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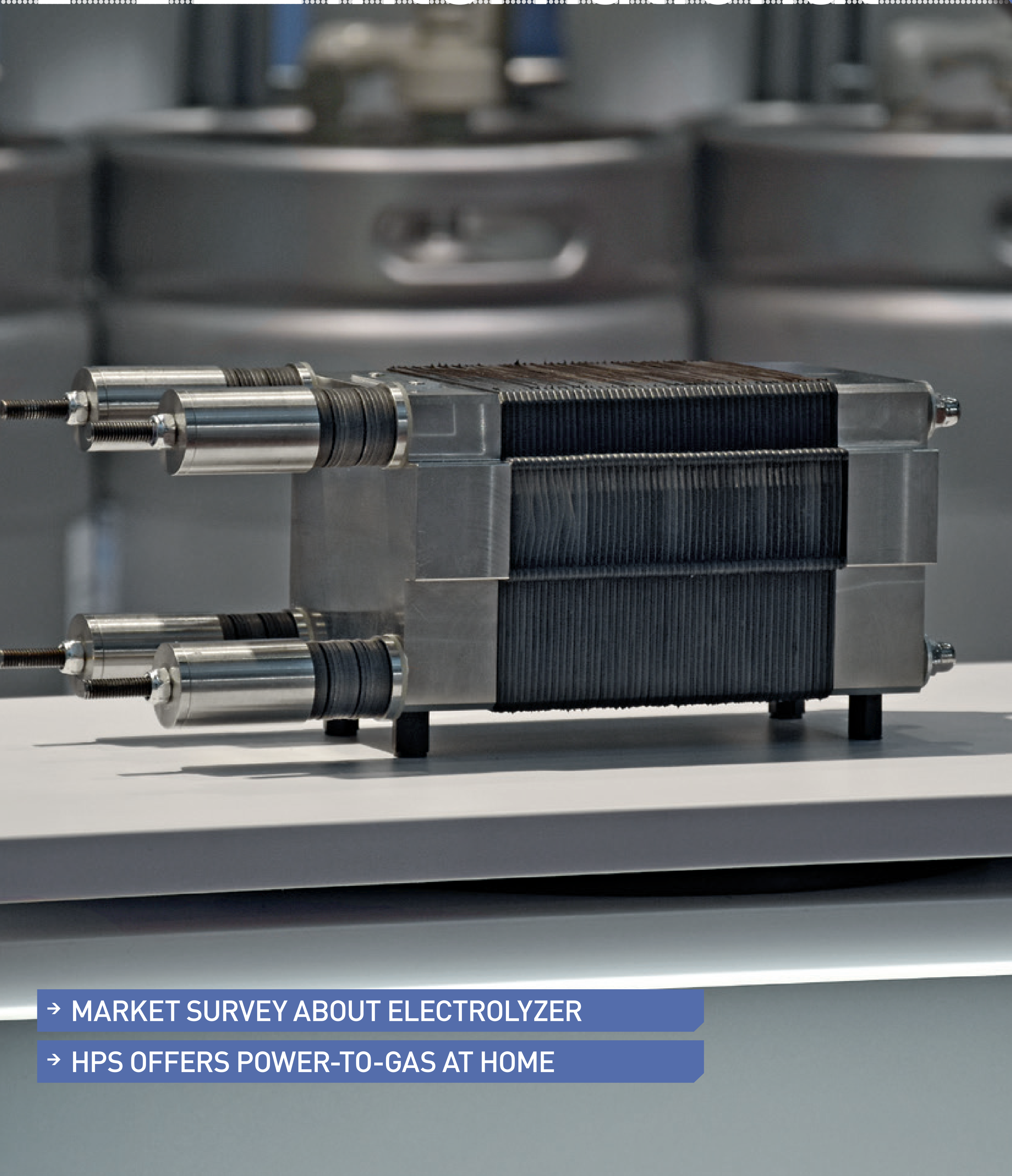
THE E-JOURNAL ON HYDROGEN AND FUEL CELLS

SPECIAL EDITION FOR HYDROGEN + FUEL CELLS NORTH AMERICA



→ MARKET SURVEY ABOUT ELECTROLYZER

→ HPS OFFERS POWER-TO-GAS AT HOME

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Source: HPS

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Cover image Electrolyzer Stack from H-Tec Systems

DWV GETS NEW FOCUS

This year's general meeting of the German Hydrogen and Fuel Cell Association, or DWV for short, took place in Erlangen, Germany, on May 12, 2017. Since there were no board elections to be held, the main issue was the association's new focus. But even an arguably debate-worthy point such as this one was not met with great enthusiasm by DWV members. Werner Diwald, chair of DWV, outlined management's ideas of establishing new expert committees (besides performing energy) or an internal group to further professionalize the association. Many of the members in attendance, however, did not seem too intent on thoroughly exploring the issues or providing their own suggestions.

One of the people who spoke before members at the meeting was Stefan Müller, parliamentary state secretary at the federal education ministry. Müller, an incumbent Erlangen councilman who has announced to run again in this year's general election in Germany, presented the DWV Innovation Award for the most outstanding master's thesis to Melanie Miller, whose research at the Technical University of Munich focused on reducing the amount of catalyst materials used in PEM electrolyzers (her report will be published in the October issue of h2-international). Jan Michalski received the award for the best dissertation. He too had researched at TU Munich: In partnership with Ludwig-Bölkow-Systemtechnik, Michalski examined the role that energy storage could play in integrating renewables into the German energy market. ||

NEW DWV PUBLICATION
Just in time for the meeting, the DWV published its revised and updated report on "Hydrogen and Fuel Cells as Strong Partners of Renewable Energy Systems." The 32-page document was created jointly with Ludwig-Bölkow-Systemtechnik and is available for free at the DWV.

Fig. 1: DWV members on a tour of Areva's facilities

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VDMA FORECASTS GROWTH

Every two years during Hannover Messe, the Fuel Cells working group of the VDMA, the German association of machinery and equipment suppliers, presents its economic outlook for the fuel cell industry at the joint booth Hydrogen + Fuel Cells + Batteries.

Table: Fuel cell industry revenue in euros (in millions)

2013	2014	2015	2016	2017
50	70	75	100	190

Source: VDMA AG Brennstoffzellen

The working group surveyed its 54 members and aggregated the data from 36 sufficiently filled-out responses to arrive at key economic indicators. "2014 didn't go so well," Johannes Schiel, formerly managing director of the group (until early May 2017; see August 2017 issue of H2-international) pointed out at that time. Even in 2015, the market rather showed a sideways movement. But now, Schiel spoke of "rapid growth." The working group's members expect revenue from fuel cell production for stationary systems and customized solutions in Germany to add up to EUR 190 million in 2017 (see table). Their assumptions are based on continuing efforts to cut costs and the first effects of economies of scale to materialize, supported by the introduction of residential fuel cell systems to the German market. In 2016, the industry sold around 1,000 fuel cell heaters, more than in the previous five years combined. In 2017, manufacturers expect more than three times as many units to be sold.

Regarding the job situation, VDMA said that job figures showed a moderate increase to 1,600 in the industry segments surveyed, up from around 1,300 the year prior. An earlier version of the business report read that there had already been around 1,900 people working in these segments of the fuel cell market in 2015. Asked about the difference in numbers, the new head of the working group, Gerd Krieger (see August 2017 issue of H2-international), said that this was due to the back and forth in the industry with respect to the "bankruptcy of Heliocentris and Vaillant's exit, both of which strongly influenced job figures."

Regarding global competition, the VDMA report said: "In terms of market volume, however, […] Europe is still far behind North America with the USA and Canada as well as Asia with Japan and Korea." ||

To create the outlook, the authors of the study added a substantial margin to the numbers given by survey respondents.

Subject: Residential Market | **Author:** Sven Geitmann

POWER-TO-GAS AT HOME

HPS to Make Homeowners Energy Self-Sufficient

It's not the first time someone has tried to use hydrogen storage for making homes energy self-sufficient. The latest company to make the attempt is Home Power Solutions, based in Berlin, Germany. When HPS unveiled its Picea unit in March at the ISH in Frankfurt am Main, the press seemed to be all over it. This may have had something to do with HPS' former parent company, Heliocentris, having filed for bankruptcy shortly before the trade show. H2-international sat down for an interview with the managing directors of HPS during Hannover Messe to talk about the company's history and new developments.

Fig. 1: Picea unit at Hannover Messe

The HPS booth at Hanover's industrial trade show was comparatively small and did not really stand out either. Had it not been set up directly on the main path through hall 27, it would have hardly been noticed. The Picea unit alone is somewhat of an eye-catcher, although it's a large gray box that doesn't have a very distinct look (see fig. 1).

FROM HELIOCENTRIS' ASHES When speaking to Home Power Solutions' two founders and managing directors, Henrik Colell and Zeyad Abul-Ella, and the company's PR consultant, I pretty quickly realized that Heliocentris was far from being a topic they wanted to talk about, though it had to come up at some point. HPS was founded in December 2014 as an independent business with a staff of four, but Colell had likewise been founder and CTO of Heliocentris Energy Solutions until early 2017, while Abul-Ella worked there from October 2012 through December 2014. Zeyad Abul-Ella is also the brother of Ayad Abul-Ella, formerly managing director of Heliocentris Energy Solutions, which went bankrupt last December 2016 – as did Heliocentris Industry, Fuel Cell Solutions, and Academia (see May 2017 issue of H2-international). On top of that, Ayad Abul-Ella is one of the members of HPS' supervisory board, together with Hans-Peter Villis, formerly CEO of EnBW and Paul Grunow, board chair of the Reiner Lemoine Foundation, both investors in HPS.

All the founders would say when asked about the timing of events – bankruptcy proceedings underway when Picea was unveiled – was that it had been a pure coincidence. HPS had always been entirely independent of Heliocentris and had no more contact with the bankrupt business. Abul-Ella said: "HPS has a business plan and a roadmap. The roadmap shows that we had always envisioned a launch no earlier than 2017." Meanwhile, HPS had grown to 30 employees, 10 of which had been taken over from Heliocentris, Colell and Abul-Ella said. "No assets" had been acquired "either before or during bankruptcy proceedings."

NEW TECHNOLOGY FOR A DO-OVER During our conversation, it was especially Colell who seemed to envision a new beginning. The clear intention was to zero in on the future. What he was most concerned with was to offer the "perfect solution for energy self-sufficiency."

Picea was "a compact unit combining energy storage, added heating and room ventilation […] at an average output of up to 8 kilowatts and a peak one of up to 20." The aim of HPS was to give homeowners "true independence from the grid," they said.

The system relies on an on-site PV system to meet immediate and later power needs (3,000 to 6,000 kilowatt-hours per year based on a PV unit with 10 kilowatts of peak output) entirely through renewables. The design can be used off grid and in virtual networks, where surplus energy could be sold on the power exchange.

EFFICIENT THROUGH AND THROUGH The solar power is being transferred either directly to the consumer or to the battery or electrolyzer. To store any excess energy, HPS primarily employs heavy, but inexpensive sealed led acid batteries (25 kilowatt-hours). Once they're at full capacity, the 2.5-kilowatt electrolyzer will use the renewably sourced power to produce hydrogen and store it in 300-bar pressure vessels (tube bundle with 1,000 kilowatt-hours on 5 m2 or 54 square feet). The thermal energy released during storage remains in the system.

Similarly, the 1.5-kilowatt low-temperature fuel cell will provide electrical energy when there's demand – meaning the sun doesn't shine and the battery is empty – and releases heat during the process. In winter, this thermal energy is transferred directly to the 45-kilowatt-hour hot water boiler through the installed ventilation unit, increasing overall efficiency to around 90 percent, a comparatively high value, although the fuel cell will "only" be at 55 to 60 percent. Still, the system would not just cut the next electricity bill down to zero, but lower heating costs too, the managing directors said.

Colell and Abul-Ella stressed that the "energy management application was developed in-house" and was a core competency of HPS. Second after second, the software tool received more than 500 input variables (e.g., weather info), meaning it could simulate and manage every building supply scenario imaginable.

The crucial aspects were Picea's electricity-based operation independent of the building envelope and no interface to an existing heater, so it could be used both with passive house designs and in old building stock, as heat supply came first and Picea could respond to demand accordingly. The system was controlled through an app that was specifically developed for this unit and showed current system values at any time.

INTRINSICALLY MOTIVATED By its own account, safety is important to HPS: The prototype in Berlin was TÜV-approved. A handful of field test units are said to come online at several locations in Germany this year. The sale of devices will reportedly start as early as this year; delivery is scheduled for 2018. The price tag would be in the mid-five figures, Abul-Ella said.

All in all, the design may still be relatively complex and costly, but both managing directors were confident that the eco-power industry had a sufficiently large customer base interested in off-grid solutions. "The first few trade shows have created quite a promising outlook," Abul-Ella said. He also stressed that he was "intrinsically motivated" and fully believed in the feasibility of the HPS unit. A study published by Stiebel Eltron, a building services supplier, in early May seems to prove him right. In the chapter on trends in the energy industry, the authors conclude that "59 percent of Germans intend to use smart home systems to utilize as much renewable energy in their consumer-side energy transformation as they can." Their conclusion: "The boiler room of the future is thought to provide the same intuitive user experience as smartphones do today." ||

Subject: Residential Market | **Author:** Sven Geitmann

BLUE HAMSTER BACK TO LIFE

Frank Duhlies, formerly managing director of Mossau Energy based in Aurich, Germany, has already had hands-on experience with small solar-hydrogen units based on his involvement in the design of *Blue Hamster,* a blue-color hydrogen generator Mossau unveiled at Hannover Messe in 2013 (see July 2013 issue of HZwei). A demonstration system with a 100-kilowatt solar unit, a 41-kilowatt-hour battery, a 2.3-kilowatt electrolyzer, a 20-cubic-meter H_2 pressure vessel and a 2.5-kilowatt fuel cell went online in 2014 at Klar Folien in Dernbach. Mossau, however, had to close down in late 2015 (see May 2016 issue of H2-international), since the then-81-year-old founder, Günter Mossau, had not found a successor or investor to take over the business. Now, Duhlies and Hilmer Heineke are in the process of setting up their own company, H5 Energy, in Oldenburg to try and reanimate Blue Hamster.

Duhlies told H2-international that the Klar Folien system, which had never been intended to run only for a short testing period, was still in regular operation. He also explained that system design was being reworked and the unit would have added functions soon, for example, its own energy manager, a weather app and a notification system for maintenance intervals. Additionally, it would be certified as a UPS unit. Designed as a stand-alone system guaranteeing full control over heat and power generation, it could also be used as a hydrogen refueling station, an electric car charging point or as one of the components of a decentralized energy cluster. The system could already be ordered, Duhlies said, although it would be delivered no earlier than this fall. The base price would be in the five digits and would increase depending on the additional equipment bought. ||

Subject: News | **Author:** Sven Geitmann

FORSTMEIER JOINS BVES

Markus Forstmeier

Markus Forstmeier, VP business development at Bavarian-based Electrochaea, has joined the board of the German Energy Storage Association, or BVES for short. During the general meeting in March 2017, Forstmeier was elected to the association's executive board. ||

Subject: Energy Storage | **Author:** Sven Geitmann

TARGET: 100 MEGAWATTS

Sequel to Our First Electrolyzer Overview

This year's June issue came with a detailed description of the electrolyzer market and in-depth reports on manufacturers and their products. But of course, the list wasn't exhaustive, as numerous businesses have entered the segment and much had to be left unsaid. Many of those suppliers exhibited at Hannover Messe, showcasing their latest developments. Considering the great interest in our previous article on the technology, we thought to create a summary of the most recent electrolyzer news for our readers, a sequel if you will.

Demand and supply on the electrolyzer market are growing. Not only is the number of manufacturers increasing, but the capacity range of the devices is rising as well. One example is HydrogenPro, a Norwegian-based manufacturer founded only four years ago. It used Hannover Messe to unveil a large-scale design based on alkaline electrolysis. This system would reportedly provide 800 normal cubic meters of hydrogen per hour at 30 bars of outlet pressure and require 4.4 kilowatt-hours per normal cubic meter, a comparatively low number for an installation of that size (see also electrolyzer overview in June 2017 issue).

Hans Jörg Fell, CTO of HydrogenPro since early 2017, said that the "world's largest electrolyzer" made it possible to produce even 1,000 normal cubic meters an hour. The benefits of such a large installation were a comparatively high efficiency at relatively low cost. Production was around 20 percent less expensive than with PEM electrolysis, and system costs added up to around USD 2 million, depending on the precise configuration – half as much as for installing a same-sized PEM unit.

Fig. 1: French 1-megawatt stack

HydrogenPro is being supplied by Tianjin Mainland Hydrogen Equipment, a Chinese-based manufacturer of high-pressure electrolyzers. THE has installed more than 300 units to date. Another important partner is Mitsubishi Hitachi Power Systems Europe, which specializes in methanol synthesis. This process uses carbon dioxide and hydrogen to produce several types of fuel (power-to-fuel).

GLOBAL PLAYERS With GreenHydrogen, founded in 2007 in Denmark, there was yet another Hannover Messe exhibitor hailing from northern Europe. Its first-ever H_2 installation had been for a small railroad operation on the island of Samso. Today, the A series of its HyProvideTM units, developed in cooperation with Siemens, produces 20, 40 or 60 normal cubic meters of hydrogen per hour at a pressure of more than 30 bars, with hydrogen purity at 99.998 percent by volume. If combined, these alkaline units are said to have a capacity of up to 1,200 normal cubic meters per hour (5 megawatts). GreenHydrogen's CEO, Niels-Arne Baden, told H2-international: "One main and exceedingly crucial aspect of the design was the development of highly efficient and durable platinized electrodes that offer very high current densities. During high-voltage and accelerated life tests, Siemens did not detect any degradation under an electron microscope even after the 10,000-hour milestone." He added: "HyProvide will be offered on the market in early 2018."

Areva H_2Gen exhibited a 60-megawatt design based on a 10-megawatt module and a 2-megawatt stack. These specifications confirmed that Areva, whose systems come from a factory owned by its French parent company and located near Paris, was primarily interested in big systems producing large amounts of H_2 – particularly at refueling stations for buses.

Meanwhile, Giner is gradually turning away from stack-only manufacture toward system integration. Before this year's Hannover Messe, it announced in April 2017 that it would create a spin-off called Giner ELX specializing in large hydrogen generators (5-megawatt modules) for renewable storage and other industrial uses. So far, Giner stacks have been utilized in projects in the United States, India, Spain, France and at carmaker Audi in Germany.

Giner's CEO, Andy Belt, explained: "The formation of Giner ELX builds on Giner's successful commercial PEM electrolysis business. We are focusing the ELX team on developing the lowest cost and highest performance grid-level energy storage solutions on the market." Hector Maza, VP business development at Giner, said that his company would be able to offer hydrogen at USD 4 per kilogram by 2020; the relevant agreement with the DOE had already been concluded. He also explained that Giner products had already

Fig. 2: Container solution with 2-megawatt PEM unit

Fig. 3: Bernd Pitschak unveils a 3-megawatt stack

achieved 350 bars of pressure directly in the electrolyzer and that the company was seeking to up compression to 900. In Hanover, the exhibit included the prototype of a 5-megawatt PEM electrolysis stack.

Giner ELX reported that H2B2 Electrolysis Technologies, a Spanish-based supplier of PEM electrolyzer systems, had placed a strategic investment with the company. In Hanover, H2B2 had joined the booth of the Spanish hydrogen association. Javier Brey, CEO of H2B2 and president of the Asociación Española del Hidrógeno, said about the partnership: "In our direct experience, Giner ELX's PEM electrolysis technology is the most advanced in the world."

ITM HEADS OFF TO MAINLAND EUROPE ITM Power, a now established and growing energy supplier and electrolyzer manufacturer based in Sheffield, UK, is aiming for the same capacity range. It has also been trying for a long time to enter the markets of mainland Europe, but has had to grapple repeatedly with bureaucracy at its finest. From ITM's German subsidiary in the state of Hesse, Phil Doran attempted for years to win orders for the British-based parent company – with little success. The only exception was a 360-kilowatt power-to-gas plant at Thüga in Frankfurt am Main. While Calum McConnell, who followed in his footsteps in the fall of 2016, has continued Doran's efforts, H2 Mobility has already made it clear that the establishment of a German hydrogen infrastructure would happen without electrolyzer-based systems and two of its own stakeholders, Air Liquide and Linde, would receive the lion's share of orders.

In Hanover, ITM exhibited two container units replete with electrolyzer technology. Graham Cooley, ITM's CEO, said that these products had been developed in response to "a dramatic increase in the number of enquiries" for large H_2 plants from bus and truck filling stations (1 to 10 megawatts) and P2G projects, refineries and steel construction (10 to 100 megawatts). Shell Hydrogen, which shared a booth with BMW at Hannover Messe, showed one project in which ITM has been involved, namely the joint construction of an H_2 filling station directly at the freeway in Cobham, to the southwest of London. Shell's first UK refueling station, which uses electrolysis for producing fuel on-site, could provide enough hydrogen to fill up 100 FC vehicles per day (if the country had that many).

Norwegian-based Nel Hydrogen – which celebrated its 90-year anniversary in Hanover – and US-based Proton OnSite had two separate booths despite the former having acquired the latter at the beginning of this year. Nel reported on the 400-megawatt plant it was designing in partnership with one of its customers from industry and said that such a large project would cut investment costs to as little as USD 450 per kilowatt.

One business that had shut down operations in the meantime was BeBa H2 Speichersysteme from the German state of Schleswig-Holstein, as reported by Hansjörg Vock from Swiss-based Diamond Lite, a Proton subsidiary and BeBa's European sister company. In 2013, Beba H2 Speichersysteme had been incorporated into BeBa Energie and had originally been thought of as providing a northern German location from where to market products.

HYDROGENICS SHOWS 3-MEGAWATT STACK On the second day of Hannover Messe, Hydrogenics presented its new 3-megawatt PEM stack Hylyzer 600 developed in Canada. This next-generation device is the successor to a 1.5-megawatt module shown a few years ago. Bernd Pitschak, managing director of Hydrogenics' German subsidiary, stressed in his short speech that the unit was notably more compact

Fig. 4: McPhy's newly developed SimpleFuel™ system

Fig. 5: Compact alkaline electrolyzer by Inabata in switchboard size

than the previous model (620 normal cubic meters per hour at more than 30 bars of pressure), a possibly essential factor in larger systems. He explained that the plant footprint (55 × 88 × 115 centimeters or 21.7 × 34.6 × 45.28 inches) "really was a problem" in general, as an increase in size would often have costs rise as well. For example, bus operators in California had only been able to fill up one, two or maybe three vehicles, whereas the new stack would make it possible to use the same space for supplying 20 to 30 buses or 280 cars each day.

MCPHY OFFERS ALL-IN-ONE STATION McPhy had something new in store too: a complete fill-up unit called SimpleFuel™. Developed in the United States in partnership with Ivys Energy Solutions and PDC Machines, it comes with an integrated electrolyzer and storage system, can fill up cars at 350 and 700 bars, and – while originally developed for the State-side market – is currently being adapted to meet European standards. The station isn't the quickest considering its capacity of 5 to 10 kilograms per day, but rather an "inexpensive entry into the hydrogen world," that would require "only water and power hookups," as McPhy put it. It is an all-in-one system combining H_2 production (purity: 99.999 percent by volume), compression, storage and supply in one single device.

The unit is being manufactured in a McPhy factory in San Miniato, Italy, and is said to be available at the end of this year. Its price tag is reportedly in the lower six figures. Pascal Mauberger, CEO of McPhy, said the device was "easy to install, all-in-one and user-friendly" and will "accelerate the deployment of hydrogen infrastructures." At the same time, Tristan Kretschmer from McPhy Energy Deutschland, told H2-international that this unit was certainly "no competition," but a complement to stationary systems. Its versatility was intended to help "accelerate market growth and promote personal transportation."

Jens Bischoff and the new head of Odasco-Heliocentris, Saad Mohammad Al Abed Odeh, formerly employed with Siemens, stood side by side at the Inabata booth to answer the questions of trade show attendee

GP JOULE AND H-TEC GP Joule based in Reußenköge, Germany, has gotten greatly involved in energy storage projects, marketing and policy. As many as four booths at Hannover Messe were used to exhibit GP products and several electric cars, and the employees attending the trade show were running around with the same-color pair of gray sneakers. And in mid-May 2017, the managing directors of GP, Heinrich Gärtner and Ove Petersen, inaugurated a new office in Berlin.

For GP Joule's subsidiary, Lübeck-based H-Tec Systems, it was the right venue to showcase its PEM electrolyzers and kick off their market launch. Featuring a four-year output guarantee, the system offers an active membrane surface area of 400 cm2 or 62 square inches, up to 30 bars of outlet pressure and 225 kilowatts of power output. It promised to reduce the cost of power-to-hydrogen conversion "to as low as EUR 0.02 per kilowatt-hour in the near future," a GP Joule press release said.

Even the former managing director of H-Tec, Stefan Höller, was a guest at the joint booth. He told H2-international that he had meanwhile launched his own start-up, Hoeller Electrolyzer. After GP Joule took over H-Tec in late

Fig. 6: ME 100/350 by H-Tec Systems

2015, his exit had already been decided, but he left the company only late last year. Soon thereafter, in December 2016, he founded his new consulting business – again, based in Lübeck. He said his aim, in partnership with interested plant equipment suppliers, was to promote particularly the use of wind power plants for hydrogen production. Their subsidies will run out at the end of this decade.

THYSSENKRUPP AND SIEMENS All previously mentioned businesses exhibited at the joint booth Hydrogen + Fuel Cells + Batteries. Directly next to it in hall 27, at the shared exhibition space of North Rhine-Westphalia, attendees could find another electrolyzer business, thyssenkrupp Uhde Chlorine Engineers. The Dortmund-based department of the thyssenkrupp corporation presented a large cell that was typically used in industrial-scale electrolysis and pointed out its expertise from worldwide over 600 electrolysis installations totaling more than 10 gigawatts.

KÄPPNER RETURNS TO HYDROGEN INDUSTRY
In July 1, 2017, Roland Käppner became thyssenkrupp's new head of Energy Storage and Hydrogen, a department of the corporation's Industrial Solutions business area. The aim is to seek out new business opportunities in the rapidly growing renewables industry.

At Siemens' Hanover booth, Gabriele Schmiedel, head of the Hydrogen Solutions business unit, made it unmistakably clear that the new strategy was to "think big, act bigger." The Silyzer 200 prototype had still been installed at Energiepark Mainz (see October 2015 issue of HZwei); its commercially available version with 1.25 megawatts came online in fall 2016 in Hassfurt. Additionally, four units with a combined capacity of 5 megawatts are being set up in northern Germany at a refinery. And the latest device generation, the Silyzer 300 with 6 megawatts, is reported to be installed in Linz, Austria, on the premises of a steel factory (see next issue). The new target beyond 2020 was somewhere above 100 megawatts, Schmiedel said.

The hydrogen from Mainz and Hassfurt is used by Greenpeace Energy for gas grid feed-in sold as proWindgas, just as in Prenzlau. The energy supplier will up H_2 production from 989 to presumably around 2,600 megawatt-hours between 2016 and 2017. Greenpeace Energy's CEO, Nils Müller, said: "Eco-wind gas could enjoy much greater success if unfair market barriers weren't slowing us down." ||

HYDROGEN POTENTIAL FOR ELECTROLYSIS
Hydrogen is required for numerous applications in industry (e.g., flat steel, glass, power plant processes). In the *steel industry,* the oxygen must be removed chemically from the iron ore, a process for which steelmakers have so far used carbon in the form of coal or coke. The oxidation that occurs will result in emissions of around 2.2 tons of CO_2 for each ton of liquid steel produced – 5 percent of the world's anthropogenic CO_2 emissions. Substituting hydrogen for carbon would have the potential to drastically cut those emissions, as H_2 is an excellent material for reduction, leaving behind only water as a byproduct.
The gas is also used in *refineries* to improve distillation quality. Conventional hydrogen production, however, releases around 10 tons of carbon dioxide per ton of hydrogen, meaning around 17 percent of the entire CO_2 emissions from European refineries are the result of creating H_2. Hydrogen produced through electrolysis and renewable sources would lead to far fewer emissions.
The *chemical industry* traditionally uses steam-reformed natural gas to create H_2. But reformers need warm-up times of more than three hours until being fully operational. PEM electrolyzers could be deployed for much faster start-up, considerably lowering the risk of undesired downtime in industrial facilities.

Subject: News | **Author:** Sven Geitmann

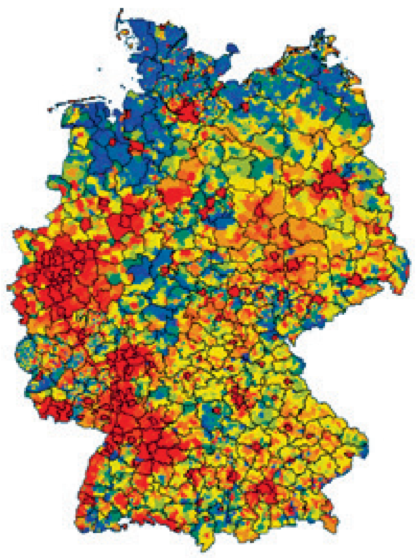
NEXT ENERGY AS NEW DLR LOCATION

The Next Energy research center has gone through uncertain times recently. Last November, the German government did make EUR 7 million per year available to fund the organization, but those millions would only be paid if Next were incorporated into the DLR, the German Aerospace Center. Its integration into the government's main research organization on aerospace and energy technology, transportation and safety in basic and applied research is intended to save 120 jobs in Oldenburg, Germany, and counter Next's greatly reduced activities in aerospace research since its foundation by regional utility EWE about 10 years ago. Said the DLR: "The topics that the institute addresses complement DLR›s portfolio very well." ||

Subject: Energy Storage | **Author:** Dr. Martin Robinius

H2 GRID NOW COST-EFFECTIVE

Using Excess Power to Produce H_2



Sources: FZ Jülich

Fig. 1: Current research findings on the power sector

Fig. 2: Hydrogen pipeline network to supply 75 percent of the German transportation sector

The German government has set clear targets for emissions reduction, starting at minus 40 percent by 2020, 55 percent by 2030, 70 percent by 2040, and 80 to 95 percent by 2050 compared to 1990 levels. One option to meet these targets is to increase renewable use to at least 80 percent of total market size (local electricity production and imports minus exports) by 2050. Intermittent renewable sources such as PV, onshore and offshore wind power will be crucial to meet demand due to their huge potential and will dominate any future electricity market. But they also generate considerable amounts of excess energy. Sector integration can help utilize this surplus, for example, in transportation. A recent study has explored potential scenarios for meeting the government's 2050 targets through sector integration.

The approach used in this study differs from other works in its application of new models to offer highly granular scenarios that meet relevant requirements. The complex and highly dynamical systems were divided into mathematically highly accurate submodels that show in-depth physical and technical data in very small intervals. Then, generalized models with reduced granularity were used to evaluate draft designs and scenarios. Both methods were employed to develop and verify one possible renewable supply future that links the power and transportation sector through a suitable gas infrastructure and offers both technical and economic opportunities for substantial GHG emissions reduction in Germany.

What is known in Germany as "residual load" is electricity demand minus feed-in from intermittent sources such as certain renewables. A positive residual load means that load-following power plants (e.g., gas or coal plants) need to cover the remaining demand. A negative residual load, however, makes it possible to store energy in hydrogen through the power-to-gas pathway.

ENOUGH ENERGY AVAILABLE For example, the study analyzed residual loads in 11,268 municipalities and extrapolated their demand by the hour up to 2050. The study also showed Germany's maximum voltage grid of 220 kV or 380 kV at different stages of expansion to illustrate that negative residual loads are highly prevalent in northern Germany (see fig. 1: blue-colored areas), whereas positive ones can be found particularly in cities or highly industrialized areas (in red, e.g., in North Rhine-Westphalia).

Table 1: Assumptions for renewables expansion by 2050

Onshore wind	Offshore wind	PV	Hydro-power	Bio-energy
170 GW	59 GW	55 GW	6 GW	7 GW
350 TWh	231 TWh	47 TWh	21 TWh	44 TWh

If the use of renewables were expanded based on the numbers in table 1, but the current power grid kept in place, excess energy from residual loads would add up to 293 terawatt-hours. Using this energy in electrolysis would yield around 6.2 million tons of hydrogen.

It should be noted that even if the grid were set up perfectly – meaning Germany were placed on a copper plate – and the existing pumped storage plants included, the surplus would still add up to 191 terawatt-hours. This would leave enough energy to produce around 4 million tons of hydrogen.

If this figure were now compared to the hydrogen amount required in transportation, the result would be as follows: To supply three-fourths of the cars owned in Germany, it will need only 2.93 million tons of hydrogen or 28 gigawatts of installed electrolysis capacity in 15 districts in the north of the country. The transmission pipeline needed to transport the hydrogen from these 15 districts to the 9,968 gas stations throughout the nation will be 12,104 kilometers or 7,521 miles long. Its construction will cost EUR 6.68 billion. The additionally required distribution network will have a length of 29,671 kilometers or 18,437 miles at costs of EUR 12 billion (see fig. 2). These results factor in both the locations of negative residual loads and several market introduction scenarios for fuel cell vehicles.

Table 2: Required pipeline network (2.93 million tons of H_2 per year; 9,968 stations producing 803 kilograms of H_2 each day)

Pipeline	Length	Investment costs [1]
Transmission	12,100 km	EUR 6.7bn
Distribution	29,670 km	EUR 12bn

[1]: incl. compressors to compensate for pressure losses

NETWORK FINANCIALLY POSSIBLE In addition to the analyses on market introduction, potential shareholders or stakeholders were identified and evaluated for their role in supporting the creation of a hydrogen infrastructure. Financial assistance could come from sources such as the German government, insurance companies, public or retirement funds. The evaluation also proved that there was no shortage of money to finance the infrastructure; rather, capital would have to be raised through economically sustainable business models. For example, the money available to

- the 15 largest public funds in the world adds up to about EUR 5.4 trillion;
- the 15 biggest insurers in the world is around EUR 9 trillion in total assets,
- the top 23 private pension funds in Germany amounts to EUR 27 billion.

Besides these potential shareholders and stakeholders – which fund projects based on duration and possible margin – there are others throughout the power-to-gas value chain, for example, mineral oil and natural gas corporations, energy utilities, automotive companies, technology firms, businesses with hydrogen know-how and ones from the chemical industry. The study shows that 16 percent of the operating income from the 31 companies surveyed would be enough to finance the entire hydrogen pipeline.

The above-mentioned research findings are currently being utilized and debated by members of the virtual Power to Gas and Heat institute, the IEA's Task 38 on Power-to-Hydrogen and Hydrogen-to-X, the H_2 System expert group of North Rhine-Westphalia's Fuel Cell and Hydrogen Network and the Energy System 2050 initiative of the Helmholtz Association.

In the future, the existing system design and the models developed in this study need to be advanced and adapted for integration into other energy pathways with an eye on GHG emissions reductions in Germany and a European or global approach factoring in regional differences in market situations. Currently, eight people are each working on their own dissertation to explicate the issues. ||

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The author of this article received the DWV Innovation Award in summer 2016 for his dissertation and would like to express his deepest gratitude to Professor Detlef Stolten, director of the Institute of Electrochemical Process Engineering at the Jülich Research Center, and his team for the excellent support during his time as a PhD student.

Subject: Energy Storage | **Author:** Sven Geitmann

Hydrogen as Baking Industry's Bread-and-Butter

Demo4Grid is an FCH JU project in the vein of *H2Future* (see next issue). It was likewise launched in Austria, in March 2017, and just as *H2Future*, it has been focusing on green hydrogen. The main differences are the test system, now a 4-megawatt high-pressure alkaline electrolyzer, and the location, this time near Therese Mölk, an industrial bakery in Völs.

The project has been subsidized with EUR 2.9 million (at a total investment of EUR 7.7 million). Project partners include Tyrol-based MPreis Warenvertriebs GmbH, FEN Sustain Systems, and Greek and Spanish businesses. The electrolyzer runs on one single stack and was manufactured by Industrie Haute Technologie, Switzerland. Industrie Haute is planning to operate the system jointly with the MPreis grocery chain as part of a showcase project until February 2022.

The hydrogen is said to replace natural gas heating the ovens and may also be used to power the bakery's delivery vans. Ernst Fleischhacker, the initiator of the project and managing partner of FEN Systems, explained: "There's growing demand for hydrogen in transportation, as fuel cell units can be used whenever you need to transport heavy loads, refuel quickly and go long distances."

Demo4Grid will continue the work of two other projects supported by FCH JU, *Elygrid* (ended in 2014) and ELYntegration (ends in August 2018). ||

Demo4Grid
Demonstration for Grid Services - Green H_2 for Tyrol

Subject: Energy Storage | Author: Anselm Strauch, Dr. Klaus Taube, Dr. Oliver Posdziech |

METAL HYDRIDE STORAGE AND REVERSIBLE HIGH-TEMPERATURE CELLS

Thermal Integration for Significant Efficiency Increases Using Excess Power to Produce H2

The supply volatility of renewable sources such as solar and wind will need to be countered by powerful and efficient systems that can store the generated energy at any time and make it available as soon as demand requires. One solution to solve this challenge is energy storage in a material such as hydrogen (power-to-gas). However, while direct-use scenarios, such as in the heat or transportation sector, result in efficiencies of 54 to 77 percent, a reconversion to electricity from this so-called "hydrogen battery" will leave one with only around 34 to 44 percent of usable output. This article will present an H_2 storage system that offers the potential to increase efficiency to 65 percent if power is converted into hydrogen and from there reconverted into electricity (power-to-power). This efficiency increase is made possible by an internal heat exchange between two main components that complement each other perfectly: the producer of H_2 and power and the hydrogen storage material.

The unit producing hydrogen and power in this scenario is a high-temperature rSOC, or reversible Solid Oxide Cell, and the material used for hydrogen storage consists of high-temperature metal hydrides. The latter can store both hydrogen and thermal energy, leading to the above-mentioned efficiency improvements.

COMBINED HYDROGEN AND HEAT STORAGE Many metals and alloys, such as magnesium or iron-titanium (FeTi), react with hydrogen to form so-called metal hydrides, where the hydrogen has been chemically bonded to the metal lattice based on the following formula [1]:

This process is reversible. To release the hydrogen, one would theoretically have to use the same amount of heat as during storage. The process of storing and reconverting hydrogen could simultaneously be utilized for storing and releasing heat. Compared to conventional pressure vessels, metal hydride storage systems have a more than 10 times higher energy density by volume at pressures of 30 to 50 bars – and sometimes even far below those values. For example, they have five to 10 times the heat capacity of molten salt storage systems at temperatures between ambient and 1,000 °C (e.g., MgH_2/Mg: 2,885 kJ/kg or 1,362 kWh/m^3 at a bit more than 300 °C). When hydrogen is stored in the form of a chemical bond, as is the case with metal hydrides, there is no self-discharge (when bonded) or heat loss (when separated) – both for hydrogen and heat.

Consequently, metal hydrides can be used in this battery to store both heat and hydrogen. Heat produced in the fuel cell during power conversion is utilized to separate the hydrogen from the metal hydride, a process known as "dehydration." Conversely, when energy is stored during hydration, the heat "bonded" in the dehydrated metal is being released and can be used to produce hydrogen via steam electrolysis, an extremely efficient method when adding heat. This makes a hydrogen battery based on rSOC metal hydrides an efficient, scalable and compact storage solution for electrical energy (see fig. 1).

PINCH ANALYSIS OF RSOC METAL HYDRIDE STORAGE Water electrolysis requires a minimum energy amount of 285.7 kJ per mole of H_2. In low-temperature electrolysis (e.g., PEM or alkaline electrolyzers), much of the demand is met by electrical sources. Conversely, high-pressure steam electrolysis in an SOEC will make it possible to provide part of the energy – for the enthalpy of vaporization and the increase to rSOC operating temperature – not by electric, but thermal means.

Another source of waste heat besides the rSOC's ohmic heating (not considered) is the heat of reaction when hydrogen is absorbed (to form metal hydride). If the waste heat provided can be used for vaporization (see also fig. 3), the calorific value of the hydrogen produced in steam electrolysis (285.7 kJ per mole of H_2) will exceed the electrical energy required at 850° C (around 250 kJ per mole of H_2) and electrical efficiency alone will be pushed above 100 percent.

Figure 2 shows one possible mode of operation (i = 0.6 A/cm², atmospheric pressure), including the specific heat of reactant streams and the one of available product flows as part of one composite curve. One can see that, when disregarding the enthalpy of water vaporization for a moment, the electrolysis products can nearly meet the entire energy demand for heating the reactants. The missing heat amount adds up to around 48 kilojoules per mole of produced or converted hydrogen, assuming a reactant stream of around 90 percent of H_2O and 10 percent of H_2, and a product flow of 82 percent of H_2 and 18 percent of H_2O (H_2 output at 80 percent) at the hydrogen electrode. In this case, what is supplied to the oxygen electrode is air.

TOTAL STORAGE EFFICIENCY The waste heat from the metal hydride reaction was selected to match the heat demand of electrolysis (ideal scenario). In this simplified model, 65 percent of the stored heat can later be provided in the form of electrical energy. Energy can be stored in the metal hydride indefinitely and long-time storage will not decrease efficiency, as the hydrogen is part of a stable chemical bond.

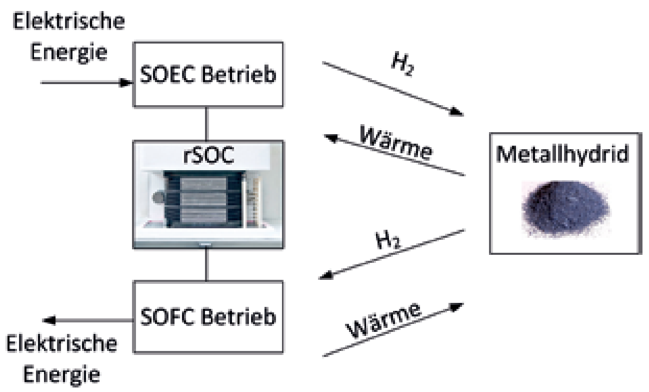

Fig. 1: Thermal integration of SOEC / SOFC with metal hydride storage

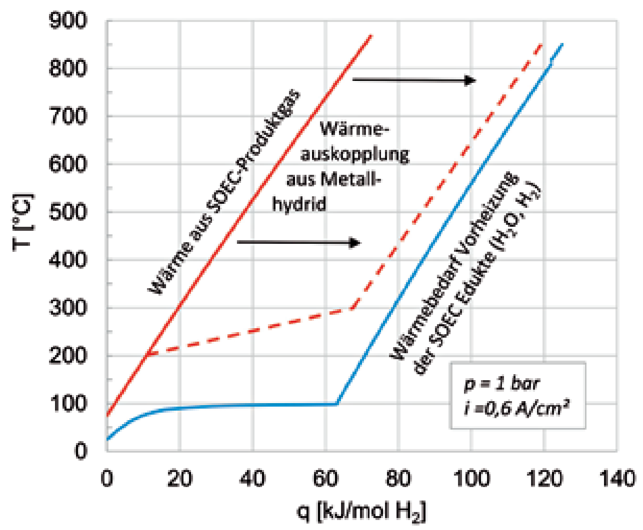

Fig. 2: Pinch analysis of internal heat exchange between rSOC and metal hydride storage. Broken red line: heat exchange, including metal hydride, at temperatures between 200 and 300 °C.

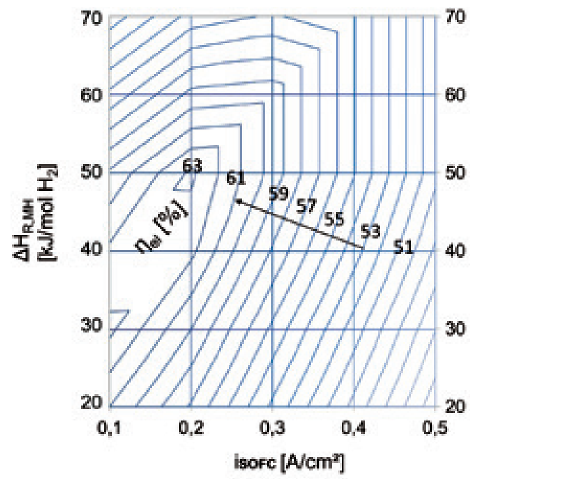

Fig. 4: Electrical storage efficiency in a thermally integrated unit continuously operated without any change in parameters

This model does not consider losses incurred during real-world operation due to power consumption by the system (blower to supply air, etc.), heat release into the ambient air or heating/cooling required for changing the operation mode.

In addition to these inevitable losses, the storage efficiency of electrical energy mainly hinges on the heat amount produced by the metal hydride reaction $\Delta H_{R;MH}$ and the current density in SOFC operation (variable "i"; see fig. 4).

METAL HYDRIDE STORAGE MATERIALS The best materials to use for the above-described system are metal hydrides with an enthalpy of reaction as close as possible to 48 kJ per mole of H_2 (see fig. 4), as they can meet the heat demand of electrolysis. Binding hydrogen with metal hydrides needs to be possible at temperatures at which the feedwater can be turned into vapor even if pressure is added. The metal hydride should also possess a good enough reaction rate even at very small absorption pressures to save energy during compression. When the fuel cells are in operation, the rSOC delivers heat at 650 to 850 °C. Discharging the metal hydride should already be possible below this temperature range.

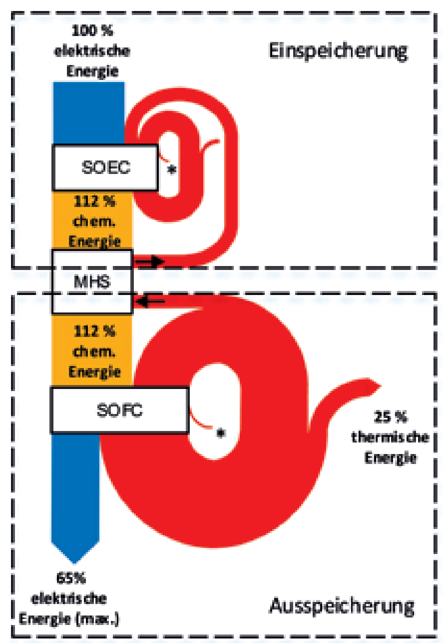

Fig. 3: Sankey diagram: simplified energy flow in an optimized system consisting of an rSOC (SOEC or SOFC) and metal hydride storage

Figure 5 shows the reaction enthalpies of a selected number of suitable materials from room-temperature hydrides (reaction close to room temperature), medium-temperature sodium aluminum hydride ($NaAlH_4$) to high-temperature hydrides with reaction enthalpies of 50 and more kJ per mole of H_2. Other hydride properties and the use of pure magnesium hydride as hydrogen storage in combination with an SOFC have already been described in [2].

Magnesium hydride could indeed be an option of great interest, as it is relatively inexpensive. However, the heat of reaction is above 70 kJ per mole of H_2, greatly exceeding the net heat demand of the SOEC and making it less than ideally suited to achieve high efficiencies (see fig. 5). And during dehydration, the SOFC would need to match the high specific heat, which limits its maximum electrical efficiency. A high-temperature alloy composite based on lithium borohydride and magnesium hydride (operating temperatures of 300–450 °C) is out of the question due to its high price.

Conversely, sodium aluminum hydride, a material with an operating temperature of between 120 and 180 °C (see fig. 5 and description in [2]) will have one expect storage material costs to be around as low as for magnesium hydride. Another point in its favor is a low reaction temperature (120 to 160 °C), meaning the reactor does not require any heat-resistant steel. All in all, it seems to be the most promising solution to date.

SUMMARY AND OUTLOOK Considering the energy balance of a power-to-power system based on rSOC-technology, the use of metal hydride storage systems has its advantages over conventional pressure vessels at the same capacity levels if the aim is high electrical efficiency. Thermal integration using the waste heat of the system, as described in this article, offers the opportunity to increase the efficiency of electrical energy stored in it to 65 percent. Such systems would only be limited in their overall electrical efficiencies by fuel cell efficiency, meaning the constraints imposed on the process by reconverting hydrogen into electricity.

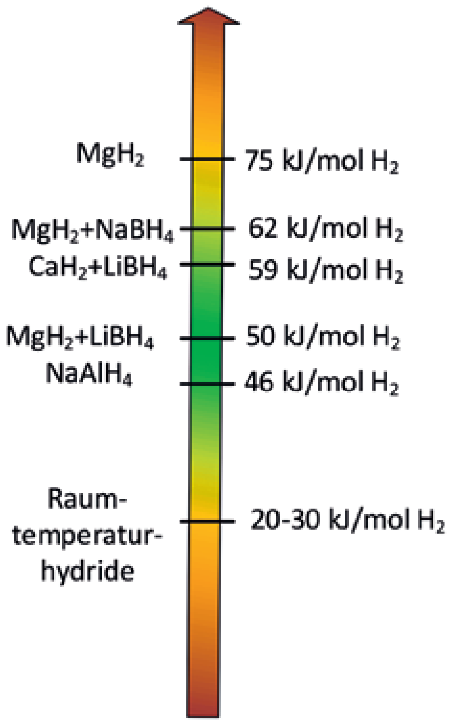

Fig. 5: Heat of reaction of some metal hydrides and composites in comparison to optimum level

Another advantage of hydrogen storage systems based on metal hydrides is the energy density by volume, expected to be around 10 times as high compared to conventional pressure systems at added pressures of 50 bars or below.

The challenges when trying to design a system of this kind are 1) formulating and synthesizing an inexpensive metal hydride having the above-described optimum properties; 2) minimizing heat losses, reducing system complexity and cutting costs by developing an enhanced system of heat exchanges, 3) reducing consumption by the system itself, 4) adding the pressure needed to bond the hydrogen in the metal hydride storage.

The consumption by the system itself is mainly dependent on the compression required to achieve the pressure levels for hydrogen absorption when running electrolysis at or slightly above ambient pressure. Developing high-temperature steam electrolysis toward operation at pressures of a few tens of bars could do away with the need for separate hydrogen compression. Electrolysis would already deliver the pressure required for absorption together with the hydrogen.

Future research activities would need to expand on the simplified linear simulation described in this article, so it can be implemented in a real-life environment. What would need to be considered are thermal mass, heat transfer and loss, and the dynamism of the process – not just a static environment, as described in this article. There also needs to be proof that the presented rSOC technology with a thermally integrated hydrogen tank containing metal hydride is not only an advantageous solution, but a competitive one. ||

The findings presented in this report were taken from Anselm Strauch's master's thesis funded jointly by Sunfire GmbH and Helmholtz-Zentrum Geesthacht.

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

H2 MOBILITY – YOUR TURN

Change from CEP to H2 Mobility

One considerable barrier to establishing hydrogen transportation in Germany is the relatively small number of filling stations that exists across the country. Until the end of 2016, setting up an H_2 infrastructure was primarily the task of the Clean Energy Partnership, or CEP for short. This year, responsibility was handed over to H_2 Mobility Germany, and while the new management seems deeply committed to the task, the transfer from publicly supported showcase project to private-sector joint venture poses more difficulties than had been expected. H2-international made a trip to the EUREF Campus in Germany's capital Berlin to see what the company consortium can do for electric transportation.

September 2009 marked the beginning of a new chapter, when nine corporations (Air Liquide, Air Products, Daimler, EnBW, Linde, OMV, Shell, Total, Vattenfall and NOW; see July 2010 issue of HZwei) founded the H2 Mobility initiative. It developed into a joint venture about five years later – one that was established without Air Products, EnBW and Vattenfall. Only a mailbox on Linienstrasse in the middle of Berlin revealed the existence of a corporate entity in early 2015 and Martin Kleinschmitt was only heading H2 Mobility on paper before being quickly replaced by interim manager Frank Sreball (see H2-international September 2016). The clear objective since then has been to set up and operate around 400 H_2 filling stations in Germany by the end of 2023.

Nikolas Iwan began his career in 2006 as an intern at Shell. He then spent two years working for Shell's financial department, another two as managing director of a subsidiary and four as the manager of the gas station business in Austria, where he oversaw 260 locations. He became managing director of H2 Mobility in May 2016 and said that it really was "the job he dreamed of" and that it had been "a very rewarding experience."
To Iwan, EUREF Campus in the middle of Berlin has been the perfect site for implementing his plans, as the around 70 innovative businesses located there include as many as 30 from the energy and electric transportation industry. It's an inspiring environment that provides many opportunities for networking.

MOTIVATED STAFF Meanwhile, the job of H2 Mobility's managing director has gone to Nikolas Iwan. During my onsite visit, he presented the consortium as a young enterprise with "highly capable and motivated" staff who "intends to connect more refueling stations to the grid in the next 12

The H2 Mobility office on the third floor of building no. 10-11 (in red), directly next to the Gasometer (left) on the EUREF Campus in Berlin-Steglitz months than have been installed in Germany over the past 15 years." He did agree that this would still be "a very modest number," but when the industry consortium "operates more than 60 stations in highly populated urban areas and on freeways in early 2018, the hydrogen transportation market will slowly but surely have started to grow."

Since February, he has a full team of fifteen employees and ten freelancers walking the halls on the third floor of the office building. On more than 300 m^2 (3,229 square feet), Iwan – whose assessment center test won him the job over numerous competitors – has created a kind of "operations center for establishing a German H_2 infrastructure."

HOW TO IDENTIFY LOCATIONS H2 Mobility has two main business units. The first, Network Delivery, is tasked with identifying locations and constructing stations and is run by Lorenz Jung. The second, Network Operations, is responsible for operations reliability and optimizing refueling stations and is headed by Frank Fronzke.

To identify suitable locations, the Network Delivery team still uses the original CEP planning documents, according to which H_2 stations are first to be set up in highly populated urban areas and on the freeway corridors in between them. Currently, the team is working its way through the planned list of refueling stations, with the lion's share of orders going to consortium members. The businesses central to the supply of gas station technology are Air Liquide and Linde, both of which have concluded blanket orders with H2 Mobility. Iwan explained that contracts had already been negotiated for around 80 percent of purchases to benefit from economies of scale and cut costs.

Considerably fewer locations remain open to other market participants, even foreign ones such as Nel – at least, in theory. But several European suppliers, such as McPhy or ITM, will have little chance of winning bids on those projects. Iwan said that the electrolyzers included in their refueling stations were not in line with the mandate based on which H2 Mobility had been founded.

In March, H2 Mobility accepted bids to supply regions outside metropolitan areas and support "regional clusters that show inherent potential for hydrogen demand." H2 Mobility's first bid invitation included a list of suitable locations or regions with the largest potential for hydrogen use in transportation. As Iwan was pleased to report, the consortium had received "a surprisingly large number of highly intriguing submissions." Nine of the nearly thirty bids "guaranteed demand for hydrogen" and came on the shortlist. Another analysis and evaluation later, the joint venture invited three applicants to Berlin to talk to them in person. In the end, the contract was awarded to Halle (Saale), which will see an H_2 filling station built at the PS Union gas station. Iwan confirmed that another bid invitation will be coming up in months ahead (please send your documents after the start of the application period to standort@h2-mobility.de).

The management of refueling stations is currently divided into five German regions and the operations manager of each region is responsible for 10 stations. Service providers take care of their installation.

FROM CEP TO H2 MOBILITY In mid-May 2017, there were 27 H_2 refueling sites in operation across Germany. H2 Mobility manages seven of them; three were built from the ground up and four were taken over from the CEP. These locations alone have had an availability rating of 100 percent.

Each site offered to H2 Mobility undergoes technical evaluation and an analysis of its economic feasibility. Iwan told H2-international: "We don't take over refueling stations that fail to meet our list of criteria." And Andreas Füßel, project manager for the CEP transfer, added: "This isn't just about handing over some documents." For example, contracts would need to be drafted to specify rent payments to station operators and the requirements for system access, and so on. To work out those agreements, H2 Mobility holds regular meetings with shareholder representatives.

One example is the completely reworked design of the Hamburg HarborCity station, as hydrogen used to be produced on-site via electrolysis. However, current regulations such as the Renewable Energy Act have made this H_2 production method comparatively expensive and Germany's pollution control standards have turned maintenance into a very time-consuming task. Iwan explained that those were the reasons for H2 Mobility's shareholders directing "the managing director to exclude electrolyzers" and concentrate on expanding the infrastructure instead.

Thomas Bystry, chair of CEP, spoke of around ten filling stations that their previous owners hadn't even offered to H2 Mobility. One of them was a station designed solely for research purposes and set up on the premises of the Karlsruhe Institute of Technology. A similar case was the solar-hydrogen installation at Fraunhofer ISE in Freiburg.

There have also been numerous restrictions imposed on existing CEP stations. For example, the systems in Geiselwind and on Jaffestrasse in Berlin cannot be taken over yet, as they will continue to receive public grants for a short while. Only when their subsequent use has been agreed on, a final report handed over and the accompanying research activities sufficiently documented will Projektträger Jülich make the stations available to H2 Mobility.

Iwan explained: "Taking over assets certainly is a complex process that will continue through most of 2017 with due diligence checks, contract negotiations, analyses of grant providers, and so on."

PUBLIC-PRIVATE PARTNERSHIP One half of the money H2 Mobility spends on constructing the refueling systems comes from shareholders, the other from the government. It's up to Iwan's team to select a grant program matching the funds from industry. While the existing CEP locations were subsidized through the National Innovation Program Hydrogen and Fuel Cell Technology, NIP 1, the new ones may be supported not only by NIP 2, but also EU projects COHRS and H2ME.

Iwan hastened to add that H2 Mobility had not been conceived to turn a profit. Rather, it had been founded to ensure that costs and risks were equally distributed among shareholders and that prices went down as fast as possible. As soon as the business was in the black (according to Iwan, "in 2023 at the earliest, but more like 2025 or later"), the association would be dissolved, as required by Germany's antitrust authority. Iwan said: "The assets will then be returned to each shareholder." There has been no word yet on what will happen to his team and the project know-how.

Asked whether they weren't basically creating an oligopoly right under the nose of the antitrust agency to shut out competitors and dominate the market, the managing director countered that other stakeholders had been invited to state their commitment and participate in the process. He stressed that "not everyone contributes equally to the targets." The number of stations owned by a member made it already apparent that OMV paid much less than Total or Shell.

Fig. 2: The new H_2 brand logo

One could also join a kind of council as an associate, just as BMW, Honda, Toyota, Volkswagen and NOW have done. They pay a member fee to fund projects such as the new app (see below) and in return, representatives from the company stay informed about activities and advances within the consortium. Intelligent Energy used to be part of this council, but has meanwhile exited out of the partnership.

NEW WEBSITE, NEW APP Just recently, on June 12, 2017, a new website called h2-live.de came online. It is said to be tailored specifically to the needs of consumers, educating anyone interested in the technology about hydrogen and refueling options. With it, Iwan intends to establish the website's freely usable H_2 logo (see fig. 2) as a brand that will outlast the H2 Mobility initiative. There is also a new app online for an easier and more comfortable user experience by smartphone. At first, those offerings would only satisfy "basic needs," as Iwan put it, but things such as mobile payment options would be added at some point.

Additionally, there are plans to simplify the "industrial refueling" instructions that have so far been necessary (e.g., explain them by video) or work toward having the requirement dropped altogether. H2 Mobility also wanted to do away with the CEP Card over the medium term, Füßel said.

One hundred stations are planned to be up and running by the end of 2018. Whether electrolyzers could be used in projects thereafter, Iwan wouldn't say. But it should be crystal clear by then whether hydrogen demand is, in fact, rising gradually. ||

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

CHANGING FACE OF CEP

The Clean Energy Partnership has decided to continue work beyond the originally planned project duration (until the end of 2016). Some CEP business partners, however, have already left the consortium. CEP's chair, Thomas Bystry, told H2-international that six businesses had left by April 2017; particularly the energy utilities no longer felt that they were sufficiently represented within the partnership. But other organizations had been joining, meaning spring time was primarily used for contract negotiations.

These weren't the only changes. Claudia Fried, a freelance PR consultant who had been CEP's spokesperson from early 2011 through late 2016, left as well. As the CEP has not gotten any financial support from the government since the beginning of 2017, but has had to rely on member fees only, this year's budget won't be comparable to previous ones either. ||

DATES 2017

SEPTEMBER 10th TO 13th, 2017
HYDROGEN + FUEL CELLS NORTH AMERICA
part of SOLARPOWER International (SPI)
in Las Vegas, USA, www.h2fc-fair.com/usa

SEPTEMBER 11th TO 13th, 2017
INTERNATIONAL CONFERENCE ON HYDROGEN SAFETY ICHS2017
Hamburg, Germany, www.ichs2017.com

SEPTEMBER 14th TO 17th, 2017
SHAPING THE FUTURE OF MOBILITY ACROSS INDUSTRIES
in Frankfurt am Main, Germany, www.newmobility.world

SEPTEMBER 18th TO 22th, 2017
EUROPEAN SUMMER SCHOOL ON HYDROGEN SAFETY (ESSHS)
part of the Joint European Summer School 2017 (JESS)
in Athens, Greece, www.jes-school.eu

SEPTEMBER 20th TO 22th, 2017,
2ND FC EXPO OSAKA
Western Japan's Largest Hydrogen and Fuel Cell Show
Osaka, Japan, www.fcexpo-kansai.jp

OCTOBER 9th TO 11th, 2017
WORLD OF ENERGY SOLUTIONS F-CELL + EVS30
on the Stuttgart Fair Ground, Germany
www.world-of-energy-solutions.de

OCTOBER 17th TO 19th, 2017,
MOBILITY 4.0: ELECTRIC – CONNECTED – AUTONOMOUS
in Munich, Germany, www.emove360.com

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

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

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

DATES 2018

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

MAY 15th TO 17th, 2018
THE BATTERY SHOW
in Hanover, Germany
www.ehec.info

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

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Diamond Lite S.A., Rheineckerstr. 12, PO Box 9, 9425 Thal, Switzerland, Phone +41-(0)71-880020-0, Fax -1, *diamondlite@diamondlite.com, www.diamondlite.com*

Giner, Inc., 89 Rumford Avenue, Newton, Massachusetts 02466, USA, Phone +1-(0)781-529-0500, *information@ginerinc.com, www.ginerinc.com*

GreenHydrogen.dk ApS, Platinvej 29B, 6000 Kolding, Denmark, Phone +45-(0)7550-3500, *www.greenhydrogen.dk*

H-Tec Systems GmbH, PEM electrolyzers for industry application, Maria-Goeppert-Str. 9a, 23562 Luebeck, Germany, Phone +49-(0)451-39941-0, Fax -799, *info@h-tec-systems.com, www.h-tec.com*

Hydrogenics GmbH, Am Wiesenbusch 2, 45966 Gladbeck, Germany, Phone +49-(0)2043-944 141, Fax -6, *hydrogensales@hydrogenics.com, www.hydrogenics.com*

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

Proton OnSite, 10 Technology Dr, 06492 Wallingford CT, USA, Phone +1-(0)203-678-2000, *info@protononsite.com, www.protononsite.com*

ENERGY STORAGE

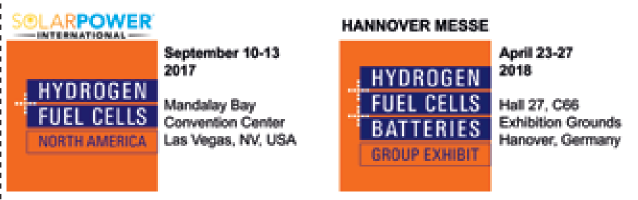
GKN Powder Metallurgy, GKN Sinter Metals, PO Box 55, Ipsley House, Redditch B98 0TL, Worcestershire, United Kingdom, *www.gkn.com/sintermetals*

HPS Home Power Solutions GmbH, Carl-Scheele-Str. 16, 12489 Berlin, Germany, Phone +49-(0)30-5169-5810, *mail@homepowersolutions.de, www.homepowersolutions.de*

Hydrogenious Technologies GmbH, Weidenweg 13, 91058 Erlangen, Germany, Phone +49-(0)9131-12640-220, Fax -29, *www.hydrogenious.net*

MicrobEnergy GmbH, Specialist in Methanisation, Bayernwerk 8, 92421 Schwandorf, Germany, Phone +49-(0)9431-751-400, Fax -5400, info@microbenergy.com, *www.viessmann.co.uk*

EVENT ORGANIZERS



24th 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*

European Fuel Cell Forum, Obgardihalde 2, 6043 Luzern-Adligenswil, Switzerland, Phone +41-(0)4-45865644, Fax 35080622, *forum@efcf.com, www.efcf.com*

Peter Sauber Agentur Messen und Kongresse GmbH, f-cell and BATTERY+STORAGE, Wankelstr. 1, 70563 Stuttgart, Germany, Phone +49-(0)711-656960-55, Fax -9055, *www.f-cell.de, www.battery-storage.de*

FITTINGS, REGULATORS, VALVES

Bürkert Werke GmbH, Mass Flow Controllers, Christian-Bürkert-Str. 13–17, 74653 Ingelfingen, Germany, Phone +49-(0)7940-10-0, Fax -91204, *www.burkert.com*

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*

FUEL CELLS

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*

Tropical S.A., 17 Krokeon Str, 10442, Athens, Greece, Phone +30-(0)210-5785455, Fax: -7, info@tropical.gr, *www.tropical.gr*

FUEL-RECIRCULATION AND AIR-SUPPLY

Gebr. Becker GmbH, Hölker Feld 29-31, 42279 Wuppertal, Germany, Phone +49-(0)202-697-255, Fax -38255, info@becker-international.com, *www.becker-international.com*

Busch Clean Air S.A., Chemin des Grandes-Vies 54, 2900 Porrentruy, Switzerland, Phone +41-(0)32-46589-60, Fax -79, info@buschcleanair.com, *www.buschcleanair.com*

GAS DIFFUSION LAYERS (GDL)

MeliCon GmbH, Metallic Light weight Construction, Porschestr. 6, 41836 Hückelhoven, Germany, Phone +49-(0)2433-44674-0, Fax -22, *www.melicon.de*

SGL Carbon GmbH, Werner-von-Siemens-Str. 18, 86405 Meitingen, Germany, Phone +48-(0)8271-83-3360, Fax -103360, fuelcellcomponents@sglgroup.com, *www.sglgroup.com*

HYDROGEN DISTRIBUTION

Hydrogenious Technologies GmbH, Weidenweg 13, 91058 Erlangen, Germany, Phone +49-(0)9131-12640-220, Fax -29, *www.hydrogenious.net*

Wystrach GmbH, Industriestraße 60, Germany – 47652 Weeze, Phone +49-(0)2837-9135-0, Fax -30, *www.wystrach-gmbh.de*

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Plansee SE, Bipolar Plates, Interconnects and Metal Supported Cells, 6600 Reutte, Austria, Phone +43-(0)5672-600-2422, *www.plansee.com*

ORGANIZATIONS

German 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*

hySOLUTIONS GmbH, Steinstrasse 25, 20095 Hamburg, Germany, Phone +49-(0)40-3288353-2, Fax -8, *hysolutions-hamburg.de*

National Organisation Hydrogen and Fuel Cell Technology (NOW GmbH), Fasanenstr. 5, 10623 Berlin, Germany, Phone +49-(0)30-3116116-15, Fax -99, *www.now-gmbh.de*

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REFORMERS

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

RESEARCH & DEVELOPMENT

Fraunhofer ICT-IMM, Reformer and Heat Exchanger, Carl-Zeiss-Str. 18-20, 55129 Mainz, Germany, Phone +49-(0)6131-9900, *info@imm.fraunhofer.de, www.imm.fraunhofer.de*

Fraunhofer ISE, Heidenhofstrasse 2, 79110 Freiburg, Germany, 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*

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*

SYSTEM INTEGRATION

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

Deutsche 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*

TESTING

SMART Testsolutions GmbH, Rötestrasse 17, 70197 Stuttgart, Germeny, Phone +49-(0)711-25521-10, Fax -12, *sales@smart-ts.de, www.smart-testsolutions.de*

TesTneT Engineering GmbH, Schleissheimer Str. 95, 85748 Garching / Munich, Germany, Phone +49-(0)89-237109-39, *info@h2-test.net, www.h2-test.net*

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