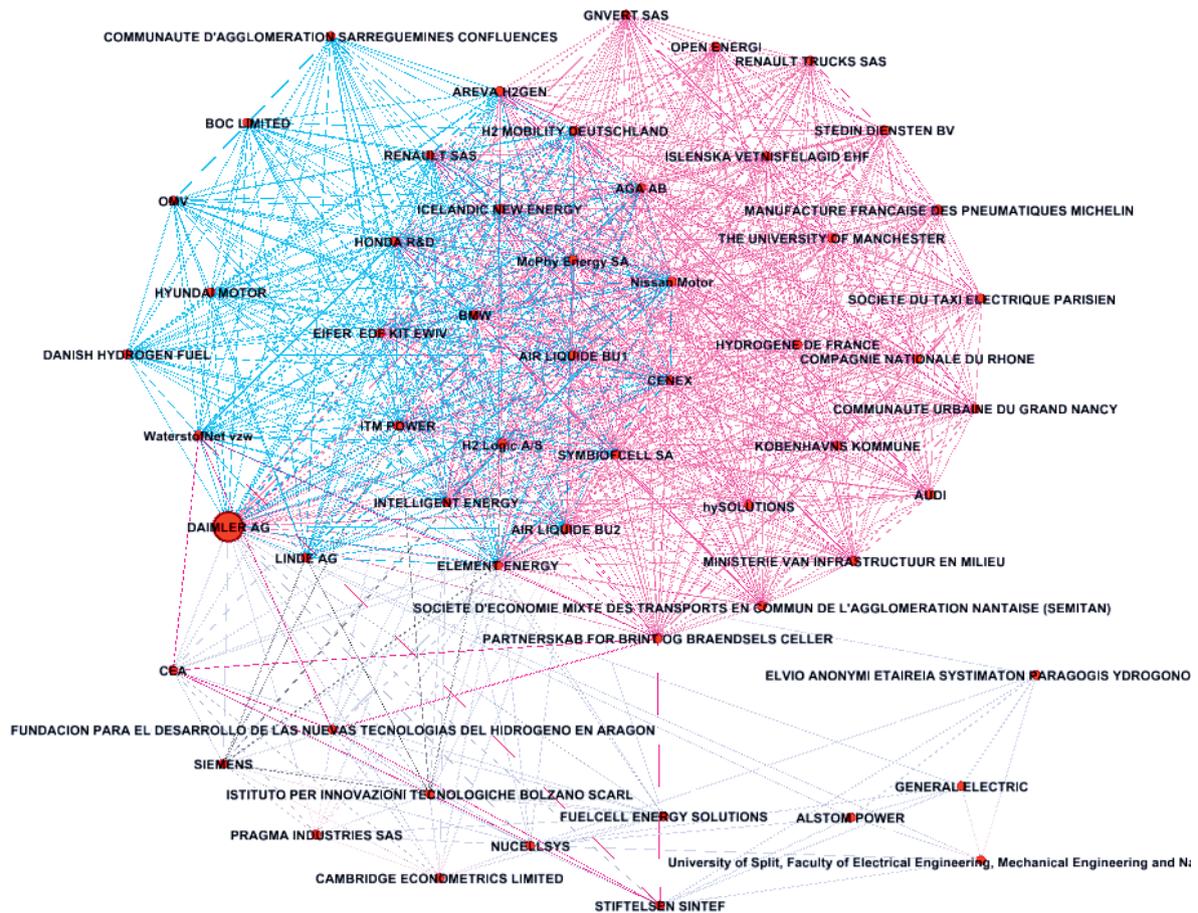


Fig. 2: Daimler’s FCH projects as part of H2020; colors highlight different types of projects

| Name | No. of Partners | Budget | max. EC-funding | to Daimler | Share in funds |
|-------------------------------|-----------------|---------------|-----------------|-------------|----------------|
| RobustSENSE | 15 | 8.663.008 € | 3.348.358 € | 335.222 € | 10% |
| DENSE | 16 | 14.530.980 € | 4.221.233 € | 1.078.194 € | 26% |
| ALLIANCE | 17 | 9.019.279 € | 7.981.773 € | 675.188 € | 8% |
| ECOCHAMPS | 28 | 28.419.785 € | 21.009.065 € | 1.712.983 € | 8% |
| OSEM-EV | 12 | 8.002.536 € | 8.002.536 € | 700.000 € | 9% |
| HDGAS | 19 | 27.801.978 € | 19.890.588 € | 1.057.359 € | 5% |
| PROSPECT | 18 | 6.931.979 € | 6.931.978 € | 660.375 € | 10% |
| AutoRE | 8 | 4.464.447 € | 3.496.947 € | | 0% |
| 3Ccar | 47 | 52.882.048 € | 17.389.083 € | 110.701 € | 1% |
| H2ME | 27 | 71.901.051 € | 32.000.000 € | 2.000.000 € | 6% |
| HY4ALL | 13 | 2.035.349 € | 1.998.339 € | | 0% |
| H2ME 2 | 37 | 106.223.891 € | 34.999.549 € | 3.300.000 € | 9% |
| PaREGEEn | 16 | 12.060.599 € | 9.952.013 € | 1.909.211 € | 19% |
| | | | | Total funds | 13.539.233 € |
| ... of which for FCH projects | | | | 5.300.000 € | 39% |

Table 1: Daimler’s H2020 projects (all amounts in EUR)

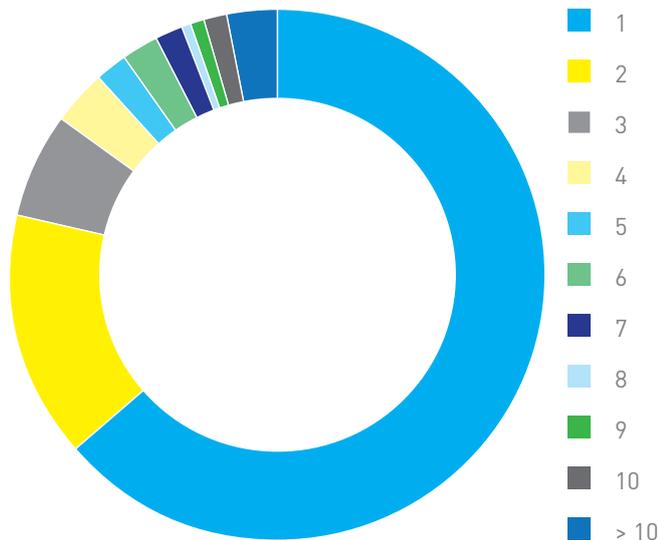


Fig. 2: No. of projects for each partner

Germany’s research institutions have lived up to expectations. They are leading in the field of R&D support and have established a broad network of contacts. But the degree of involvement at EU level depends on the individual organization (see table 2).

EXAMPLE: DAIMLER Daimler is the automaker with the highest rate of participation in the EU’s R&D support programs. Only Linde shows a greater number of projects among all German businesses that were part of the analysis.

Taking a closer look at individual organizations will help to identify their project partners. Even corporations as large as Daimler tend to be involved in no more than a few EU projects, so that graphic representation can be simplified, for example, through the display of FCH projects and H2020 partners only (see fig. 2).

Within FP7, Daimler was part of 35 projects, of which five were FCH-related. The carmaker is also participating in the H2020 ventures shown in table 3. For the first three of these, it is also the coordinating organization. The four highlighted ones among the 13 in total are FCH-focused. Daimler’s collaborations often involve a comparatively high number of other organizations.

| Name | FP7 | H2020 | Total |
|-------------|-----|-------|-------|
| DLR | 22 | 5 | 27 |
| Fraunhofer | 14 | 5 | 19 |
| FZ Jülich | 10 | 6 | 16 |
| Next Energy | 5 | 1 | 6 |
| ZBT | 4 | 1 | 5 |
| ZSW | 8 | | 8 |
| Overall | 63 | 18 | 81 |

Table 2: FCH projects of selected research institutions

| Name | FP7 | H2020 | Total |
|------------|-----|-------|-------|
| Linde | 8 | 2 | 10 |
| Daimler | 5 | 4 | 9 |
| BMW | 2 | 4 | 6 |
| Siemens | | 3 | 3 |
| Volkswagen | 3 | | 3 |
| Bosch | 1 | 2 | 3 |
| Audi | | 1 | 1 |
| Overall | 19 | 16 | 35 |

Table 3: FCH projects of selected industrial companies

From the EUR 13.5 million in subsidies allocated to Daimler across all projects, 39 percent has been invested in two FCH endeavors called Hydrogen Mobility Europe 1 and 2. Considering the automaker’s planned 2017 to 2018 R&D budget of more than EUR 8 billion, it seems unlikely that money is the driver of its participation at EU level. However, being part of these projects will enable users, i.e., potential customers for future vehicle generations, to test out the technology.

CONCLUSION An analysis of EU projects provides an important contribution to painting a clearer picture of the market’s competitive environment. The fuel cell and hydrogen community in Europe shows a high degree of networking activity. Especially when it comes to large projects, organizations one would expect to be competitors on the market are collaborating closely to advance the technology. ||



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Theme: Research & Development | Author: Sven Geitmann |

EZELLERON PARTNERS WITH INFINITI

Buyers of “kraftwerk” fuel cell chargers may have to wait a little longer still. The manufacturer of the devices, eZelleron, cited an ongoing legal dispute about trademark rights and intellectual property as the reason for having to postpone shipments even further. Sascha Kühn, CEO of eZelleron, told H2-international that he would like to provide more details on the situation, but the charges which Kraftwerk, an electronic music band, had brought against the company just 5 days after its crowdfunding campaign ended (see July 2015 issue of H2-international) prevented him from making any com-

ment at all. And eZelleron put out a statement saying, “We are required by law to remove the project from the public’s view until the dispute has been settled.” The decision did not impact any of the orders placed or payments made, it added, as the crowdfunding venture had been successfully completed.

At the same time, the company has been trying to get a foothold in the automotive industry. In late 2016, eZelleron partnered with Infiniti, Nissan’s luxury brand. Kühn said that the objective of the partnership was to develop a new electric car engine. ||

Theme: Research & Development | Author: Sven Geitmann |

NEW BUSINESS-INSTITUTION CO-OP FOR INTRALOGISTICS



NOW has established a new organization to support the fuel cell industry in Germany. Wolfgang Axthammer (see photo), one of the company’s two managing directors and head of its Special Markets program, confirmed that the first general meeting of the Clean Intralogistics Net, a network of fuel cell businesses and institutions that deal with the logistics side of the industry, took place on May 30, 2017, in Berlin. The network is the first “innovation cluster” based on NIP 2. The spokesperson for the new group is Hannes Schöbel from Linde Material Handling, with Franz Geyer from carmaker BMW serving as deputy. The group’s other business members are Air Liquide Advanced Technologies, Bosch Engineering, Daimler, ElringKlinger, Fronius Deutschland, Heraeus Fuel Cells and Jungheinrich.

The Clean Intralogistics Net, or CIN for short, was introduced on Nov. 3 last year, at an international workshop focused on industrial fuel cell trucks and organized in partnership with the German association of machinery and equipment suppliers. Another workshop on the same subject, titled “Status quo and Outlook,” took place in Stuttgart on Sept. 27 of this year. The emphasis on industrial trucks makes sense, since efficient fuel cells could cut these trucks’ CO₂ emissions by at least 25 percent, up productivity and lead to significantly reduced charging times and less of a need for warehouse space.

Axthammer added, “CIN concentrates on hydrogen and industrial fuel cell trucks for intralogistics [forklifts, tugs and materials handling equipment]. This will require cooperation between fuel cell producers, industrial truck and tug

manufacturers, gas suppliers and logistics businesses. We have all that planned out already.” In a press release, NOW said that to “tap the potential of Europe’s mass market for vehicles in materials handling, experts believe that we will need around 1,000 industrial trucks at a minimum of 20 locations by 2025. The industry foresees Europe-wide sales of 20,000 units per year from then onward.” ||

→ www.cleanintralogistics.net



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HYDROGEN FROM HEAT

Pyroelectric Materials for Energy Conversion

The conversion of waste heat into electrical energy could very well make an important contribution to CO₂ and GHG emissions reduction and improve energy efficiency. A typical process chain will be based on a thermodynamic cycle, such as organic Rankine, a Stirling engine or a thermoelectric generator. A relatively new method uses pyroelectricity to advance both water electrolysis and power generation. This property of some materials has yet to attract much attention or research. However, considering global efforts to transform the energy market, its importance may grow over time.

Pyroelectricity is a physical property of crystal structures that possess a permanent electric dipole moment. Well-known examples of such materials include barium titanate (BaTiO₃), lithium niobate (LiNbO₃) and the polymer polyvinylidene fluoride (PVDF). A gradual change in temperature – for example, through adding waste heat – will cause positive and negative charges to migrate to opposite ends of the material and establish an electric potential. This potential can be measured by devices such as infrared thermostats, i.e., contactless temperature probes, or motion sensors, i.e., passive infrared sensors that detect heat emitted by objects and people.

HOW IT WORKS A research team led by Tilmann Leisegang and Hartmut Stöcker from the Institute of Experimental Physics at TU Bergakademie Freiberg has developed a demonstration system that operates based on the above-mentioned phenomenon and can create hydrogen through pyroelectric means. It was first shown to the public at Hannover Messe last year (see fig. 1). The system, which was designed and built over the course of several research projects, uses barium titanate powder and low-temperature waste heat to split water into hydrogen and oxygen. First, externally supplied waste heat is led through a heat exchange into a secondary loop. Then, the water circulating in this loop is directed through a reactor containing the pyroelectric material.

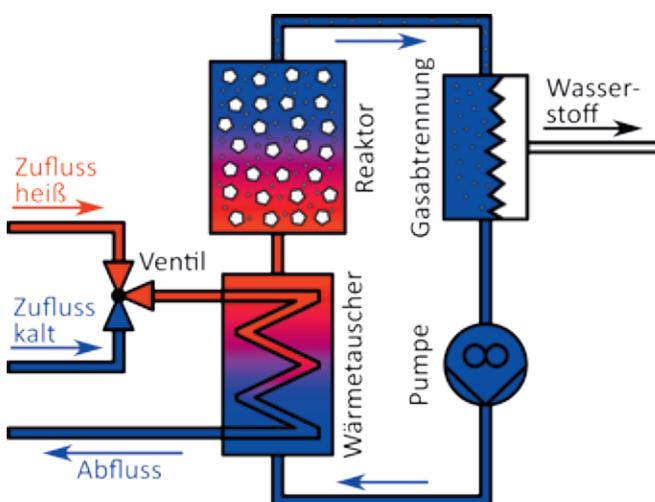


Fig. 2: Process diagram [1]



Fig. 1: Demonstration system to produce hydrogen based on pyroelectric materials

The heating and cooling cycle causes a reaction in the water molecules on the surface of the pyroelectric material, splitting them into oxygen and hydrogen. A subsequent membrane separates the products of the split before they are stored away. This means that the pyroelectric effect makes it possible to convert previously unused waste heat into electrical and chemical energy. In turn, the hydrogen produced by the process can later be utilized in a variety of energy supply scenarios, for example, in hydrocarbon conversion or fuel cell power generation.

The system can be deployed where waste heat is available at below 120 °C; but even much higher temperatures, as typical of many industrial processes, can be accommodated with little difficulty. Agencies and institutions from the energy sector estimate that more than 72 percent of the global heat input in industrial processes dissipates into the atmosphere. This adds up to 246 exajoules or 68 petawatt-hours, three times Europe's primary energy consumption. Sixty-three percent of it is generated by applications requiring less than 100 °C, meaning 45 percent of the world total is lost as low-temperature waste heat to the environment. Often, there are no suitable or efficient conversion methods to recover the heat.

ALTERNATIVE TO KNOWN METHODS Methods to convert waste heat into electrical energy have been around for dec-

ades. One example is Ormat's Rankine cycle, which uses organic heat transfer fluids instead of water. The advantage is that heat is transferred at temperatures lower than that of a water-steam cycle, which allows for lower temperatures throughout the entire process.

Compared to two-phase flow units that need to condense and evaporate fluids – from gas to liquid and vice versa – solid-state energy conversion systems have great appeal because of their simple and low-maintenance design. Thermoelectric materials operate based on the Seebeck effect, in which a usable electric potential is created by the generation of a temperature gradient in the solid. One company developing industrial-scale thermoelectric generators for waste heat use is Alphabet Energy.

A related method is power generation by thermogalvanic cells through a temperature gradient in an electrochemical unit, similar to a battery. The conversion efficiency of the organic Rankine cycle is, in theory at least, the Carnot efficiency, whereas that of thermoelectric and especially thermogalvanic generators is significantly lower.

OTHER USES Pyroelectric materials can also be employed to convert heat into electricity. The electrical cycles that have been developed to create energy-efficient process chains [2] are akin to thermal ones, but are based on solid connections in which electrons are rearranged to create polarizations and thus energy. The process requires periodic changing of the temperature and polarization, for which several designs are available. The generated electrical energy can be stored or used to generate hydrogen [3].

The pyroelectric material surface is suitable for electrolysis to directly produce hydrogen. A lack of electrodes and electrical circuits will lead to a significant reduction in technical complexity and the opportunity to use a greater amount of active material in the same space within the device. As shown in figure 3, direct surface contact will mean that hydrogen and oxygen are split from water on opposite sides of the material [4], which might be powder immobilized on a filter or sponge. The dependency of the attainable output on feed-in temperature is currently being explored.

Using waste heat to produce hydrogen is certain to significantly improve the energy efficiency of existing equipment. The Institute of Experimental Physics at TU Bergakademie Freiberg is cooperating with the Fraunhofer Technology Center for Semiconductor Materials, Kurt Schwabe Research Institute in Meinsberg, Freiberg Research Institute of Leather and Plastic Sheeting and GE Global Research on several projects to explore how today's considerable amounts of lost low-temperature heat can be sensibly directed back into the economy [5]. Starting in 2020, their efforts will be supported by the Center for Efficient High Temperature Substance Conversion, or ZeHS for short [6], and its director, Professor Dirk C. Meyer. The focus of ZeHS' research activities has been the catalyst effect of pyroelectric materials, while its overall objective is to develop resource- and energy-efficient technologies for the basic materials sector. ||

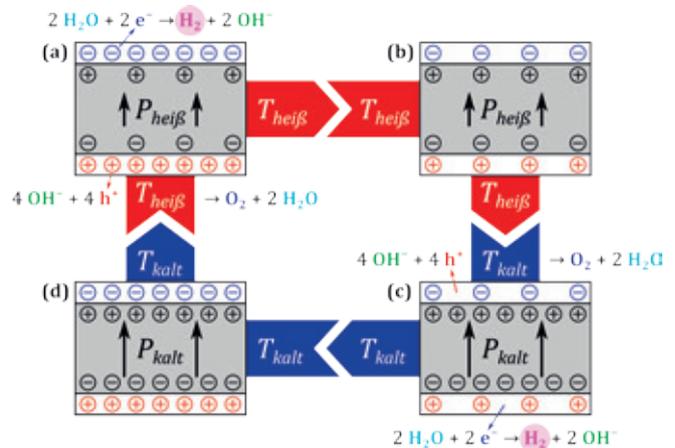


Fig. 3: Pyroelectrocatalytic cycle for water splitting. The partial reactions of water electrolysis can be observed on the surface of the pyroelectric crystal in accordance with a temperature change, as shown in figures a and c. At constant temperature, as in figures b and d, the reaction stops until the temperature changes again [4].

REFERENCE(S)

- [1] T. Leisegang, D. C. Meyer et al., Vorrichtung und Verfahren zur Energie- und Stoffwandlung mittels pyroelektrischer Materialien zur Herstellung von Spaltprodukten, German patent application no. DE102014003815A1
- [2] R. B. Olsen, D. A. Bruno, J. M. Briscoe, Pyroelectric conversion cycles, *Journal of Applied Physics* 58 (1985) 4709–4716, DOI: 10.1063/1.336244
- [3] M. Xie, S. Dunn, E. Le Boulbar, C. R. Bowen, Pyroelectric energy harvesting for water splitting, *International Journal of Hydrogen Energy* (2017), DOI: 10.1016/j.ijhydene.2017.02.086
- [4] E. Gutmann, A. Benke et al., Pyroelectrocatalytic Disinfection Using the Pyroelectric Effect of Nano- and Microcrystalline LiNbO_3 and LiTaO_3 Particles, *Journal of Physical Chemistry C* 116 (2012) 5383–5393, DOI: 10.1021/jp210686m
- [5] <http://blogs.hrz.tu-freiberg.de/pyro>
- [6] www.zehs-freiberg.de/index_en.html

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DURABLE H₂ SENSORS



Source: STW

The increase in fuel cell applications makes detecting hydrogen and identifying related physical properties an ever more important task. Wiedemann, a German supplier of sensor equipment, has now made its *M01 pressure transducer range* hydrogen-resistant. *Customers can choose between 20 pressure ports, 10 electrical connectors and 9 electrical connections to assemble their own probe for measuring hydrogen pressures from 3.5 bars to 900 bars.* Many variants of the modular M01 product offering, which is designed for high-volume production, are also available in small batch sizes. The components deliver accurate and stable measurements and have been designed with overpressure, hydrogen embrittlement and permeation protection in mind. ||

SELF-LUBRICATING AND LOW MAINTENANCE



Source: Haskel

Haskel, an American supplier of pressure systems, is offering a new hydraulic booster for gas-tight, non-contaminating compression. The company has said that the unit called H-Drive (see image) guaranteed the highest quality and reliability. It has a low-maintenance, self-lubricating seal design and was developed for several applications, including gas boosting for H₂ high-pressure vessels at refueling stations. It was unveiled at Hannover Messe last year and customers have been able to place orders for it since spring 2017. ||

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ULTRASONIC LOW FLOWRATE METERING



Source: Celeroton

Some fuel cells require only a relatively low amount of different fluids. With an eye on small and micro-amounts, Bronkhorst High-Tech, a Dutch manufacturer of measurement and control equipment, has developed ES-FLOW™. Thanks to new ultrasonic wave technology, this volumetric flow meter offers high accuracy, short response times and reliable operation irrespective of the transfer fluid used. Measurements are based on the Coriolis method, which means that the device delivers highly precise figures for flow rates between 4 milliliters per minute and 1,500 in small-diameter pipes at high linearity and little pressure loss. Metering results will not be impacted by liquid density, temperature or viscosity. Bronkhorst's list of typical applications includes monitoring catalysts and reagents in the chemical industry as well as fuel consumption measurements and dosing in industrial settings. ||

GAS-SUPPORTED TURBO COMPRESSOR



Source: Bronkhorst

Celeroton from Volketswil, Switzerland, has unveiled a new gas-supported turbo compressor labelled CT-17-700.GB. The unit does not require lubricants because of its gas bearings and has a nominal speed of 280,000 rpm. It is relatively small and lightweight but efficient, which makes it particularly suited for air intake in fuel cell systems. It was presented for the first time at Hannover Messe, where the company had its own booth this year at ComVac, the leading international show on compressed air and vacuum technology. Cornel Bartholet from Celeroton told H2-international that “integrating the compressor into a fuel cell system can [at 50 percent fuel cell and 70 percent electrolysis efficiency] save 3,600 kilowatt-hours during 3,000 hours in operation.” Celeroton’s turbo compressor range offers solutions for air pressure differentials between 100 millibars and 700 millibars, mass flow rates from 1 gram per second to 55 grams and volumetric flow rates from 50 standard liters per minute to 2,500. The units can be operated with several fluids and under different inlet conditions. ||



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MEMBRANES AND SEPARATORS

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functional membranes for fuel cells
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Fax -999, www.fumatech.com**PLANSEE**Plansee SE, Bipolar Plates,
Interconnects and Metal
Supported Cells, 6600 Reutte,
Austria, Phone +43-(0)5672-600-2422, www.plansee.com

ORGANIZATIONS

DWV
Deutscher Wasserstoff- und
Brennstoffzellen-VerbandGerman Hydrogen and Fuel Cell
Association, Deutscher Wasserstoff-
und Brennstoffzellen-Verband e.V.
(DWV), Moltkestr. 42,
12203 Berlin, Germany,
Phone +49-(0)30-398209946-0, Fax -9, www.dwv-info.de**NOW**
Nationale Organisation Wasserstoff-
und BrennstoffzellentechnologieNational Organisation Hydrogen and Fuel Cell Techno-
logy (NOW GmbH) Fasanenstr. 5, 10623 Berlin, Germany,
Phone +49-(0)30-3116116-15, Fax -99, www.now-gmbh.dehySOLUTIONS GmbH, Steinstrasse 25, 20095 Hamburg,
Germany, Phone +49-(0)40-3288353-2, Fax -8,
hysolutions-hamburg.de

REFORMERS

WS Reformer GmbH, Dornierstraße 14, 71272 Renningen,
Germany, Phone +49-(0)7159-163242, Fax -2738,
www.wsreformer.com

RESEARCH & DEVELOPMENT

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ISEFraunhofer ISE, Heidenhofstrasse 2, 79110 Freiburg, Germa-
ny, Phone +49-(0)761- 4588-5208, Fax -9202, www.h2-ise.de

SUPPLIERS

Anleg GmbH, Advanced Technology, Am Schornacker 59, 46485 Wesel, Germany, Phone +49-(0)281-206526-0, Fax -29, www.anleg-gmbh.de



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



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

Pajarito Powder, LLC, 3600 Osuna Road NE, Suite 309, Albuquerque, NM 87109-4427, USA, Phone +1-505-2-935367, Fax -448040, www.pajaritopowder.com



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

SYSTEM INTEGRATION



Areva GmbH, Paul-Gossen-Str. 100, 91052 Erlangen, Germany, Contact: Mrs. Gemmer-Berkbilek, Phone +49-(0)9131-90095221, www.areva.de



Deutsches Zentrum für Luft- und Raumfahrt (DLR) / German Aerospace Center Institute of Engineering Thermodynamics Energy System Integration, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany, Phone +49-(0)711-6862-672, Fax -747, www.dlr.de/tt

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