

# H<sub>2</sub>international

THE E-JOURNAL ON HYDROGEN  
AND FUEL CELLS



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# CONTENT

## 3 Legal Notice

## 4 Editorial

## 5 News

Kühn Tries His Luck with kraftwerk TUBES  
GP Joule Shuts Down H-Tec Education  
ElringKlinger Divests SOFC Business  
Linde Invests in Hydrogen

## 7 Trade Shows

f-cell – Back to the Roots  
Economy Ministry Supports Hydrogen Clusters

## 11 Stationary Systems

BlueGen: The Next Generation  
A Story About Trying to Buy a Residential Fuel Cell  
Extremely Efficient Energy Production

## 18 Energy Storage

Politicians in the North Show Their Support  
New Prospects for Bremerhaven  
Reap Wind Power, Fill Up Hydrogen  
Economy Ministry Draws Up National Hydrogen Strategy

## 28 Electric Transportation

Electric Workhorses, Up Close  
Thoughts on the Future of the German Auto Industry  
Who Is First to Abandon ICEs?  
A Car That'll Make You Smile  
Potsdam Meets 50-Station Target  
Double the eMove360° Experience  
Zero Emission Shipping Symposium in Hamburg  
e4ships 2.0 – Maritime Projects to Last

## 46 Research & Development

## 48 Stock Market

## 52 Global Market

Hydrogen and Fuel Cell Opportunities in the UK  
French Hydrogen Days in Toulouse  
Linz' Hydrogen Initiative

## 56 Events

## 57 Business Directory



7

Visit to SOLIDpower in Heinsberg



8

Hyundai Forges Ahead, Offers Cars and Trucks Alike



14

Most Cruise Liners as Dirty as Ever

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Fuel Cell Boats (Sources: Sandia National Laboratories, Broedre Aa, Water-Go-Round)

# CERTIFIABLY COMPLICATED

Dear readers,

One thing that became apparent at the IAA Commercial Vehicles was that the issue of hydrogen tank approval had yet to be resolved. Though it had already been said years ago that tanks “must only get approved,” the process is taking much longer than expected. At present, there are few 700-bar type IV units for sale in Germany.

The key reason for the lack of products seems to be that European automakers have not made a firm commitment to purchase tanks in large quantities for their vehicles. So far, OEMs have been ordering only few units for testing or integration into prototypes. At the same time, they have been demanding a lot from the manufacturers of those tanks, for example, by restricting the space in which units could be installed.

Tank manufacturers in Europe are deeply frustrated about the entire situation. Circumstances will not permit them to ramp up production capacity and make their business economically viable, so they are waiting to get products approved until companies start asking for more.

The outlook is a bit of a different for those manufacturing tanks for a pressure of 350 bars or 500 bars. Type IV units in that pressure range are available for sale. The needed tank volume is a bit higher than that for 700-bar ones, as the lower pressure level reduces energy density. However, 350-bar tanks, for example, are mainly used in commercial and railroad vehicles, which offer more space to install a unit. And 500-bar tanks are typically found in stationary systems, which is why they are produced in higher numbers, so that unit prices have fallen as well. Sometimes, more than a hundred of them make up a single system, which is sold as a containerized solution. For instance, in Meckenheim, Cologne’s mass transit company is planning to install a fueling station that includes a stationary container housing 162 individual 500-bar pressure cylinders with a total weight of 1 metric ton.

In Asia, the above-mentioned issues have already been dealt with. Toyota has built tank factories and uses 700-bar units in its Sora buses. Hyundai has partnered with a manufacturer that can rely on Nexo car sales to drive demand. By contrast, reports say Daimler will need barely more than 1,000 units for the time being and after a few fuel cell vehicles leave the factory, production will again be put on hold.

As for the tank manufacturers, they said that those many delays in bringing fuel cell cars to market in Germany had nothing to do with their products. The bottleneck was not the tank: Approval could be obtained in around 12 months.

Duisburg’s ZBT research institute, however, has determined that there is still some more work to do when it comes to hydrogen tank regulations. In partnership with the National Organization Hydrogen and Fuel Cell Technology, or NOW for short, and Germany’s Materials Research and Testing Institute, BAM, it will hold a workshop in Berlin for tank manufacturers from all corners of the country to figure out whether there really is a need for all those efforts to remove a pressure vessel from a system and test it for leaks by filling the tank with water.

Not without reason did the German transportation ministry launch a project called Delfin right before year’s end. Its aim is to develop a pressure vessel at a reduced cost

and weight. The ministry said that it would provide around EUR 7.5 million to “clear away one of the main barriers to market growth.” It is worth noting that the list of project partners includes not only automaker BMW, Daimler subsidiary NuCellSys and supplier Nproxx but also Ford. It has been a long time since the corporation announced anything fuel cell-related.



It seems there are still some points to clear up.  
Best wishes,

Sven Geitmann  
*Editor-in-Chief of H2-international*



## LINDE INVESTS IN HYDROGEN

Industrial gases producer Linde has a new hydrogen production system in Leuna, providing more evidence of the company's shift in strategic focus. On Oct. 24, 2018, Linde announced that it would add another hydrogen liquefier to its chemical manufacturing facilities in Saxony-Anhalt. The unit, scheduled to come online in 2021, would double production capacity to ten metric tons of hydrogen a day and would, like the old one, be linked to the regional pipeline system, through which it would be connected to the hydrogen production process. To meet customer demand for the ultra-cold fluid, Linde was likewise planning to increase the number of trailers carrying liquid hydrogen.

Jens Waldeck, who is in charge of operations in middle Europe, said that "the increasing use of hydrogen as fuel for road and railroad vehicles makes a liquefier a valuable, future-proof investment." Besides offering increased shipping capabilities, the unit was meant to improve product quality as well, he added. ||

## ETC SWEARS BY HYDROGEN

UK-based Enrichment Technology Company, or ETC for short, has decided to split its German E&MS subsidiary into two: On Sept. 27, 2018, it announced separate contact numbers for the new companies located in Jülich, where Nproxx Jülich has been put in charge of constructing hydrogen tanks, while Pronexos will manufacture carbon-fiber composites and rollers, among other things.

# NPROXX

ETC, which has offices in France, the Netherlands, the UK and the United States, had originally grouped several production services under a single brand, named EMS. Growing interest in hydrogen technology has prompted company management to create separate business units, with Nproxx B.V. developing the hydrogen tanks, so-called carbon fiber pressure vessels, and Pronexos B.V. taking on the remaining tasks.

The core business of ETC is uranium enrichment, particularly centrifugal technologies. The company originated with the UK-based Urenco Group, which underwent restructuring in 2003 and founded ETC in partnership with Orano, formerly Areva, in 2006. The joint venture has years of experience in building pressure vessels: In 2001, its engineers designed the first certified 300-bar Type IV tank. It is offering stationary tanks, including a storage system, for fueling stations but also Type III and Type IV carbon-fiber composite units for buses, trucks, vans and railroad vehicles, as well as ships and other sea vessels.

Reinhard Hinterreither and Olivier Marques-Borras, who have been managing Nproxx together from their new head office in Heerlen, Netherlands, said that the company believed in making hydrogen "a key energy source in the future." Production capacities would be expanded to meet that challenge. The EMS brand, however, will reportedly be discontinued. ||

## KÜHN TRIES HIS LUCK WITH KRAFTWERK TUBES



Fig. 1: Sascha Kühn [Source: Consilium Rechtskommunikation]

Many German fuel cell fans are still angry at Sascha Kühn, mostly not because his company's kraftwerk fuel cell charger has yet to be delivered but because Kühn has practically disappeared from the public eye. Months have passed since there was some kind of statement about if and how the original idea of manufacturing small high-temperature fuel cells with the help of crowdfunding could still be brought to market. Little is known about the company Kühn founded in the United States in 2016 following the bankruptcy of German-based eZelleron (see H2-international, August 2016). The same is true about the lawsuit filed against Kühn in early 2018 because of his late request for bankruptcy protection (see H2-international, April 2018).

In early December 2018, it came to light that Kühn was attempting a reset. In a letter H2-international received in reply to multiple requests for comment, his public relations agency Consilium Rechtskommunikation quotes Kühn as having said that he had obtained "a six-figure sum from Silicon Valley investors," in an effort to resume operations in Dresden. His company in the United States, kraftwerk Inc., had started to focus on manufacturing "only kraftwerk's core technology: the tubes." These small tubular-shaped solid oxide fuel cells, made of nano-laminated metal, were said to be at the core of every kraftwerk device and would be capable of generating electric power from a variety of fuel sources.

Kühn is further quoted as having said that his company's "customers have the expertise to incorporate our key technology into their products. kraftwerk has become an automotive supplier – nothing more, nothing less." In the letter, it also said that "three automakers, including Nissan's premium brand, Infiniti, have been working on kraftwerk cars to help transform the transportation sector." Likewise, there was mention of a manufacturer of drones named Sky-Watch. Furthermore, production had begun at the company's German subsidiary kraftwerk TUBES in November 2018. The subsidiary was established in October 2016 to succeed eZelleron tubes, set up in Dresden in May of the same year, around one month after the start of the eZelleron bankruptcy case. ||

## ELRINGKLINGER DIVESTS SOFC BUSINESS

Automotive supplier ElringKlinger has divested its department that manufactured solid oxide fuel cell, or SOFC, systems. In September 2018, the business based in Dettingen, Germany, announced that it would focus on low-temperature fuel cells used in vehicles. It sold SOFC operations, and its assets in new enerday, headquartered in Neubrandenburg, to Dresden-based Sunfire. ElringKlinger's chief executive, Stefan Wolf, said that "the PEM fuel cell is among those kinds of fuel cells especially suited for vehicle applications. It is also the kind of fuel cell that we have developed to maturity in past years and the one we intend to improve going forward."

Fittingly, Sunfire announced that it wanted to concentrate the development and production of residential SOFC systems in Neubrandenburg. Up until that point, the company's main offerings had been uninterruptible power supply systems with an electric capacity of 3 kilowatts. It was also intimately involved in the design of Vaillant's stacks for residential fuel cells. With the help of new enerday's fuel cell expertise and its 16 staff members, the company was planning to design a new decentralized power supply system. A limited number of 500 so-called Sunfire-Home units will reportedly be marketed this year through suppliers of liquid gas. ||

## SFC ENTERS HYDROGEN MARKET

SFC Energy, which has so far focused on methanol-powered fuel cells, intends to branch out into the hydrogen fuel market. In November 2018, the company based in Brunnthal, Germany, announced that it had signed an agreement with adKor to develop and license the required fuel cell know-how. The deal reached with adKor's chief executive, Hartmut Kordus, will grant SFC Energy non-exclusive access to the technology of three former fuel cell companies: FutureE, Heliocentris and P21.

Kordus said, "We've known the technology developed by FutureE, Heliocentris and P21 for a long time and we acquired the expertise and patents of all three because, based on 30 years' experience in telecommunications, we see great potential for fuel cells. SFC has been successful in designing and bringing to market fuel cells for demanding applications, which makes it an excellent partner for improving product quality and expanding the market."

Peter Podesser, the chief executive of SFC Energy, added that "the entry into the hydrogen world and the new, powerful hydrogen fuel cell technology will make for an ideal offering alongside our successful direct methanol fuel cells. The high-capacity products will allow us to show our customers new areas of application and explore large new markets." The aim was to design fuel cell systems that offered a capacity of up to 100 kilowatts and could be used especially for critical infrastructure, such as phone lines and backup generators. ||

## GP JOULE SHUTS DOWN H-TEC EDUCATION

December 31 last year was the date on which work at H-Tec Education officially ended. Still, the Fuel Cell Store (fuelcell-store.com) will continue the brand, as well as production, distribution and customer service. However, it was reported that, following the decision, 13 employees had been let go.

A GP Joule spokesperson told H2-international that management had a hard time deciding whether to divest its teaching materials business, but development and production could not be sustained, given the circumstances. "The budgets for purchasing models to show the workings of this forward-looking technology at public schools, universities and other educational facilities have been cut year after year," he said.

The industry was not all too surprised by GP Joule's announcement. It is well known that companies operating in the education industry have been facing some tough times. One of the business's competitors, Berlin-based Heliocentris, filed for bankruptcy protection as early as October 2016. Several others offering fuel cell courses have lamented the low attendance rates for their seminars. Consequently, the Energy Education and Training Center by the city of Ulm's trade association WBZU has drastically cut the number of courses it provides. And the East Bavarian Technology Transfer Institute, or OTTI, another organization that had offered hydrogen and fuel cell seminars from time to time, had to close down entirely in May 2017.

GP Joule stressed that the close-down was not a case for the bankruptcy court. All employment contracts were terminated for operational reasons, and after advance notice. In early December last year, it was reported that Trygve Enterprises was planning to acquire the rights to the brand, plus assets linked to product development and manufacturing, by inking an asset deal with GP Joule. Trygve has its own brand called Fuel Cells ETC, known for custom-made fuel cell components. In 2013, the company bought the Fuel Cell Store, an online marketplace with multiple hydrogen and fuel cell offerings, particularly in the field of education. At that time, the store and H-Tec had already been in a long-term collaboration dating back to 1999.

GP Joule, a project company based in Reußenköge, Germany, acquired H-Tec in 2011. After shutting down the teaching materials division, it is now planning to focus on H-Tec's remaining assets in hydrogen production and electrolyzer manufacturing. ||





Category: Conferences &amp; Trade Shows | Author: Sven Geitmann

# ECONOMY MINISTRY SUPPORTS HYDROGEN CLUSTERS

## NIP General Assembly in Berlin

Following a three-year break, the National Organization Hydrogen and Fuel Cell Technology held another NIP General Assembly between Dec. 5 and 6 last year. About 400 people came to Berlin to catch up on the latest developments regarding the National Innovation Program Hydrogen and Fuel Cell Technology, also known as NIP 2, or provide others with information about the same. The highlight of the event was the announcement of a new regional funding opportunity.

Steffen Bilger, who works at Germany's federal transportation ministry, was only present on the second day of the meeting but offered the most fodder for debate. He presented a new strategy to support the establishment of regional hydrogen clusters. More precisely, the aim was to integrate hydrogen as an energy carrier into local energy systems, especially in transportation.

Bilger said, "Support will be provided for heightening awareness of the technology and helping projects to take off, for creating integrated energy concepts and in-depth analyses, and for purchasing equipment to turn ideas into reality." Those interested in one of three new programs created by the government could submit requests to the National Organization Hydrogen and Fuel Cell Technology, or NOW for short. However, the only program accepting applications at present is HyStarter, which offers stakeholders advice on technical and organizational matters and two years of support to flesh out ideas. Every region in Germany can apply for HyStarter: There are no specific requirements that have to be met.

This spring will then see the launch of two more programs, which will rely on a panel of experts to rate projects and award grants. One of them is HyExperts, which specifically targets regions that have already identified their potential or have had experience in managing hydrogen or fuel cell endeavors. The grant total for this program will be EUR 1 million. By contrast, HyPerformer will have a budget of EUR 20 million to award money to clusters that are implementing preexisting plans.

**LACK OF STRATEGY** At the beginning of the meeting, the chief executive of NOW, Klaus Bonhoff, spoke about the achievements of NIP 2 in its first years in operation. He concluded that "all of us together succeeded in building up an industry." He said that "we really don't have to play down our accomplishments." Still, he cautioned that "we are without an actual strategy for hydrogen, even though we need one, and fast." He went on to mention countries such as Japan, which intended to make hydrogen a crucial part of its G20 presidency. To keep up, he called for a yearly 3 percent increase in the registration numbers of zero-emission vehicles. Implementing his idea would result in every fourth vehicle being powered by renewables in 2025 and every second in 2030, he said.

Afterward, the representatives from the three federal ministries involved in energy policy took the floor. What came as a bit of a surprise was that no high-level staff mem-



Fig. 1: Opening remarks prepared by the economy ministry.

bers seemed to have been sent to the meeting. For Wolfgang Langen, who works in the economy ministry's energy research department, it was one of few times he had ever stood before the hydrogen and fuel cell community. Langen succeeded Georg Menzen, who, after many years of serving in the ministry and as the chairman of the NOW advisory board, had gone into retirement. ||

7

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## BACK TO THE ROOTS

### Stuttgart's Haus der Wirtschaft hosts f-cell

In 18 years of managing the f-cell show, its organizers have seen many trends, and businesses, come and go. Some companies that used to exhibit at the event no longer exist. Some of the speakers at past events have worked for multiple employers in the meantime. And before last year's decision to move back to Stuttgart's Haus der Wirtschaft, the show itself took place on the city's showgrounds. No change seemed to have had a negative impact on the growth of the hydrogen and fuel cell community. Judging by the mood at last year's f-cell, quite the opposite has been true.

It seemed as if Peter Sauber and his team took up where they left off six years prior to the move to Stuttgart's trade show premises. The mood of those coming to the Haus der Wirtschaft was as optimistic as it had been in 2011. The number of exhibitors was about the same as well, with 41 showcasing their products last year versus 46 in 2011. Attendees also received a warmer and friendlier welcome than at the Landesmesse showgrounds, outside the city, where all of it had seemed much more impersonal. In his opening remarks, Helmfried Meinel, who works at the state's environment ministry, thanked the organizers for the warm reception he had gotten, stressing that the f-cell show had everything needed to make it a very special event. Klaus Bonhoff, the chief executive of NOW, agreed, saying it felt "good to be back in the Haus der Wirtschaft. I enjoyed coming here."

Of note was that the event's organizer, Peter Sauber Agentur Messen und Kongresse, had all but reinvented its business over the last years. A more up-to-date booth design was not the only new development. The biggest change came in the form of added opportunities for networking. For example, one area had been specifically designed for business matchmaking. Another became the location for roundtable discussions, with up to ten attendees coming together at one of three tables to have an hour-long debate about an issue suggested by a moderator. The tables had been set up in another room, away from the hustle and bustle of the show.

Another new feature: the workshops. While these were not limited in the number of people who could attend, moderators were still able to adapt the format to suit individual needs. For example, Frank Sreball gathered six attendees to

"Building more and more fueling stations is of little use if there aren't any more vehicles on the market. But all manufacturers can do is procrastinate. [...] The f-cell show is a mainstay of the sector."

Andreas Truckenbr

host a debate similar to the one during a political talk show, an experiment that was well received by the audience despite the hot and humid air in the room. Other moderators seemed to have some difficulties finding their rhythm, but there was much more discussion and social interaction than there had been in previous years.

**INPUT FROM ALL CORNERS OF THE GLOBE** Overall, the conference attracted a large enough audience. Most seats in the Haus der Wirtschaft's König-Karl-Halle were taken during the morning session on both days, right before people spread out to attend follow-on sessions in other rooms. The presentations given by speakers from Europe, North America and Asia painted a vivid picture of current developments in the hydrogen and fuel cell sector and the Austrian city of Linz provided attendees with some breaking news, as it was the place where the Hydrogen Initiative was founded around the same time f-cell was taking place. Furthermore, it was said that 800 hydrogen fueling stations would be in operation across Europe by 2025 and the Hydrogen Council announced that it had grown to 54 members. And a report about Japan mentioned a Hydrogen Energy Ministerial Meeting, which had taken place in October 2018.

Consequently, Bonhoff said that the "time was ripe to turn to mass manufacturing." He hoped for hydrogen to play an even bigger part in energy policy in the future. The demand was there, and commercial fleets powered by the gas would arrive soon, but "we still have work to do if our goal is to convince the government of a pro-hydrogen agenda," he said.

Some intriguing news came from Norway, last year's partner country. For example, in late September 2018, Nel opened a factory for manufacturing hydrogen fueling stations. Located at the headquarters of Nel's subsidiary H2 Logic in Herning, Denmark, it will reportedly put out 300 H2Station® units a year. Jon André Løkke, the chief executive of Nel, said his company built the large facility not just to demonstrate to automakers that it had the production capacity to ensure the rollout of fuel cell vehicles would continue, but that the plant's streamlined manufacturing operations could create the economies of scale required to meet demand in the future.

**THE NEED TO DELIVER** A highlight of the show was the panel discussion near the end of the second day, though some attendees who left early missed this interesting and entertaining opportunity. The key question during the session was what politics can do to help along a stuttering market transformation process and ease the challenge of establishing an integrated energy system.



Fig. 1: The conference room was as crowded as ever.



## DESERTEC

Ulrich Büniger, of Ludwig-Bölkow-Systemtechnik, suggested at the f-cell show to revive Desertec, after adapting the project to use gas pipes instead of power lines. Desertec originates with a business network that was set up in 2003 with the aim to collect solar energy in North Africa and export it to Europe. In partnership with energy suppliers, stakeholders in Desertec then founded a business called DII. The electric power companies that were involved in the project abandoned it in the middle of this decade, but the idea lives on. The gas industry could, in a second run, take over and transport solar energy, stored in hydrogen, from the Sahara to western Europe, Büniger said.

[www.desertec.org](http://www.desertec.org)

From time to time during the debate, Jorgo Chatzimarkakis raised his voice and lamented the lack of action by Europe's automakers, which drew spontaneous applause from the audience. He emphasized that "too little is happening, I can't stress that enough. German businesses act too cautiously. We need to deliver." He also said that those who used to slow down the process had been replaced by staff more open to new approaches. And he acknowledged that "disruptive technology," as he called it, would bring many changes to the market, noting what happened to Nokia. Once a cell phone giant, the company came under a lot of pressure in 2012. It was a rise-and-fall story that automakers would want to avoid repeating.

Chatzimarkakis sees profound change as an opportunity to seize rather than a risk to avoid and stated multiple times during the debate that "as a European industrial association, we are now calling for tangible results." He believes there is great potential for hydrogen, especially in energy storage. In that context, he spoke about an alliance to build 40-gigawatt electrolyzers and large-scale projects that could provide jobs and energy security.

Another issue discussed by the panel was the German government's missing guidance on the transformation of energy markets. Time and again, one could hear people saying that "what we need now is a strategy."

**F-CELL APP** The organizers offered a smartphone app created specifically for this event. While it was a modern approach to communication and logistics, frequent server errors and a rather non-intuitive graphical interface created some difficulties. Yet, the idea of digitizing the show has the potential to provide new opportunities for collaboration and networking. What needs to be kept in mind is that most attendees were, and most likely still are, not used to communicating in this way.

**F-CELL AWARD** In 2018, the f-cell award ceremony took place in Stuttgart's Stadtpalais building. Andre Baumann, who works at the German state of Baden-Württemberg's environment ministry, noted in his speech that the "auto industry is experiencing disruptive change." He spoke about both the many opportunities of electric transportation and its drawbacks, saying that "the extensive use of critical materials is riddled with issues. All too often, they originate in countries rife with conflict." He added that fuel cell production was much less controversial.

Baden-Württemberg's environment ministry supported the f-cell awards with EUR 40,000. Last year's spotlight



Fig. 2: Baumann (l.), together with last year's winners

on Norway originated with a trip taken by the head of the ministry, Franz Untersteller, who could see in person how much progress the Scandinavian country had made in the hydrogen and fuel cell sector. What he observed left such an impression on him that he was intent on finding a way to recognize Norway's achievements.

Daimler was part of the debate as well, albeit for a different reason. It seemed as if not a single Daimler staff member had made it to the show. Some may interpret this as having been a conscious decision to boycott the event, although once upon a time the automaker had been f-cell's main sponsor.

**AN OPTIMISTIC OUTLOOK FOR 2019** Speakers and attendees agreed that it was time to act. Never before have calls for politics to intervene been as detailed as they are today. More pressure needed to be put on market players and stricter emission limits had to be set, many were heard saying. Politicians would need to signal that they were willing to do something and create a stable environment for businesses and the ongoing energy market transformation.

The number of attendees – around 1,000 overall – was markedly below that of 2011, since this time around, no separate tickets were available to see only the exposition and no invitations had been extended to students or teachers, as in the years before. Still, most exhibitors were satisfied with how the show went.

Accordingly, nearly all attendees left f-cell in a good mood, certain that 2019 will see an engaging event return to the Haus der Wirtschaft. The one in 2018 had given everyone a lot of new ideas.

One heartwarming moment was Sauber's speech at the end of the show, when he said how grateful he was to have a staff like his, and especially an assistant such as Silke Frank. Frank again proved her organizational skills in 2018 by preparing and managing the f-cell show, making it clear that if she needed to take over management of the company someday, she would be ready from day one. ||

Besides organizing FC Expo in Tokyo, Peter Sauber Agentur staff will be flying to Vancouver this May 22 and 23, when the North American f-cell edition is scheduled to run in parallel with the Hydrogen and Fuel Cells summit by Canada's fuel cell association CHFCA.

# FUEL CELL ENGINES MADE IN SAXONY

## HZwo Technology Forum in Chemnitz

The German state of Saxony is slowly turning into a hub for hydrogen and fuel cell technologies. On Nov. 29, 2018, around 160 people headed to Fraunhofer IWU in Chemnitz to attend the HZwo Technology Forum, at which Martin Dulig, Saxony's economy and transportation minister, started up a new system manufactured by Fuel Cell Powertrain.



Fig. 1: Thomas von Unwerth

Like Hydrogen Power Storage & Solutions East Germany, or Hypos for short, HZwo was set up by a consortium of companies with the aim to spur investment in the hydrogen and fuel cell sector across middle and eastern Germany. While the HYPOS network stretches over multiple regions and focuses on hydrogen production and storage, the main target group for HZwo is Saxony's supplier industry. Based in Chemnitz, the HZwo innovation cluster is being backed by prominent figures from the state, such as Saxony's economy minister Dulig, who said in his keynote speech that the state needed more than "just new ideas: We need opportunities to create added value." To strengthen partnerships between participating organizations, the state government will provide the cluster with around EUR 1.6 million until 2022.

Now, multiple stakeholders are seeking to convince as many businesses as possible to relocate to the region, in an effort to build "engines for Saxony," as the tagline goes, and set up collaborations. For many years, the area between Dresden and Freiberg has been home to companies and research sites that develop high-temperature fuel cells running on natural gas. Among them are DBI GUT, multiple Fraunhofer institutes and businesses such as Sunfire and kraftwerk TUBES (formerly eZelleron, see p. 6). In essence, the region is already on its way to becoming a hydrogen cluster.

Professor Thomas von Unwerth, HZwo's founder and chairman and the director of the Institute for Automotive Research at Chemnitz University of Technology, had set up a platform for networking, the Chemnitzer Initiative Technologien der Elektromobilität, as early as 2011. His goal was to deepen cooperation with the Fortis Saxonia student team, which participates in Shell's Eco-marathon on a regular basis. By contrast, HZwo focuses mainly on securing Saxony's leading role in the development of fuel cell vehicles and hydrogen equipment.

Two years ago, HZwo was made up of only three companies based in the state, namely WätaS Wärmetauscher Sachsen, Auerhammer Metallwerk and Von Ardenne, and three research organizations, Chemnitz University of Technology, the Steinbeis-Innovationszentrum Fügetechnik and the Institut für angewandte Energieforschung. In the meantime, the cluster has grown to more than 50 members.

The project is being managed by the HZwo association, Chemnitz University, Fraunhofer IWU and a partner to the consortium, the Energy Saxony association. The aim is to determine what potential a state such as Saxony has for establishing an entire value chain centered around fuel cell vehicles, while medium-term plans include the construction of a hydrogen and fuel cell center of excellence on the Smart Systems Campus in Chemnitz. And that is not all: Starting in 2020, Fuel Cell Powertrain will reportedly build one of the largest testing facilities for fuel cells and electric motors in Europe in the city.

In short, Chemnitz is intent on becoming a region known for its fuel cell products throughout Europe. And so it was Dulig who started up Fuel Cell Powertrain's new PEM system at the Technology Forum while all eyes were on him – a clever PR move. The company's chief executive, Thomas Melcer, showed at-

"We don't need any more debates about whether the technology can be brought to market. We put that issue to rest a long time ago."

Martin Dulig,  
Saxony's economy minister

"Hydrogen will be the key to future resource management."

Professor Welf-Guntram Drossel,  
Executive Director of  
Fraunhofer IWU

tendees at the event what the 2.5-kilowatt air-cooled prototype is capable of. Once it comes to market, it will be sold as an uninterruptible power supply, for example, to guarantee the availability of telecommunications at all times. But Melcer's ideas go far beyond stationary applications. He said that he could imagine the company's water-cooled 30-kilowatt systems being used in vehicles too.

Fuel Cell Powertrain is a joint venture between PTT Power Train Technology and Chinese Investor HET. It has 24 staff and is planning to start initial low-volume production of 2.5-kilowatt modules this summer. HET will invest about EUR 120 million into the Chemnitz site over three years, it is said, even though the commercial version of the modules will be produced in China. ||



Fig. 2: Uninterruptible power supply by FCP



# FUEL CELLS AT HOME: LOOKING FOR OPTIONS

## *A story about trying to buy a residential fuel cell*

What do you do when your heating system stops working? Of course, you call the company that installed it. And what if they tell you that repairing your 22-year-old gas boiler isn't worth it anymore? Which system is affordable yet state of the art? Do you want a condensing boiler or rather a home fuel cell? Where can you get the information you need? Who can you talk to? H2-international's Editor-in-Chief Sven Geitmann went looking for answers and this is his story of what happened.



Fig. 1: Oliver Koukal and Marcus Hahn, both for Bosch Thermotechnik, standing next to Alberto Ravagni, the chief executive of SOLIDpower Italy, and Andreas Ballhausen, the CEO of SOLIDpower's German subsidiary. [Source: Florian Gerlach/vor-ort-foto.de]

The breakdown of our heating system wasn't really a surprise. It started causing trouble several years ago. But luckily for us, we had a maintenance contract with the manufacturer. Since we signed that contract, numerous components, including the igniter and the seals, had had to be replaced to keep the heater operational. Then, right at the beginning of the heating season, the thermostat turned off on its own several times a day, so the system was barely up and running. It was the day it became obvious we needed a new heater.

First, I called the installer who had given me the sad news of the impending end of the unit and asked him for a quote to install a new condensing boiler. He promised to forward the request in-house but said that he couldn't offer me much. He didn't know enough about residential fuel cells and a heat pump wasn't an option either, as there was no underfloor heating in my house and the pump needed a low flow temperature. So, I went looking for some alternatives.

**CHAOS ONLINE** My initial, spontaneous search online didn't yield much beyond some general descriptions of residential fuel cells, their workings and the chemical processes that take place inside a stack. Homeowners who end up in a situation like mine, however, would be much more interested in, for instance, a list showing them what kinds of heaters they can buy, what these heaters can be used for, which benefits and drawbacks they have, and how much they would cost. Likewise, a useful tool would be an online calculator to compare the prices and running costs of condensing boilers and home fuel cells.

I took a look at the new website of the Fuel Cell Initiative, or IBZ for short. It not only featured a nice set of ads but immediately showed me some information about home fuel cells and their manufacturers. After searching for a bit, I even managed to uncover more details on those units currently for sale on the market. However, the fuel cell device list that the IBZ used to publish had apparently been taken down. I went through my magazines and pulled out the H2-international issue from November 2016. I turned the pages until I found the article I had thought about. It included a table replete with specifications, images and prices of fuel cell devices people could buy two years ago.

Several things happened within the last two years, though. For one, Vaillant put fuel cell development on hold. Additionally, Elcore was acquired by Freudenberg. I emailed Freudenberg anyway. SOLIDpower's Blue-Gen unit would not go on my list and neither would inhouse engineering's inhouse5000+. Both were designed mainly for use in larger buildings, such as apartment complexes and offices. >>

### KEY QUESTIONS:

- Do you have a gas hook-up available?
- Are you the only family living in the building?
- Are you building a new home or are you renovating one? If it is the latter, what year was your home built?
- How many people are part of your household?
- How much space needs to be heated?
- How much electricity and gas do you use per year?
- Do you have a solar thermal or PV system installed?
- Is the ceiling at least 6.6 feet (2 meters) above floor level?
- When do you wish to start?
- What is your ZIP code?
- Do you want to apply for the government's incentive program?

**WHEN WILL IT PAY OFF?** One glance at the prices, and it became clear to me that I had to pay a lot more, or, more specifically, six times as much, for fuel cell technology than for conventional heating. Yet, home fuel cell buyers are rewarded with an incentive of up to EUR 11,000 and the units are seen as more efficient than traditional systems. What I had to ask myself was, “Do lower running costs mean I’ll be able to recoup my investment at some point? And if not, will I at least break even?”

I contacted the suppliers that I wanted to speak to, either by emailing them or filling out their online forms. The first to respond was Viessmann, which did so in the morning of the following work day. A highly competent call center employee took me through the process and asked me some key questions (see box). She also wanted to know whether I had contacted any other companies, to which I replied I had, and said that a local dealer would get in touch with me as soon as possible. Likewise, I would receive an email containing all relevant information. A few minutes after our call, a new message popped up in my inbox, showing me the name of the installer that I could arrange an appointment with to discuss my options.

I searched the web again and was able to find some more products. SenerTec’s devices are one example. The business’s website features several short video clips to provide potential customers with more information on the company’s CHP technology. Besides its well-known Dachs Gen2 unit, SenerTec has a fuel cell system by the name of Dachs InnoGen. It is a good fit for homes with low heat requirements. Several conversations by phone and email later, I was given the address of the company’s Berlin-Brandenburg call center. However, even after 10 days, I still hadn’t received a reply. Well, the marketing department sent me some material.

Buderus and Junkers, whose products and online presence have a similar look and feel because they are owned by the same company, Bosch Thermotechnik, answered my requests for quotes with their own questions about my home’s boiler room, so they could offer me a custom solution.

Freudenberg emailed me back too, providing me with detailed information and asking me questions about the installation space reserved for the device. However, “the recent purchase of fuel cell technology,” the company said, had made it necessary to postpone deliveries of Elcore devices until spring 2019. I couldn’t wait that long, of course, so I struck the business off my list.

The manufacturer of my old heating system presented me with an offer only two days after I had sent images of the boiler room in my house. Its quote for an 18.2-kilowatt wall-hung condensing boiler came to EUR 4,750. This included not just the VAT but the cost of dismantling and removing the old and shipping and installing the new unit. The estimated installation time was as little as one day – we wouldn’t need to sit in the cold for very long.

**A CHAT WITH AN EXPERT** I had the first opportunity to discuss my fuel cell options with one of Viessmann’s local installation companies, MAWI Haustechnik. The business’s president himself, Uwe Kamenz, showed up for the meeting. We had a very pleasant conversation, throughout which he provided expert advice and in-depth insights into the workings of the system. He also found some time to chat with me about the situation in the market. As I thought, we were soon faced with two problems regarding my idea of installing a residential fuel cell. First, the installation space was not big enough, as there was neither a basement nor a laundry room to put the system in. Second, I would have to pay almost EUR 29,299 including VAT, that is, EUR 20,000 after taking off the incentive.

During an earlier phone conversation with someone at Viessmann’s headquarters, I had already found out that the Vitovalor PT2 unit, which the business had been offering with or without a backup system since April 2018, would be a bit cheaper than the older product, named Vitovalor 300-P and priced at EUR 19,500 without VAT. However, the question was if that was still true even after taking into account the amount of work required at my house to install the device.

Kamenz said the new Vitovalor generation offered some improvements. For example, the fuel cell was capable of generating electricity for 43 hours straight before entering a two-hour charge cycle. Viessman had also been able to extend maintenance intervals from two to five years, although the backup system would still need to be inspected once a year. The backup was “a tried-and-trusted boiler, Viessmann 200 series,” with some tweaks to the hydraulics, he said. One minor drawback was the lack of smartphone-based energy management, but that feature would be added soon.

If everything went according to schedule, an authorized dealer would install the device in around two days

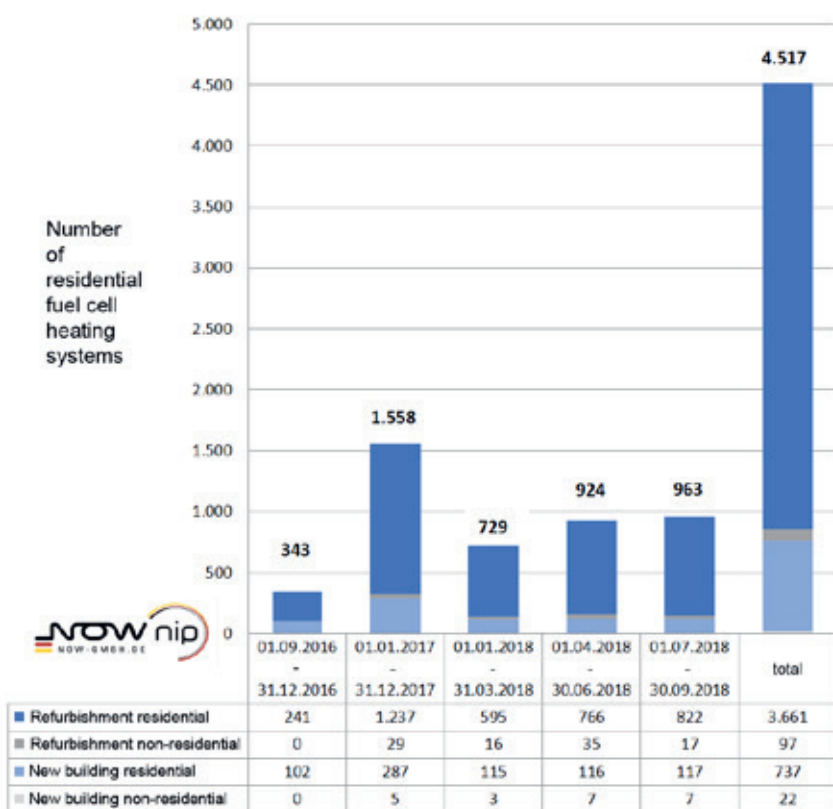


Fig. 2: Funding applications approved until June 2018 [Source: NOW, KfW]



and employees of the fuel cell manufacturer would start it up. The only caveat: Funding applications would have to be submitted before anything else was done. In all, it would take four to six weeks to bring the device online.

When I asked Kamenz about the lifetime of a fuel cell stack, he openly told me reliable information was hard to come by, even in Japan. Panasonic had said its stacks had a 10 percent degradation rate and an estimated 15-year lifetime, he added. And because changing a stack could cost several thousand euros, Viessmann's fuel cell unit came with a 10-year guarantee on workmanship and performance, one of the government's requirements for paying out a fuel cell incentive at all.

**BABY STEPS** The other manufacturers I asked gave comparatively short replies. Bosch Thermotechnik forwarded my emails to its distribution partner Thermo-ondo, but the latter no longer offered fuel cell devices. A company employee confirmed that the supplier had partnered with multiple manufacturers many months ago. Yet, after thinking it over, the business had decided to take down its fuel cell offerings. I was told to try it again at Bosch.

Bosch Thermotechnik is indeed designing home fuel cells of its own. But although it has made devices available through its Buderus and Junkers brands, a spokesperson said those were still in development and not yet ready for sale. To speed up the process, the business announced last June that it would partner with SOLIDpower to sell systems starting in the last quarter of 2018. At the time of my search, Bosch had neither a Logapower FC10 unit made by Buderus nor a Cerapower FC10 one made by Junkers in store. Originally, it had wanted to launch those two solid oxide fuel cells with 0.7 kilowatts of electric and 0.62 kilowatts of thermal power in 2016.

By contrast, the BlueGen device produced by SOLIDpower has been available for sale since 2012, though it was designed mainly for consumers with higher electricity needs. Oliver Koukal, the head of Bosch Thermotechnik's business unit dealing with residential heaters, explained that the aim of the collaboration with SOLIDpower was to "combine BlueGen units with our current product offerings to create efficient, comprehensive solutions." At the same time, Bosch cautioned that the "while the German market for residential fuel cells has grown at a fast rate, the cost of today's units means that these heat generation devices are confined to a niche market, at least for the time being."

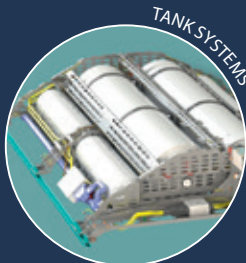
**IN SHORT** The results were mixed. At the time of writing, I was still waiting for quotations from MAWI and Viessmann. In my situation, it seems there is little in the way of alternatives to a gas condensing boiler, since it would require a much greater monetary commitment than I was willing to make. Luckily, the old system is running again, just like that, without any repairs, but no one knows for how long. The story will continue. ||

#### KFW FUNDING

KfW program 433 has been supporting the residential fuel cell market since 2016. Erik Schumacher, the head of the stationary fuel cells division at the National Organization Hydrogen and Fuel Cell Technology, also known as NOW, said that funds would be available to all who had a "consultation with an energy efficiency expert, during which the feasibility of the installation could be assessed." He also said the "funding program has been quite popular [see fig. 2]."

13

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# BLUEGEN: THE NEXT GENERATION

## *A site visit to SOLIDpower in Heinsberg*

Twelve years after the first BlueGen system came to market, SOLIDpower will launch the next generation of its fuel cell units, called BG-15, in spring. On Nov. 21, 2018, it celebrated the new product announcement by taking partners, employees, the press and many other invited guests on a tour of its manufacturing plant in Heinsberg, Germany.

After many years of turmoil, during which SOLIDpower was reorganized several times, the business can now focus on marketing and selling its new fuel cell device. Andreas Ballhausen, the chief executive of the German subsidiary, took advantage of the opportunity offered by the factory tour to outline his plans for growth. The aim was to have a broad product portfolio in a few years' time, including devices in other application areas, such as datacenters. To raise production capacity and cut costs, the company also intended to build a production plant at its headquarters in Mezzolombardo, in northern Italy. Further plans were to add LNG systems to the business's range of natural gas-powered systems and gradually offer higher generation capacity, up to 100 kilowatts.

**FROM MANUAL TO SEMI-AUTOMATED** One will have to wait and see whether those expectations can be met on schedule. What is more important at this time is that the BlueGen BG-15 unit is making the business automate part of manufacturing. While a lot of progress has been achieved since October 2009, when SOLIDpower, formerly known as CFC, started production in Heinsberg (see HZwei, April 2010), BlueGen devices are still assembled manually. It takes two hours to stack 51 cells on top of each other before layers and seals can be added, and some workstations are staffed by not one but two employees to minimize errors. Additionally, to meet the standards the company has set for itself, inbound goods are inspected visually, partly under a microscope. "Today, the focus is on making top-notch products," said Ballhausen.

He believes that there is still much work to do to convince people, particularly installers and end customers, of the technology's benefits. Of course, putting in all that effort comes at a price. Hopes are that the new production plant in Mezzolombardo, where stacks would be made starting in 2020, will increase annual capacity to 16,000 units, the equivalent of 50 megawatts, while reducing the time and money spent on individual components.

Despite continuous improvements to the micro-CHP setup during the production run of the previous unit, of which the company sold over 1,000, Ballhausen said the new BlueGen device was a big leap forward. The assembly line is already being adjusted to prepare for the start of manufacturing, and the plan is to complete the switch to the new technology by May 2019.

SOLIDpower Italy, based in the region of South Tyrol, was created in early 2015 from SOFCpower, a company set up in northern Italy in 2006, and HTceramix, which was spun off from the Swiss EPFL research institute and sold to the former in 2007. Shortly after its founding, the newly minted business acquired the technology portfolio of Ceramic Fuel Cells, or CFC, based in Australia. CFC, which had been the first ever to make BlueGen devices, had just filed for bankruptcy protection along with its German subsidiary. Today, SOLIDpower has 230 staff members and offices in Australia, Germany, Italy and Switzerland. It currently aims to expand its influence in the market and explore new business opportunities in Asia and the United States.

It should be noted that the BlueGen micro-CHP unit was not designed to meet the needs of small families. Rather, it is suited for those using a somewhat greater amount of electric power. The unit's 1.5 kilowatt of capacity will result in about 13,000 kilowatt-hours per year, roughly four times the electricity a family of four needs in that time. It also produced around half as much carbon dioxide as an energy generation device powered by internal combustion, the company said.



Fig. 1: Alberto Ravagni standing next to a BG-15 unit.



BlueGen is an electric-led system. This means the solid oxide fuel cell inside the unit prioritizes electricity over heat, though it produces both at the utmost efficiency. Any surplus can, for example, charge an electric vehicle or supply the grid. The latter will make the owner eligible for incentives under Germany's CHP Act. The system also produces thermal energy. This energy can now be stored in a 250-liter tank, larger than that of the old unit. It is used for hot water production and space heating, albeit some system will simply release the heat into the atmosphere.

Even though the electric efficiency of the BlueGen B-15 unit is around 5 percent lower than that of the old product, a few modifications to the setup have increased thermal capacity to 850 watts, from 600 watts. "Customers won't notice the difference," said Ballhausen. "It's just an industry expert's numbers game." In short, round-trip efficiency will be about the same.

Nevertheless, the company has introduced some fundamental changes. For example, the unit can now be managed through an app. Power output can also be modulated, that is, adapted to room conditions. The fuel cell will still run continuously, but capacity can be set to anywhere from 0.5 kilowatts to 1.5 kilowatts. However, adjusting output is certain to put some strain on the stack, so that the setting should not be changed to a point where it would prompt a sudden, large difference in electric power generation. The exhaust pipes used to be made of stainless steel, since the device produced high temperatures at the outlet, but the new unit can be sold with plastic ones too. Likewise, installation and maintenance will be carried out at the front and no longer at the sides, which will make it easier to put multiple devices next to each other without having to leave much space in between.

Installing the mCHP system was a simple task, said Guido Schäfer, the president of a BlueGen partner company: Put it in place, connect it, turn it on. All of that took maybe 15 minutes, he added. "It's a dream come true for installers. But you need to know a bit about both, electricity generation and heat production." He had installed as many as 15 BlueGen devices personally, though he spent most of his time discussing each job with the customer. However, that might be necessary if the system could also charge an electric vehicle on-site, Schäfer said.

To ensure that customers can enjoy the system for a long time, the company offers a 10-year maintenance contract to cover all eventualities for a net price of EUR 600 a year. The agreement includes not only repair jobs but also the stack replacement, which will likely be required after five to seven years. "The guaranteed minimum efficiency is 50 percent throughout," Saxo Dyzak, sales and business development manager at SOLIDpower, said during the factory tour. The price for the new unit would be close to the old one.

**BOSCH MAKES THE SALE** SOLIDpower uses a twin approach to grab the attention of the market. As for the old device, it signed a cooperation agreement with Buderus, a brand owned by Bosch Thermotechnik, which gives the fuel cell manufacturer access to a sales network used by suppliers of conventional heating systems, such as Bosch and Viessmann. The agreement is a big benefit to a business that hasn't been around for decades. Alberto Ravagni, the chief executive of SOLIDpower Italy, said the idea was "to create a mass market for fuel cells to cut production costs and stop relying on incentive programs." And Ballhausen added that "Buderus' popularity and reach will help make BlueGen a household name."



Fig. 2: Andreas Ballhausen flanked by the old and new generation of BlueGen devices.

He also explained that the new unit was not distributed in this way but offered by SOLIDpower's around 200 retail partners. At the event marking the product launch, he seemed confident that it wouldn't need large market players to sell the heater. He noted that the device could be put next to an existing one to upgrade the heating system and added that he could imagine it also being used to create entirely new business models, for example, by integrating on-site electricity generation into a so-called energy cloud. Overall, there seemed to be enough ideas being floated to seek out new markets. First, though, one will need to see if customers take a liking to the new BlueGen system. ||

"We have partnered with Shell to build a fueling station that can deliver both hydrogen and electricity."

*Alberto Ravagni, SOLIDpower Italy*

"We expect the government to start reducing incentives in 2020 or 2021."

*Andreas Ballhausen, SOLIDpower Germany*

# EXTREMELY EFFICIENT ENERGY PRODUCTION

## Fuel Cell Innovation Forum



Fig. 1: IBZ spokesperson Timm Kehler



Fig. 2: IBZ spokesperson Andreas Lücke

Early into the Fuel Cell Innovation Forum, organized by the BDH and Zukunft Erdgas, both spokesmen for the Fuel Cell Initiative, or IBZ for short, were visibly tense, seemingly worried that the government might drop its support for residential fuel cells. But after Thomas Bareiß, who works at the German economy ministry, told those gathered on Oct. 10, 2018, in Berlin the heaters had been short-listed for incentives in 2019, you could hear them breathe a sigh a relief. Then, last November, the Bundestag confirmed that it would keep funding home fuel cells. Now, work can start on cutting through all the red tape that has been haunting applicants to this day.

In fact, there was no reason to be worried, as the government had, on multiple occasions, assured the industry that the National Innovation Program Hydrogen and Fuel Cell Technology, also known as NIP 2, would run until 2026. But since program funds must be approved every year following an annual budget debate in parliament, there was some uncertainty as to whether lawmakers would release the mon-

ey allocated to incentive program 433 beyond August 2019. By making funds available until the end of this year, they have prevented what would have been the first setback in the buildup of a nationwide market for residential fuel cells.

Incentive program 433, which is being managed by the German KfW bank and was launched in 2016, had been “popular among consumers,” said the two IBZ spokesmen, Andreas Lücke, the executive director of Germany’s national heating association BDH, and Timm Kehler, the chief executive of the Zukunft Erdgas advocacy group. By August 2018, the government had approved around 4,200 applications.

The IBZ sees a bright future for fuel cells, saying residential systems were the key to a new energy system, since they were “a mature technology that is, without exception, available to everyone across the country.” The Fuel Cell Innovation Forum was the first big event to see the new make-up of the Fuel Cell Initiative taking shape. Up until early 2018, it had mainly been a consortium of companies dedicated to research and demonstration. Now, after two large organizations representing the gas and heating industry have joined the group, its members are hoping for a fast-track way to growth. This development is especially important considering the few changes in the home heating market, where investment in renewable energy is typically limited to new construction, even though “the biggest opportunity to combat climate change is in existing building stock, where more than six in 10 heating systems are out of date and thus inefficient,” the IBZ stated.

“Our aim is to create a market environment in which fuel cell businesses can thrive.”

*Andreas Lücke, BDH*

“This event marks the start of a new era in launching fuel cell products.”

*Timm Kehler, Zukunft Erdgas*

“NIP 2 is going to continue.”

*Thomas Bareiß, German economy ministry*

**A SLOW-CHANGING MARKET** The current challenges in home heating are that it is plagued with burdensome regulation, which is particularly unnerving to those trying to install combined heat and power systems, and, according



to Kehler, that it “is one of the slowest-changing markets in manufacturing.” For example, while condensing boilers were introduced 30 years ago, their market share is still sitting at around 30 percent. Bareiß concurred and said that “transforming the energy market will be a massive undertaking.” But he also said that “we urgently need to ease the pressure on fuel cell companies, in the realms of policy and public opinion.” Sustainability targets could not be achieved if “we focus all our efforts on making every device run on electricity. We likewise need to advance the creation of an integrated energy system.”

He stressed that the current government-sponsored program to renovate existing building stock had “as much money available as never before.” The situation in the market had improved in part because of a stark increase in carbon prices, which rose from EUR 5 per metric ton of carbon dioxide in mid-2017 to more than EUR 20 on some days in the middle of last year.

The downsides of any incentive program are the huge amount of paperwork people have to complete and the time they need to spend on writing applications and answering questions. Gerd-Dieter Krieger, the director of the VDMA association’s Fuel Cells working group, said that while as many as 200,000 home fuel cells had been installed in Japan, Germany first needed to cut down the red tape surrounding the process before the market could grow. Lücke agreed, saying that those operating a CHP system in Germany had to register as businesses and fill out a myriad number of forms each year, and anyone submitting those forms past the deadline would face severe penalties.

Andreas Ballhausen, SOLIDpower’s chief executive, said that Germany’s renewable energy laws, energy and gas taxes, and the questions asked by chimney sweepers would also deter some prospects from buying those kinds of systems.

“Had I known how much of a pain all of this would be, I wouldn’t have ordered the system.”

*Hagen Fuhl,  
of SenerTec Kraft-Wärme-Energiesysteme,  
quoting a customer*

“What have I ever done to you that you’re asking me to fill out this boatload of papers.”

*Frank Ziegeler,  
of Ziegeler Solar + Haustechnik,  
quoting an employee*

Additionally, attendees at the Fuel Cell Innovation Forum agreed that the industry needed a new and improved communications and marketing strategy. In particular, businesses would have “to keep everyone involved up to date and train the trades and the developers,” according to the IBZ. Only then would greater production output translate into lower prices and higher sales. Frank Ziegeler, the owner of Ziegeler Solar + Haustechnik, who has a lot of practical experience in dealing with home fuel cell installations, said the “new technologies are not only available but have matured enough. What we need is to show less hesitation and put them to good use.” ||



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# WIND POWER BOOSTS HYDROGEN TRANSPORTATION

## *Renewable gas for industry and vehicles*

Thanks to NEW 4.0, the German state of Schleswig-Holstein is rapidly turning into a showcase for the energy market transformation in the country. The abbreviation stands for a growing innovation alliance, formed on the threshold of the fourth industrial revolution, which intends to create a smart and interconnected energy system. One of the many NEW 4.0 projects is Wind to Gas Energy's hydrogen venture in Brunsbüttel. Within three years, the business's chief executive, Tim Brandt, managed to secure funding and build an electrolyzer supplied with clean electricity from a nearby wind farm. Now, the business is planning to bring an injection point and a hydrogen fueling station into operation.

Brandt's project is one of a number of endeavors being launched in many places in the north of Germany. All of them aim to establish a smart energy system to prevent wind farm output from being curtailed, so that it could be used, in the form of renewable hydrogen, to fill up the tanks of fuel cell vehicles or the natural gas grid. Ever since turbines were repowered statewide, surplus wind energy has been available in abundance.

To push forward with ideas for using the surplus, Brandt, who, around three years ago, wrote his thesis on the application of power-to-gas, and Hans-Reimer Thießen, a pioneer in wind energy since the early 1990s, set up Wind to Gas Energy. Thießen is also its second chief executive. Today, they manage a 15-megawatt wind farm, made up of five Enercon systems, north of Brunsbüttel. The electric power is transferred through 3.5 miles (6 kilometers) of cable running 89 feet (27 meters) below the Kiel Canal to the Covestro industrial area. As part of a test launched at the end of 2017, some of the energy is then stored in a 2.5-megawatt battery made by ADS-Tec and located at the Ostermoor substation.

As of late, the core of the project has been an electrolyzer with a capacity of 2.4 megawatts. It can produce 450 normal cubic meters of 30-bar hydrogen per hour. This corresponds to 40 kilograms at a fueling station cost of EUR 9.50 a kilogram. Daily output could power a fuel cell vehicle for 2485.5 miles (4,000 kilometers), explained Brandt. Considering that the wind farm was in operation for 3,000 full-load hours a year, it could produce two million cubic meters of hydrogen, or around 180,000 kilograms, that way.

During an on-site visit, Brandt proudly presented the innards of the HyLYZER-400-30 unit. He said Hydrogenics had won the bidding because it had offered the best value for money among five companies.

It was reported that the injection point had not been put up as scheduled at Bioenergie Contracting (see H2-international, December 2017). Brandt said the Covestro industrial area in Brunsbüttel, where the system is now located, was "a significantly better site to inject the gas into the network."

**INJECTING GAS AT 70 BARS** However, what exactly is happening in the marshland, where hydrogen is being produced by electrolysis? At first, it will reportedly be Schleswig-Holstein Netz that will inject the gas into pipelines. Last fall, construction began on two redundant compressors to provide hydrogen at 70 bars at the injection point. It was reported that the system would come online in early 2019 and then run continuously. That megawatt-size amounts of hydrogen can be injected at this point throughout the year is a rather distinguishing feature of the system, as the hydrogen content of these pipelines is typically limited to 2 percent as per current regulations. However, Brunsbüttel is home to industrial companies that consume large amounts of natural gas, and it is one of few sites in the country where volumetric flow rates are that high. One large consumer in Brunsbüttel is fertilizer company Yara. Tim Brandt hopes to supply Yara and the others with large quantities of green hydrogen in the future.

**SOFTWARE IN CONTROL** To ensure smooth operation, an energy management system is monitoring and controlling all processes and equipment related to the project. It analyzes demand from the electrical grid and the price on the electricity exchange to choose when



Fig. 1: Hydrogenics electrolyzer in the Covestro industrial area in Brunsbüttel, [Source: Niels H. Petersen]



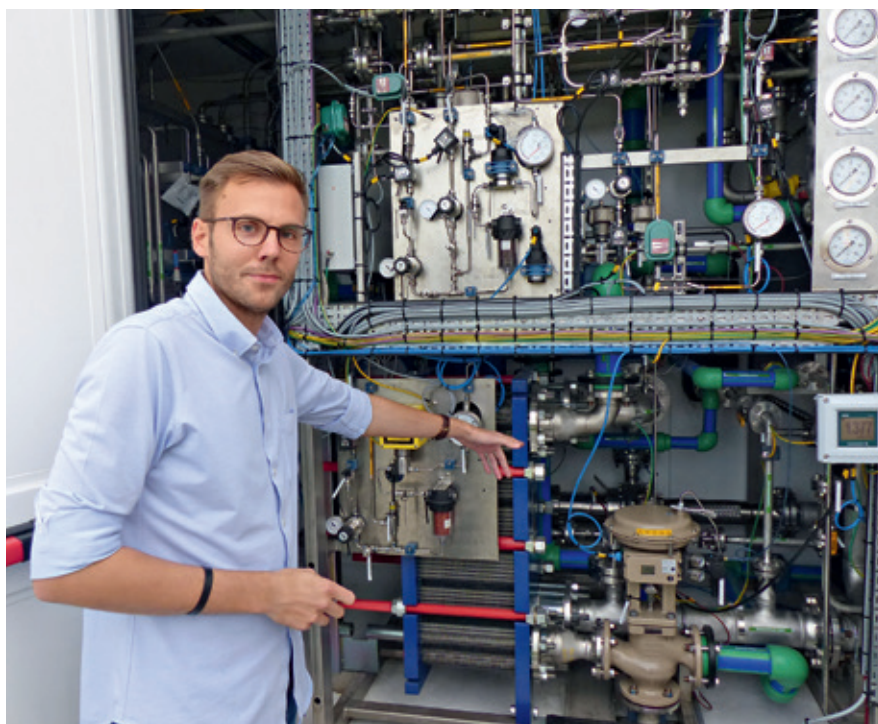


Fig. 2: Tim Brandt standing in front of the PEM electrolyzer. [Source: Niels H. Petersen]

to produce hydrogen via the electrolyzer or when to feed battery-stored electricity into the grid. It also records how full the system's hydrogen tank is to determine, for example, when to inject hydrogen into the natural gas network.

The software is being developed by Wind to Gas Energy in partnership with an IT company. When all systems are put up, the program will be field-tested and improved. Early this year, everything is supposed to be ready for tweaking the system once it is in operation.

**WORK ON FUELING STATION SINCE JANUARY** In the interest of creating an integrated energy system, transportation has been part of the project throughout. It means the business is building a fueling station next to the electrolyzer, though construction has faced some delays. Brandt suspects they are the result of H2 Mobility's tight schedule. After all, the organization has been coordinating work on 43 hydrogen fueling stations. In late October 2018, the company stated the Brunsbüttel station was "still under review. Construction is scheduled for January 2019. At present, we are conducting tests only. We will kick-start the project once the injection point is up." The tank would then store 200 kilograms of hydrogen at 45 bars, enough for around 40 fill-ups. "Theoretically, we could fill the tank in five hours," Brandt said.

He added that at least 15 potential customers had to each sign a letter stating their intention to buy a fuel cell vehicle before H2 Mobility would consider the site at all. "We had nearly 100 of them," said Brandt. That was why he quickly signed a cooperation agreement with Hyundai Germany, so the startup business is now also a distribution partner for the South Korean automaker and can offer test drives with a Nexo (see also p. 34). In the meantime, it had "sold 12 Nexo vehicles, mostly to customers from the region but also to some based in and around Hamburg. Additionally, one will go to southern Germany and another to Flensburg," Brandt told H2-international. A joint marketing campaign was in the works as well.

**TECHNOLOGICALLY ADVANCED BUT EXPENSIVE** The entire venture is a demonstration project that is not yet economically viable, as, bar few exceptions, most regulations do not credit the reduction in carbon dioxide emission levels. This is something the German energy storage association BVES is criticizing too. "The charges and fees imposed by the renewable energy law on our use of electricity need to go," Brandt said, adding that it would help if the government set a reasonable carbon price for hydrogen sourced from fossil fuels. The one currently paid by industrial companies was only a third of what his business needed to turn a profit.

It would be enough if he could get electricity at energy exchange prices, he said. However, for that to work, the government would have to lower the electricity tariff to pre-legislation levels. Additional methanation, though, would not be viable at that point either, since converting the energy twice in a row would drive up the cost to three times its base value.

In his experience, Brandt said, "we have mature technology that works." There was also enough space available to expand the current system by a factor of ten or more. However, surcharges needed to be paid for electricity consumed on-site, as stipulated in the country's renewable energy law, because the electrolyzer was classified as an end consumer, despite the use of renewable sources. That increased the cost of electric power produced via electrolyzers, for example, in Schleswig-Holstein, from an average EUR 30 for one megawatt-hour to up to EUR 180 for the same amount, depending on local charges and fees. ||

#### NEW 4.0

Schleswig-Holstein is the new Eldorado of eco-power. For several years, this state in the northernmost part of Germany has been generating surplus electricity. By contrast, renewable energies meet less than 5 percent of demand in Hamburg.

NEW 4.0 is a network of energy suppliers and consumers across multiple sectors. The aim is to transform the region into an all-renewable area by 2035. The NEW 4.0 showcase for smart energy grids has been funded by the German economy ministry since early 2017. The government will have spent EUR 45 million on it when it ends in 2020. Around 60 businesses and institutes are investing another EUR 60 million to EUR 80 million.

In August 2018, two regionally important mass transit companies, namely Verkehrsbetriebe Hamburg-Holstein and Hamburger Hochbahn, joined NEW 4.0. Professor Werner Beba, the project's coordinator, said at the time that "only if we include the heat market and transportation will the changes in the electricity sector grow into a transformation of the entire energy system."

# NEW PROSPECTS FOR BREMERHAVEN

## *H2BX sees opportunities in hydrogen*

Eleven founding members set up H2BX – Hydrogen for Bremerhaven Region as recently as two years ago. At the first meeting, the number had already climbed to 25, while there were more than 60 last November. The subsequent information event on “Hydrogen Technology in Practice – Prospects for Bremerhaven” attracted more than 150 attendees. This is how fast it can go if a group of strongly dedicated people sense it is exactly the right time to push ahead because the will across the country is there. Today, this is true for the rapidly growing interest in hydrogen, not only, but especially, in this city at the sea.



Fig. 1: Claas Schott wants to make hydrogen a mainstay at the North Sea.

Claas Schott, the president of H2BX, did expect a certain crowd but was a bit surprised how many showed up in the end. Originally, he wanted to hold the event in a much smaller room at the Klimahaus Bremerhaven 8° Ost building on Nov. 20, 2018. But now, even the big one was maxed out.

On Germany's North Sea coastline, energy production has long been a topic of great importance. In his opening remarks, Nils Schnorrenberger, the chief executive of BIS, which has, for all intents and purposes, assumed the role of Bremerhaven's economic development department, reminded attendees of a similar meeting about 20 years ago, when the issue was offshore wind farms. At the time, Bremerhaven was ahead of the curve and has benefitted from that for years. Now, it seemed as if hydrogen could develop in the same way, Schnorrenberger said.

Schott, the one who has come up with a lot of ideas and launched H2BX, then spelled out why the region at the mouth of the Weser river was especially suited for not only generating electricity from wind but producing and storing

hydrogen. First, it offered the ideal environment thanks to many devoted stakeholders, who had helped get numerous projects underway in a matter of months. Second, the city possessed the ideal spot for hydrogen production, he said.

Plans are to turn a formerly uninhabited Weser island named Luneplate, which is part of Bremerhaven's South District, into a hub for innovation and development by 2035. It already has an 8-megawatt wind farm installed. Now, startups and forward-looking demonstration projects would have to settle in the area and an electrolyzer would need to be put up as well. Professor Carsten Fichter, from Bremerhaven's university, is preparing a road map for hydrogen use in the suburb and on Luneplate on behalf of Bremen's economy senator.

“We are looking forward to receiving applications,” said Jörg Peters, who works for the economy department in the state, promising that his department would also become a member of H2BX. However, support didn't pour in from the realm of politics only. Those who presented their businesses and products at the information event had much to say about getting new projects set up. For example, Pierre Steffen, Keyou's CSO, explained how to use a hydrogen combustion engine to make transportation by commercial vehicle a zero-emission trip. Joachim Hoffmann provided attendees with an overview of Siemens' extensive work in hydrogen and fuel cells, ranging from submarines and ferryboats to fuel cells and electrolyzers. Kathrin Schulz presented Storengy, a subsidiary of Engie and an operator of underground natural gas storage facilities. All of them stated their great interest in implementing projects across the region.

Even after the event was officially over, an informal get-together showed how good the region's prospects are. Schott said that he had more than 10 years' experience in offshore wind energy and that the idea to set up an association had been conceived in a discussion with two of his friends over a bottle of wine. A lot has happened since then. For example, H2BX has developed close ties to H2 Mobility, as Schott really wants to see a hydrogen fueling station being built in Bremerhaven. In February 2018, he was told it would require multiple declarations of intent to buy fuel cell cars to secure the city a spot on H2 Mobility's list, and all of them had to be submitted by the end of March the same year if Bremerhaven wanted to be among the first hundred to be considered for a fueling site. In four weeks, Schott, whose main job is with Bremerhaven's university, collected the signatures of 40 individuals who pledged to purchase 46 vehicles. Now, he is waiting for positive news from H2 Mobility's Berlin headquarters.

Although everything went very quickly in the case of H2BX, one association member didn't think it went quickly enough. He ordered his own fuel cell car, a dark blue Mirai, and has made it available to other members of the organization. The side of the car now features the association's name in big letters, albeit the vehicle still needs to be driven 43.5 miles (70 kilometers) to Bremen to be filled up. This could change soon, since Bremerhaven is already a dot on the latest H2 Mobility map that shows the hydrogen stations in Germany. ||



# POLITICIANS IN THE NORTH SHOW THEIR SUPPORT

## *Ministers Buchholz and Lies come out as pro hydrogen*

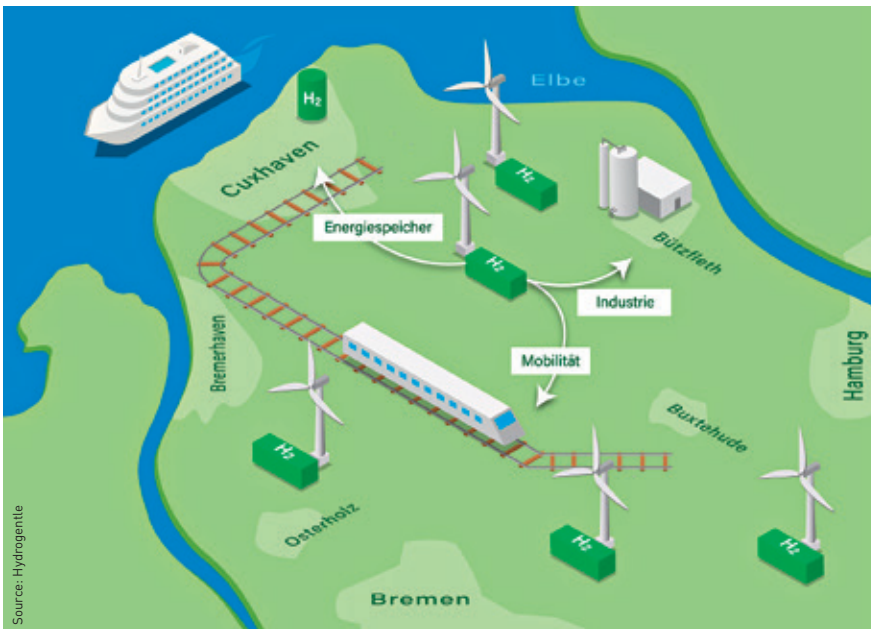


Fig. 1: Idea of a Hydrogen Valley spanning the area between the Elbe and Weser rivers.

On the German North Sea coast, interest in hydrogen is reaching new heights. More and more organizations are discovering the technology, while an increasing number of communities are mapping out concrete plans, and the number of politicians pledging their support is becoming greater each day.

At the beginning of September 2018, several regional business associations in Cuxhaven signed a memorandum of understanding under the tagline: “Clean cruise liners only.” In it, they emphasized that, like in Hamburg, they were committed to reducing additional pollution, especially since Cuxhaven was a seaside resort and wanted to become a port for cruise liners once again.

By signing the document, the associations joined calls by Olaf Lies, the environment and energy minister in the German state of Lower Saxony, to produce clean hydrogen from wind energy and make Cuxhaven a showcase for sustainable energy supply.

In late November 2018, Lies presented a proposal for a hydrogen strategy to the Bundesrat, the legislative body representing the 16 German states. He called on the federal government to “seek out effective ways to unlock Germany’s potential and increase funding for large industrial hydrogen projects.” He then presented his seven-point program, explaining that “if we turn technological innovation into real-world application, we will not only give better protection to the climate, but we also increase prosperity and secure jobs. The industry goes where the energy does. It used to be that way and it still is. Green hydrogen will assume a key role as an energy carrier and a means of storage in the future. This makes it all the more important to set up a hydrogen strategy for the entire country to advance the transformation of the energy sector.” Else, progress would be reduced to “partial successes.” He went on to say that Germany had “the technology to benefit from hydrogen and convert it into carbon-neutral natural gas or directly use it in industrial processes. [...] We should seize this opportunity.”

**ECONOMIC FORUM ON HELGOLAND** Shortly before, the independent mayor of Helgoland, Jörg Singer, had invited people to the Offshore Economic Forum. Someone from the economy ministry was supposed to deliver opening remarks at the event attended by around 70 people. However, as no one had yet been named

to take charge of the ministry’s energy division, the task fell to Enak Ferlemann, who works at the transportation ministry and had been elected to the German Bundestag to represent Cuxhaven. He told the energy industry executives and politicians gathered at the forum on Helgoland that “today’s battery-powered electric vehicles are only one step on the way to hydrogen fuel cell vehicles,” adding the country needed to “create an industrial-scale market for electrolysis that splits water into oxygen and hydrogen. The amount of electricity required for it can only be delivered by offshore wind farms.”

He also noted that the target for offshore wind capacity in 2030 in the revised version of the renewable energy law might be raised to 17 gigawatts or even 20 gigawatts. At present, the capacity is 5.8 gigawatts in Germany’s territorial waters. He went on to say that the government and the country’s BSH maritime administration were considering several options for connecting electrolyzers near offshore wind farms without going the land route, so as to avoid adding more charges and fees to the price.

**LIVING LABS FOR STORAGE SOLUTIONS** The state of Schleswig-Holstein’s economy and transportation minister, Bernd Buchholz, also spoke in favor of using hydrogen and called for raising the offshore wind farm target to between 20 gigawatts and 25 gigawatts by 2030. Likewise, he announced the creation of “a living laboratory from the refinery in Heide to the port and industrial area in Brunsbüttel, with the aim to design renewable energy generation and storage solutions. Then, we could use hydrogen to produce, for example, synthetic kerosene for Hamburg’s airport (see p. 18).”

Hamburg’s new senator for economy and transportation, Michael Westhagemann, immediately took up the idea after being sworn in. A former high-level executive at Siemens and vice president of Hamburg’s chamber of commerce, he has no political affiliation. In November 2018, he replaced another senator >>

without political allegiances: Frank Horch, who retired from politics for personal reasons. One of the freshman senator's first announcements was to speak to other northern states about broadening the use of hydrogen technology.

**FIVE STATES PRO HYDROGEN** More concrete plans were unveiled during the Coast Conference held on Nov. 26, 2018, in Wilhelmshaven. At the JadeWeser-Port, the government officials running the economy and transportation departments of Bremen, Hamburg, Lower Saxony, Mecklenburg-West Pomerania and Schleswig-Holstein called for transformative ideas for transportation and energy, with hydrogen to play a key role in the process. Westhagemann said during the event that “we want to develop this future-proof technology and intend to advance the buildup of a hydrogen economy in the north of Germany. As a consequence, we have decided to work together to create a hydrogen strategy for the northern part of the country.”

Buchholz added that “although there is a broad consensus these days that transforming the energy system will require hydrogen, the federal government has yet to speak about it and seriously advance the technology. [...] We coastal states have decided to stop waiting for some sign and instead come together to forge ahead with creating a hydrogen economy.” ||

“Categorizing storage units as end consumers, which means the burdening of power-to-gas installations with energy-related fees and charges, such as those based on the renewable energy law, is a systemic error.”

*Fabio Longo, lawyer specializing in administrative law*

Category: Energy Storage | Author: Joachim Berner |

## UNTYING THE GORDIAN KNOT

### *Fronius starts up green hydrogen fueling station*

22

At the beginning of October 2018, Fronius, a power electronics manufacturer based in Pettenbach, Austria, commissioned a demonstration system of a solar-hydrogen fueling station at its research and development facility in Thalheim, near Wels. The business expects the system named SOLH<sub>2</sub>UB to become not only a part of its 24-hour solar strategy but also a decentralized component of a future hydrogen economy.

Vehicles had already played a key role in Fronius' corporate strategy when the company was founded in 1945. At that time, Günter Fronius began building a device to charge car batteries by using 50-hertz technology. This was not a common method, just as it is not common today to see someone fill up their vehicle with hydrogen. The company, which has since become well-known for its expertise in welding, solar

inverter technology and battery chargers, made a conscious decision to go down that road. On Oct. 12, 2018, it unveiled SOLH<sub>2</sub>UB, its modular fueling system for hydrogen produced with the help of on-site solar resources. SOLH<sub>2</sub>UB is short for Solar Hydrogen Hub.

The system's PEM electrolyzer can produce up to 4.35 kilograms of hydrogen per day. It is not quite enough for the new Nexo SUV, which needs 6.33 kilograms for each fill-up. However, its modular design allows for several modules to be combined, so hydrogen production capacity can be increased to up to 100 kilograms a day.

The electricity required to create the hydrogen is provided by a PV system with 6 kilowatts of capacity. If there is not enough sunlight, the unit will draw electric power from the grid. The gas is stored in 24 cylinders that can hold 50 liters of hydrogen each and a total of 27 kilograms. The installation has also been equipped with a fuel cell, which will convert the gas into electricity and heat when needed.

**FULLY RENEWABLE** “SOLH<sub>2</sub>UB is used as a central hub for solar energy and makes for an innovative combination of producing heat and electricity and powering vehicles,” explained Martin Hackl, who heads the company's solar energy division, adding that Fronius was convinced green hydrogen would play a larger role in energy supply in the foreseeable future, both as a sustainable alternative to fossil fuels in transportation and as renewable energy storage.

The company's product department began developing hydrogen technology 16 years ago, in line with Fronius' efforts to grow from an inverter manufacturer into a one-stop solution provider. In 2016, the business started pursuing a 24-Hour Solar strategy, that is, “to create an all-renewable solution for meeting global demand,” as Hackl put it, saying that the aim was to “develop technology to solve the problems associated with intermittent energy sources.” Nowa-



Fig. 1: The SOLH<sub>2</sub>UB container houses a fuel cell to generate electricity, an electrolyzer to produce hydrogen and a storage device to make use of waste heat. [Source: Joachim Berner]

"We are convinced that hydrogen has the potential to become a key energy carrier in the future."

*Martin Hackl, head of Fronius' solar energy division*

days, the solar energy division is manufacturing not only inverters for grid-connected PV systems but also monitoring, storage and microgrid equipment.

**A SYSTEM FOR ON-SITE POWER CONSUMPTION** When marketing its SOLH<sub>2</sub>UB, Fronius is not focused on public fueling stations but businesses, cities, towns and distribution centers, all of which have roof space for PV systems and aim to produce hydrogen at the site of use to power the vehicles they own. "What this means is that the gas doesn't have to be transported," said Thomas Rührlinger, who works in Fronius' hydrogen solutions division. He noted that it was a big plus, for example, for community vehicles, trucks, vans and buses, as each of them required large amounts of energy while hydrogen promised a high range and fast refueling.

One advantage of Fronius' design, he remarked, was that the gas could be stored without difficulty. It could be used to not just power fuel cell vehicles but generate electricity by means of a stationary fuel cell. According to Rührlinger, extensive use of on-site generation would take some pressure off energy grids. It was why he could also imagine citizens' associations as a target market, and it was the reason why the system included a fuel cell to produce electricity from hydrogen.

**HEAT USE RAISES EFFICIENCY** When asked about how much the hydrogen produced by its demonstration system costs, Fronius had currently no data to share but gave a target price of EUR 10 to EUR 12 per kilogram. To put this in perspective: A price of EUR 9 per kilogram is about the same as a diesel price of EUR 1.20 per liter. The company also said that round-trip efficiency was between 55 percent and 60 percent. It could go as high as 90 percent when using the waste heat from the electrolyzer and the fuel cell to heat water on-site.

Hackl knows that hydrogen comes with the infamous chicken-and-egg dilemma. To break even, a station needs to sell enough fuel. For any sale to be made, it will require fuel cell vehicles. However, they will be bought only after enough fueling stations are available, so round and round it goes. Hackl hopes corporate and government clients that could benefit from SOLH<sub>2</sub>UB will help establish the fueling infrastructure.

Hackl is not worried about competition from battery manufacturers. "In logistics, every cent counts. Idle time, for example, when filling up or charging vehicles does play a role." Since refueling a fuel cell car is much faster, the company is pushing ahead with its SOLH<sub>2</sub>UB to solve the fueling station issue. ||

Last October, Fronius was recognized for its SOLH<sub>2</sub>UB product with the Austrian award for environmental and energy excellence in the category Research and Innovation.

23

## REAP WIND POWER, FILL UP HYDROGEN

Plans are becoming more concrete in Germany's northernmost region, where communities are rapidly taking the lead in the production of renewable hydrogen and the creation a future-proof transportation system co-designed by citizens. In March 2017, project company GP Joule, based in Reußenköge, Germany, published a feasibility study to show what this renewable system could look like (see H2-international, May and December 2017). Then, in early December 2018, it provided details on a project to power vehicles by renewable hydrogen.

The aim of this project, which GP Joule calls eFarm, is to offer buyers of hydrogen vehicles the opportunity to meet all of their cars' fuel needs through locally produced renewable gas. Plans are to install electrolyzers at five sites and build two hydrogen fueling stations in Husum and Niebüll (see image). GP Joule's André Steinau told H2-international that the company would purchase two fuel cell buses to sell them at the market price of comparable diesel models to the region's transit company. Five fuel cell passenger cars were also part of the project, which is being supported by the federal government with EUR 8 million.

GP Joule's chief executive, Ove Petersen, highlighted the social component of the project, for which it founded a company called eFarming. "We chose the name eFarm on purpose. We intend to provide a collaborative and sustainable way to generate revenue. We will produce, transport, process and market hydrogen in partnership with other stakeholders, just like a milk producers cooperative would. If renewable energy production is tied to consumption and if it becomes clear that society can benefit from the variety of uses and the



Source: GP Joule

added value, and if people can participate in the prosperity we create, then they will truly come to appreciate why we are about to transform the energy markets. Our eFarm project will allow direct participation by citizens, get stakeholders involved, and prepare them for an integrated energy system." Project launch is scheduled for this year, while the buses are to start operating in 2020. ||

"Citizens welcome change if they know how, with their help, renewable energies can add value to a region."

*Ove Petersen, GP Joule*



# DVGW SUGGESTS GREEN GAS QUOTA

## Power-to-gas for non-electrified areas

A nightmare scenario is making the rounds in the gas sector: All of Germany comes to rely on electric power alone, abandoning the pipeline system. It is a future that can easily be dismissed as an unlikely horror story but one that gas companies are trying to prevent at all costs. It is why an industry that has so far focused on traditional means of heat production is slowly warming to power-to-gas and energy systems integration and why the DVGW gave an update on the market by presenting a new study, including policy recommendations, last September.

"If today's entire wind energy capacity were converted into hydrogen, we would have 10 percent of the gas in the natural gas grid. [...] Our aim is 20 percent to 25 percent."

*Gerald Linke, DVGW*

"The pipelines would be capable of storing a blend of up to 50 percent hydrogen through typical modernization programs."

*René Schoof, Uniper Energy Storage*



Fig. 1: Prof. Gerald Linke



Fig. 2: Prof. Michael Sterner

Some years ago, members of the gas and water industries association DVGW started thinking of hydrogen as a cousin of natural gas, introducing it to both the pipelines and the organization. Now, a clear majority within the association is advocating for a shift in strategy from fossil fuel to green gas supply.

**RENEWABLE FUTURE INSTEAD OF FOSSIL PAST** The reason for this shift in attitude is simple. In Germany, there is no future for a fossil fuel such as natural gas, coal or oil. One factor is the agreement made at the COP21 climate change conference in Paris, where the aim was to keep global warming below 2 °C compared to preindustrial times. Meanwhile, the German government has confirmed national climate protection targets, with the intent to achieve an 80 or a 95 percent reduction in GHG emissions across all sectors by 2050 compared to 1990 levels. [1] But it has yet to choose which of the two will guide its actions till then. The chief executive of dena, Andreas Kuhlmann, recommended that it stick to the latter objective.

Whatever the outcome, however, the natural gas industry is under pressure. The members of the DVGW have earned most of their money with fossil fuel gas and some of them have made large investments in the relevant infrastructure. Now, they believe they have no choice but to look for alternatives.

Take Leipzig-based Ontras Gastransport, for example. The company operates pipelines in multiple regions, has 450 injection points and its entire network is around 4,350

miles (7,000 kilometers) long. But all of it would be useless if transporting gas were no longer an option. Now, the business is "going green," as its tagline suggests, aiming to use more renewable sources of energy and gradually shift from natural to green gas (see box).

The existing infrastructure can be used for both natural gas and biogas or hydrogen, although the proportion of hydrogen to be injected would still need to be determined. The current limit is two percent by volume, as some consumers, such as glassworks, gas turbines, fuel tanks and LNG vehicles, only accept natural gas. According to Ina Adler, energy policy adviser at Ontras, the network consisted of high-pressure pipes primarily made of steel and could be adapted for use with hydrogen, as the town gas the pipes had transported at one point contained a relatively high percentage of it. To convert the system, one would need to do no more than to replace some fittings and shorten maintenance intervals. Adler likewise told H2-international that some companies had been conducting tests to see whether it could be economically viable to inject greater hydrogen quantities into grids that ran only throughout one region.

### GREEN GASES

Biogas is being produced in 9,000 plants in Germany. Their generation capacity is 4,166 megawatts of electric power. Similar to landfill, mine and sewer gas, the main compound of biogas is biomethane, or CH<sub>4</sub>, so that all of them are subsumed under one label.

By contrast, e-gas is synthetic gas. It is manufactured via electrolysis with the help of green electricity before carbon dioxide is added to create synthetic methane. The DVGW calls this process "adding value to the gas."

### BIOGAS PLANTS

The growing number of sites to process biomass into biogas has led to a rise in corn production in recent years. Corn is planted on around 20 percent of all agricultural land, at the risk of harming the environment because of the negative impact of monocultures. Critics fear that substituting biogas for natural gas could prompt yet another increase in the size of corn fields and the number of biogas plants.

**SWITCH FROM GREY TO GREEN** The DVGW, however, is not just planning to switch from fossil fuel to renewable gas, as current energy demand could not be met in this way. Besides a Content Switch, that is, a steady increase of the amount of zero-carbon gases in the pipelines, the association's concept includes a Fuel Switch bringing changes to each energy-related market.

The DVGW also lists a Mode Switch, which "controls the links between existing infrastructures in an integrated energy system." Through these three methods to transform the markets, the DVGW, as well as dena, wants to guarantee supply security. Other studies take a different approach, which involves a complete withdrawal from coal, oil and gas in favor of letting everything run on green electricity. That all-electric pathway was doable but more difficult and expensive than if the gas network were part of the transformation, read a statement by the DVGW and dena. Werner Diwald, the chairman of the German Hydrogen and Fuel Cell Association, also known as DWV, added that using both, electricity and gas, would generate savings of as much as EUR 500 billion.

**INTEGRATING GREEN GASES** The DVGW presented the findings of its latest study, titled "Integrating Green Gases into the Energy System," in Berlin on Sept. 11, 2018. Born out of the SMARAGD project, the document examined renewable gases for their importance to the energy transformation and includes suggestions for policy and regulation.

Professor Gerald Linke (see fig. 1), the DVGW's chairman, said in Berlin that "from a technical viewpoint, coal could be gone tomorrow." However, if nuclear energy were

abandoned at the same time, energy supply might take a hit. This was the reason why, besides making four concrete recommendations, he advocated for the expansion of electrolyzer capacity (more: H2-international April 2019). Likewise, when he attended the DWV's parliamentary evening (see p. 27), he asked how existing valuable infrastructure could be utilized and suggested rethinking the approach to hydrogen delivery, saying "what we need are pipelines. Instead of delivering comparatively small amounts of hydrogen by trailer, we need to create a hydrogen grid," adding that "this puts hydrogen and natural gas on an equal footing."

Professor Hartmut Krause, the chief executive of DBI Gas- und Umwelttechnik, also wanted to keep the current system in place and adjust regulations instead. A company employee, Gert Müller-Syring, said in more concrete terms that lowering electricity prices would be an especially potent means to stimulate growth. Carbon pricing, on the other hand, was not helping that much. By contrast, eliminating the fees and charges that were imposed because of Germany's renewable energy law could result in the economically viable operation of power-to-gas systems by 2030. The important thing was to implement relevant measures in time, so they could be gradually removed starting that year.

Michael Sterner, a professor at Regensburg's OTH university, made clear that neither an "all-electric world" nor green gases alone would be the answer. Rather, both pathways should be combined. Peter Ahmels, who works at the German Umwelthilfe environmental association, agreed and remarked that "there are some areas where electric power cannot be used. We have come to realize that."

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25

## THIS IS JOE CARGNELLI, CTO OF HYDROGENICS. AND HE'D LIKE TO INTRODUCE YOU TO THE WORLD'S MOST COMPACT HYDROGEN ELECTROLYZER.



Joe is feeling a strong sense of accomplishment. Our Chief Technology Officer has lead a big advance in hydrogen technology. At 3 megawatts, we have the world's most power-dense electrolyzer stack. It's a technological achievement, capable of producing enough hydrogen to fuel over 300 fuel cell cars every day. And it's changing grid-scale energy storage and hydrogen

fueling for a cleaner, carbon reduced environment. While our leadership comes from our technology, our success is the result of one essential ingredient – the human one. Our experts, our engineers, our researchers and our day-to-day people are advancing technology for a better, earth-friendly energy source. Learn how the human factor is changing the world at [Hydrogenics.com](https://hydrogenics.com)

# HYDROGENICS

The human factor. The most advanced part of our technology.

	Electricity	Heat	Transportation
Fuel Switch	coal → renewable gas	oil → renewable gas	diesel → renewable gas

**DISCUSSION AND CRITICISM** During the panel discussion that followed the presentation of the DVWG study, it was said that just removing the renewable energy charges was not a solution in and of itself. In fact, the question arose who was going to pay for the amount saved, as all agreed that someone somewhere would have to foot the bill.

“Keeping the pipeline system running is of fundamental import.”

*Timm Kehler, chairman of Zukunft Erdgas*

Attendees also agreed that a notable proportion of synthetic gases would have to be imported in the future, as Germany’s renewable energy capacity could not be ramped indefinitely if the aim was to prevent further public acceptance issues. The co-manager of dena, Kristina Haverkamp, said about the DVWG study, which dena had created for the association, that “most green fuels will have to come from outside Germany.” She also stressed that the target of “95 percent cannot be achieved without power-to-X solutions.”

One thing that remained unclear even after the discussion ended was how it could be guaranteed those energy imports complied with national standards. Öko-Institut’s Felix Christian Matthes warned that Australia would, if it had to, deliver hydrogen produced with the help of electricity from those coal plants that did not use carbon, capture and storage, and that a country such as Somalia would hardly be predestined for power-to-X, as it had too little fresh water resources. Then, there was the question of where to get the carbon dioxide for power-to-X processes from, to which no one seemed to have a satisfying answer.

The dena study [2] found that a fully energy system would be both sensible and financially viable and would, in northern Germany especially, lead to exponential growth rates and many export opportunities. Additionally, an ambitious expansion of renewable energy capacity and power-to-X technology would be essential to successful decarbonization. If a wide range of technologies and energy carriers were in use by 2050, costs could be cut by EUR 600 billion compared to a rise only in the number of mainly electricity-based devices (see H2-international, July 2018).

In another study, titled “Renewable Gases – An Update on the Energy Transformation [3]” and published by the Initiative Erdgasspeicher (INES) and the Bundesverband Windenergie (BWE) associations, it said “the impact of dark and still days could become history thanks to gas storage systems.” Sebastian Klein, who works at ener-vis energy advisors, added that “the use of power-to-gas to produce green gases offers the chance to integrate gas tanks and pipelines into a carbon-neutral energy system. This would allow for a further use of renewable gas in the heat market, from which the entire economy will benefit.”

There was nothing to report from the political front. Carsten Müller, who is a member of the working group on economy and energy in the Bundestag, could not tell attendees whether the federal government would adjust renewable energy tariffs. However, he was cautiously optimistic that, after it had taken the government a few months to form a coalition, it could now concentrate on policy work. He did think power-to-X sounded like an interesting option but thought it mostly relevant for surplus energy.

**WHAT ABOUT A GAS QUOTA?** Near the end of the event, the DVGW floated the idea of a quota for renewable gases, asking if it could inspire some clear political objectives. Most of the 11 panelists were open to the idea or even embraced it, since that type of measure could provide a stable outlook for the electrolyzer market and the conversion of the gas grid. However, some cautioned that the proposal should not turn into some kind of renewable energy law, with the same impact as the first one. The skyrocketing numbers of PV and wind installations caused by the passing of Germany’s renewable energy act, as well as the resulting obligations, had been an experience none of those in attendance wanted to repeat. And yet, a well thought-through and reasonably implemented gas quota across all sectors could prevent reduced investment in the gas industry and avoid public acceptance issues regarding an increase in wind farms and large-scale solar systems.

The most important takeaway from the discussion, the panelists said, was that gas did not have to become an outdated technology but would merely need to be adapted to meet the challenges of a changing market. And combining the electrical grid and the gas network would certainly make sense, as both had their advantages.

An early abandonment of one of these two options would eventually mean that investments into keeping the functionality of one would lead to the unfortunate situation that in some places, only electricity could provide energy and in others, only gas. To avoid a scenario where the energy system would end up with gaps in supply and reliability issues, it would need political assurances to keep up both. ||

Electrical grid	Gas pipelines
+ extensive network	+ extensive network
+ short response time	+ seasonal energy storage
	+ high storage capacity
+ connected to the rest of Europe	+ connected to the rest of Europe

□ [1] “Klimaschutz mit grünen Gasen” by DVGW, September 2018

□ [2] “Leitstudie: Integrierte Energiewende” by dena, July 2018

□ [3] “Erneuerbare Gase – ein Systemupdate der Energiewende” by BWE and INES, December 2017



# ECONOMY MINISTRY DRAWS UP NATIONAL HYDROGEN STRATEGY

## *A parliamentary evening in Berlin*



Fig. 1: Werner Diwald (right) explains the benefits of hydrogen vehicles to Czech ambassador Tomáš Podivínský.

At least once a year, the German Hydrogen and Fuel Cell Association, better known as the DWV, organizes a so-called parliamentary evening in Berlin. Last year, on Nov. 8, 2018, the event took place in the Embassy of the Czech Republic. A roll call vote prevented most members of the German Bundestag from attending. Still, what Oliver Wittke, who works at the German economy ministry, had to say that evening about “Changes to the Energy System – Is Green Hydrogen the Solution?” did catch the attention of the industry representatives who had gathered at the meeting.

First, Czech ambassador Tomáš Jan Podivínský welcomed the many business representatives who had come to his embassy by saying that “although hydrogen and fuel cells are at an early stage of development in the Czech Republic, we have already witnessed the launch of many exciting projects.” He pointed to a workshop that was held on Sept. 4, 2018, at the embassy and was aimed at Czech and German fuel cell professionals, as well as to current plans for introducing fuel cell buses into the mass transit system in Ostrava, the third-largest city in the Czech Republic. He also took advantage of the opportunity to announce the Hydrogen Days 2019, which are scheduled to take place from March 27 through March 29 in Prague.

Afterward, attendees listened with great interest as Oliver Wittke, who works at the economy ministry and is, by his own account, the one primarily responsible for developing policy on the energy market transformation, said “traditional energy sources are losing in importance. In 2019, we will no longer mine black coal in any part of the country, which doesn’t mean that we will no longer produce energy.” Rather, he underlined that “people in those communities that will bear the brunt of the coal exit need our support” and that “hydrogen will offer them a lot of opportunities.”

He added that “we have so far designed an energy system around the lowest-hanging fruit.” It was now time to set up living labs to test promising hydrogen solutions in real-world conditions. These projects would be funded with EUR 100 million in total. “We believe there is great potential for using hydrogen to revitalize former coal communities,” he said.

### POLITICIANS HOPE FOR PRIVATE SECTOR INTEREST

Of central importance was his pledge that the economy ministry would “map out a whole-systems strategy for hydrogen and synthetic fuels.” He noted, however, that the endeavor would need “industry partners” to make hydrogen another success story, similar to what had happened with battery production. He said the ministry would “gladly support the effort, but we need the private sector to contribute.” As for electric transportation, he affirmed that “businesses made the biggest investments, which is why we offered that much funding.”

The DWV’s chairman, Werner Diwald, said the “industry is more than willing to invest,” adding that the market was being disrupted while trade relations were being reset. In this context, he again floated the idea of setting up a Hydrogen Airbus project, in reference to joint European projects in the aviation and battery industries. But this time, the focus would be on hydrogen, with the aim of establishing a competitive fuel cell and electrolyzer sector in middle Europe.

Subsequently, René Schoof, who works at Uniper Energy Storage, criticized the lack of political decision-making and the power-to-gas demonstration systems, at sites such as Falkenhagen and Reitbrook, which had been put “on hold for who knows how long.” Many millions of euros in incentives and grants had been poured into them and the money was, in fact, being wasted, as the systems would be fully operational should they be started up. He said that instead of living labs, it would need a market-wide incentive program. Roland Käppner, head of thyssenkrupp’s energy storage and hydrogen division, agreed, saying that “we need to get away from research and development. We are past the laboratory stage.” He added that his company would “ramp up capacity in time” if the market environment became more favorable. ||

“We need a strategic road map.”

Werner Diwald, DWV

# ELECTRIC WORKHORSES, UP CLOSE

## IAA Commercial Vehicles in Hanover

Never before had a commercial vehicle show featured as many electric models as the 2018 edition of the IAA Commercial Vehicles, which took place from Sept. 20 through Sept. 27 in Hanover, Germany. Most exhibitors that had a booth at the event displayed battery-electric or, at the very least, hybrid trucks or buses. Vehicles powered by hydrogen or fuel cells were few and far between, though compared to past shows, their number had jumped up quite a bit. And, as a sign of how much promise they hold, large market players used the time to make some major announcements.



Fig. 1: VW showcased its Crafter HyMotion cargo van.

For the hydrogen and fuel cell community, the two most important pieces of IAA news were VW's concept car, a cargo van named Crafter HyMotion, and Hyundai's goal of having 1,000 hydrogen trucks drive on Swiss roads in the early years of the next decade.

The Crafter HyMotion, the e-Crafter's fuel cell counterpart, stood in the center of VW's main stage area, beside the I.D. Buzz Cargo, an autonomous minibus the automaker is planning to launch in 2022. Both, though, had yet to move past the concept stage. While the 4.25-ton van may not be a winner in the looks department, its drive unit could close the deal with customers. Reportedly, the vehicle's underbody will include four large tanks that can store 7.5 kilograms of hydrogen, giving it a maximum range of 311 miles (500 kilometers). The idea behind equipping this model with a fuel cell to increase the range was to inject a bit of variety into VW's previously all-electric product lineup. In an interview with electrivene.net, Volker Becker, who designs alternative fuel vehicles at Volkswagen, said that the Crafter HyMotion would be the right choice for customers looking to purchase an electric van that, compared to other models, offered an increased payload capacity, a longer range and a faster fill-up, as well as the full performance envelope even in winter.

"Right now, this is only a concept car. But from a technical point of view, it is close to production ready."

*Heinz-Jürgen Löw, head of sales at Volkswagen Commercial Vehicles*

**A THOUSAND FUEL CELL TRUCKS FOR SWITZERLAND** Despite some striking similarities between the design of the Crafter HyMotion and the H350 Fuel Cell Concept van showcased by Hyundai, the latter had been on display at the IAA as early as 2016, giving the South Korean automaker a head-start of two years to make improvements. At the IAA 2018, the company's progress on the fuel cell front prompted In Cheol Lee, the head of Hyundai Motors' commercial vehicle division, and Rolf Huber, the chief executive of H<sub>2</sub> Energy, to sign a memoran-

dum of understanding to deliver 1,000 heavy-duty fuel cell trucks. Meeting that target would mark "another milestone in advancing sustainable transportation," Hyundai said.

Reportedly, the vehicle has been created from scratch and will be equipped with eight tanks capable of storing 33



Fig. 2: Hyundai new 135-kilowatt drive unit

kilograms of hydrogen at 350 bars of pressure. The tanks, which can be filled in 7 minutes (see photo p. 3), offer a range of 249 miles (400 kilometers). Initial shipments have been scheduled for this year, with more units to be delivered before the end of 2023. H<sub>2</sub> Energy, a Swiss engineering firm co-managed by Rolf Huber and Hansjörg Vock, will act as the middleman and sell the trucks to its customers in Switzerland. The firm made its first foray into fuel cell truck operations by joining forces with Coop for a project involving the AutoStack unit developed by the German ZSW – Solar Energy and Hydrogen Research Center. This stack is now part of products made by PowerCell (see H<sub>2</sub>-international, July 2018).



Fig. 3: Prototype of a hydrogen drive that FPT is developing for Iveco. [Source: FPT]

Like Hyundai, Canadian manufacturer Ballard had only a small booth at Pavilion 11, the venue for New Mobility World. Still, it gave attendees their first opportunity to see the company's new 50-kilowatt stack called FCgen®-LCS, which was designed specifically for commercial vehicles (see H2-international, October 2018). Reports said the stack would be integrated into fuel cell trains that the manufacturer was developing together with Siemens and that the latter would bring to market in 2021. But first, Ballard would focus on LCS-based power modules for forklift trucks and similar vehicles. Those modules would be made available sometime in 2019.

Meanwhile, Iveco displayed a truck chassis equipped with a fuel cell drivetrain and hydrogen tanks. The drive unit, which resembles an oversized skateboard, is being developed by the automaker's sister company, Turin-based FPT Industrial, a subsidiary of CNH Industrial.

**UBIQUITOUS STREETSCOOTER** However, the IAA attracted more than just the big names in the industry. One smaller business that had rented booth space to tell attendees more about itself and its products was Streetscooter. It had a main exhibit in hall 13, but its vehicles were standing at another two dozen booths all over the premises. The business's marketing and sales director, Marcus Arens, told H2-international that Streetscooter had to "press on" to stay one or two years ahead of the competition. The reason, he said, was that the company operated in a niche market and did not have deep enough pockets to survive an all-out price war against a big competitor.

Elsewhere, hydrogen and fuel cells were rarely a topic. Ford had nothing new to announce. It was reported that the corporation had been designing fuel cell equipment for commercial vehicles in the United States. But when asked by H2-international, no one at Ford's offices in Germany seemed to know how many staff members were involved in that venture. The automaker's only reply was that it kept "close tabs" on the market.

Additionally, Opel said that it was trying to rebuild its fuel cell division after most of its expertise in the area had been transferred to General Motors several years ago. Its acquisition by PSA had given it the boost it needed to restart development in Germany, the company stated.

**SUPPLIERS COME PREPARED** Much more intriguing conversations could be had with auto industry suppliers. For example, Mahle showcased the components it offered for fuel cell truck systems. Among them were humidifiers, heat exchangers, cooling units and fans. Unsurprisingly, one of its customers is truck maker Nikola Motor Company, based in the United States, which has integrated the supplier's cooling and air conditioning system into its Nikola Two model. Arnd Franz, the head of Mahle's automotive sales division, said the business's nearly 80,000 staff members had been working tirelessly for several years to advance innovative fuel cell powertrain technology, with the focus being on thermal management. "We are now in a position where we can scale production quickly and effectively and assist customers such as Nikola with launching their products," he added.

A similar truck, made of Plexiglas, stood at the booth of ElringKlinger, which used the model to demonstrate its own expertise in designing battery and fuel cell solutions. After having sold new enerday, its subsidiary making SOFC units, to Sunfire, the company announced it would concentrate development on PEM fuel cells (see p. 6).

Meanwhile, Faurecia showcased a whole range of products. Among those were hydrogen pressure vessels that the supplier produced in-house. They elicited a much more positive response in 2018 than they had some years ago, when hydrogen had hardly been talked about.

The last mile, as the short-distance transportation of goods from the warehouse to the customer is called, was also a topic at the event. Rytle, a startup business producing cargo bikes (see H2-international, October 2018), seemed to have just one motto: "All good things come in threes." First, it had a relatively large booth in hall 27. Second, it had a space at Pavilion P11. Third, the company demonstrated the capabilities of its bike on the New Mobility World track.

**SHOW KICKS OFF** On Sept. 20, 2018, the IAA Commercial Vehicles kicked off with several speeches, including one by the German transportation minister, Andreas Scheuer. The first to address the many company heads who had shown up at the convention center, in the midst of the expo area, was Bernhard Mattes, the president of the German auto industry association VDA. And he made clear where he stands on the future of transportation.

With pride in his voice, he said that the "world's most important logistics show" had set a new record by having 2,174 organizations exhibit on more than 3 million square feet (280,000 m<sup>2</sup>). He did talk about "new avenues to design a future transportation system" but without mentioning hydrogen or fuel cells. Instead, he continued by saying that "the latest diesel technology will give us the clean vehicles we'll be 'driving to-morrow.'" He also said that "natural gas is another eco-friendly solution," while "electric transportation will not be the best option for every situation. This is why diesel engines won't lose their importance any time soon."

Scheuer confirmed that his ministry would "promote natural gas, LPG and electric transportation." He did note that "current technical advances have been encouraging" but added that "electric vehicles need to be ready for everyday use." At the time, there had been no more than 113 battery, 15 fuel cell and 371 hybrid buses among those 35,000 owned by mass transit companies. Their percentage would need to go up, he added. ||



Fig. 4: Rytle displayed its fuel cell cargo bike for the last mile.

#### SOLARIS

At the InnoTrans show, which opened in Berlin on Sept. 18, 2018, shortly before the IAA, a Polish manufacturer named Solaris displayed its design study of a catenary fuel cell bus. It said the bus would be used in test runs at mass transit company RĖgas Satiksme in Lithuania in the second half of 2019, when it would be equipped with a fuel cell to extend the minimum range, without using overhead lines, to 62 miles (100 kilometers). According to Solaris, RĖgas Satiksme had ordered a total of 10 buses, type Trollino 18.75, which would be powered by an 80-kilowatt fuel cell and a battery with a capacity of 29.2 kilowatt-hours.



# THE DIESEL IS DEAD – LONG LIVE THE EV

*Thoughts on the future of the German auto industry*



Fig. 1: VDA President Bernhard Mattes, flanked by Bernd Althusmann (left) and Andreas Scheuer (right)

Few expected something to be different after the change at the top of the German transportation ministry. The replacement of Alexander Dobrindt by Andreas Scheuer didn't usher in a new era at the department. It is true that Scheuer is four years younger than his predecessor. But both belong to the same political party, and Scheuer's time as head of the ministry has likewise been little more than an exercise in cozying up to the auto industry. Chances for a real turnaround in the transportation sector are getting slimmer by the day.

I am not about to dedicate another article to climate targets and dieselgate, and I won't use these next lines to write about an energy market transformation that may have already failed. Instead, I will focus on how politics could make or break the success of a new transportation system. Most of what you will read below has little to do with technology.

Whether we will soon drive fuel cell cars or battery-electric vehicles, or both, isn't the most critical question at this point. A more important one to ask is who has benefitted or who is still benefitting from past and current decision-making.

**WHERE WE ARE** Many of the issues surrounding the diesel emissions scandal remain unresolved. In Europe, there have been no lawsuits filed against the perpetrators of the cover-up, which means that the courts haven't weighed in either. This explains why the public debate about the fuel's future is still raging.

A completely separate issue, though often conflated with the results of rigged emissions tests, is that of particle pollution, also known as particulate matter. But despite multiple rulings in this case, there is a lot of uncertainty as to where driving bans will be next.

The debate over electric transportation has been just as heated. Some see electric vehicles as the solution to all our worries. Others have warned repeatedly that we would only replace one type of resource dependence with another and create new environmental challenges along the way. What's more, the electric vehicle community comes across as hopelessly divided, with one side favoring BEVs, that is, battery-electric vehicles, and the other FCEVs, or fuel cell electric vehicles. And even though some have stressed time and again that it is not an either-or situation, most won't even acknowledge that the other side has as much right to promote their ideas as they do. A good opportunity to watch this ideologically driven – and sometimes frantic – exchange between BEV and FCEV fans is to follow the discussion on social media.

Above all, what needs to be asked is if transforming the energy market will, should or must be accompanied by changes in the transportation sector. Eight years have passed since the Fukushima disaster. Yet, almost nothing has been done to transition to a more sustainable energy system. Also, what exactly is sustainable? Has anyone ever come up with a comprehensive definition of what a sustainable market should look like? Is there a plan or a road map to guide the market transformation at each step?

To engage the public in a debate about the above is the right thing to do. But for how long? With what result? And who will benefit from it?

Will we see a repeat of what happened when the European Union weakened restrictions on vehicle emissions because of the combined efforts of Chancellor Angela Merkel and the German economy minister at that time? Are lobbyists for the German auto industry the only ones that have the chancellor's ear?

"Our transportation system puts up a lot of resistance to change. Ultimately, though, we will see a revolution similar to what happened in the manufacturing industry when it entered the digital age."

*Henning Kagermann, president of NPE,  
as quoted by the Handelsblatt magazine*

In hindsight, this has me wondering aloud if the choice Merkel and her economy minister made in 2013 had the desired effect. By making sure that the European Union would impose less stringent limits, they essentially told the industry that there was no reason to invest in new technology to bring about a turnaround. It was a missed opportunity, and that decision affects us to this day.

**THE AUTO INDUSTRY'S REACH** German automakers still firmly believe that "the latest diesel technology will give us clean vehicles." That was how Bernhard Mattes, the president of the auto industry association VDA, put it when giving a speech on Sept. 20, 2018, at Hanover's convention center, at the start of the IAA Commercial Vehicles (see also p. 28). He went on to say the industry would support "realistic targets for reducing carbon dioxide emissions," but not without adding the thinly veiled threat, or, in his words, "call on lawmakers," not to "overdo it."

"What we need are technically feasible limits," Scheuer said when it was his turn to speak, seemingly following suit. In fact, his entire speech sounded as if it had been written by lobbyist Mattes, who had noted earlier that "we can count on him, and Lower Saxony's deputy minister Bernd Althusmann, to adopt our position."

Fittingly, the minister then told the corporate heads of German automakers and their suppliers gathered at the show that he flat-out rejected the idea of a hardware fix for diesel cars, saying the cost of upgrades outweighed the benefits. Instead, he called for the replacement of the country's entire fleet.

Sure, upgrading all those dirty diesel models would be an expensive task. But, then again, who deceived whom exactly? Obviously, selling new cars would be more profitable and eliminate the emissions issue too. But would it be a sensible economic decision and a move toward more sustainability?

Scheuer then zeroed in on one of his colleagues in the government, environment minister Svenja Schulze, going so far as to encourage industry representatives to hit back at her for trying to push through hardware upgrades that the automakers would need to pay for. Schulze herself seems to leave much of the debating to others. But it is reasonable to assume she has the backing of most consumers considering her intent is to hold automakers accountable for their lack of oversight. Yet, the idea of making car buyers share in the cost of vehicle upgrades was revived at a "diesel summit" held at Merkel's office in late September last year.

Some time ago, my daughter asked me how to make sense of all the back and forth. I must admit I had no idea how to respond. How do you explain to the next generation that carmakers will not face any consequences for deceiving and defrauding their customers but may be rewarded with a stimulus package? Why would someone buy a vehicle that, basically, came without a road permit only to be asked >>

## Efficient air supply of stationary fuel cells



The new generation of Becker's successful VASF side channel blowers offers reduced power consumption and improved performance for a higher overall fuel cell system efficiency. The modular design as well as the single-phase AC- and DC-drives with corresponding frequency inverters for optimised system integration complement the essential features of the new VASF generation.

## NEW GENERATION AND NEW LEADERSHIP

In light of the above, it is encouraging to read reports that Daimler's director of research and development, Ola Källenius, is slated to replace Dieter Zetsche as the company's chairman at the annual general meeting in May. Granted, in 2017, the 49-year-old Swedish-born manager held a fiery speech defending the combustion engine, and he did so at EVS30, an electric vehicle show of all places. But then, last September, in an interview with the Stuttgarter Nachrichten newspaper, he said Daimler "has always considered the possibility that fuel cells could gain in importance over time." However, the initial batch of GLC F-Cell cars, which left the factory in November last year, were shipped only to partners of the automaker. Consumers will have to wait until sometime this year at least.

Källenius added that in the meanwhile, Daimler had been working on "the next generation of fuel cell engines. These engines will be as compact and powerful as never before. Nevertheless, costs need to come down." He said that the company didn't "know yet if and when we will produce a car like this for the mass market [but] I wouldn't be surprised to see one of our bus models being the first vehicle to make ample use of fuel cells."

to pay for a hardware upgrade later, should it become available at all? Is this just? Do we want those with pivotal roles in tomorrow's society to emulate this kind of behavior?

I know that you shouldn't compare apples to oranges, but the government's response to the emissions scandal has not been its first misstep. In another recent yet unrelated situation, it also underestimated the population's strong sense of justice and the backlash that followed. Should it continue to sweep issues under the rug to help out large market players, it may find it impossible to regain the public's trust.

**NOW OR NEVER** It is long past due to remind those corporations, which have raked in huge profits each year, that they acted on their own accord and continue to do so. Moreover, it would be wrong for the government to let BMW, Daimler, Volkswagen and others do whatever they want without so much as a slap on the wrist, only to see them share the fate of Kodak, at which time lawmakers will feel pressured to save them with taxpayer money.

To be honest, it will already be all but impossible to try and catch up. While Japan and China are pushing ahead, widening the gap, German automakers seem more interested in securing shareholders' dividends and do what is needed to prevent a dip in their profits.

This is why I'm calling on everyone to look for common sense solutions. Ignore the old boys' club and turn your focus to start-up businesses: Not only do they see the tide turning, but they also have the flexibility to respond to changing demand.

Electric vehicles are disrupting the market. Be they battery-powered passenger cars or commercial and railroad FCEVs, all of them could play a key role, particularly in a new integrated energy system supported by thoughtful policies.

Of note is that several electric models have already come to market. In Europe, however, automakers have only as many available as they need to meet the EU's limits on carbon dioxide emissions from new cars. As a result, they have long wait times. Likewise, they can cost a small fortune, even though several innovative entrants have proved that they don't have to.

Plus, fuel cell cars are a complete no-show in Europe. In the meantime, Hyundai and Toyota are fast-expanding production capacity. Their reservation lists are long, showing that the demand is there. New fueling stations are being added too. Over 50 are now in operation in Germany, so the claim of having no station to fill up your fuel cell vehicle has become pretty much an excuse. Those that need to act at this point are the automakers, which ought to establish a viable alternative that offers a higher range and faster refueling than a battery-electric car.

"We were a bit surprised about how strong demand was. Each unit manufactured in 2018 has been sold."

*Oliver Gutt, Hyundai Motors Germany*

Nevertheless, automakers require a stable market environment in which to operate. This is where politics can make a difference. Instead of inviting corporate heads to crisis meetings, the government needs to map out a strategy to ensure that, in the medium and long term, prospects remain bright enough for investors, of which there are still more than a few, to promote innovative, future-proof technology.

If we knew roughly what the market transformation looked like, if we saw that change was coming to modes of transportation and heat supply, and if we were certain that energy storage was about to play a more important role in transforming the market, we would have a foundation on which to build. Businesses in many industries, from gas suppliers and wind farm operators to steelmakers and refineries, have been calling for a sustainability road map like the one driving energy policy in countries such as China and Japan.

If it were certain that, across all industries, Germany's target for 2050 was to reduce greenhouse gas emissions not by 80 percent but 95 percent compared to 1990 levels, we would have something to strive for. Instead, we are faced with prolonged uncertainty and, not knowing where to go, have come to a standstill. Nothing is being done, all the while those exciting prospects people had talked about often enough have vanished, giving way to a gloomier outlook. Even the EU thinks that German companies especially are too slow to adjust. The German government and the European Union have invested a great deal of money into hydrogen and fuel cell projects, particularly in the greater Stuttgart area, as well as in Bavaria and Lower Saxony. Now, both want to see results.

Germany could again lead by example, as it did when parliament passed the renewable energy law. Moreover, the whole of Europe expects as much from the country. The German chancellor could set the tone for a debate over the future of our energy system. But whatever she decides to do to kick-start growth, she will need to do it soon.

Her actions could show to the world that Germany is not backing down from its commitments. ||

## TIME TO SEND A SIGNAL

On Sept. 18, 2018, representatives for 25 EU countries and the European Commission signed a joint declaration in Linz and founded the Hydrogen Initiative (see p. 55).

On Oct. 23, 2018, Japan hosted a Hydrogen Energy Ministerial Meeting, attended by department heads from those key countries that are most supportive of hydrogen technology. The aim of the meeting was to discuss global hydrogen policy with representatives from business.



# WHO IS FIRST TO ABANDON ICES?

## Germany to cling to internal combustion engines until 2050

Manufacturers of gasoline and, especially, diesel vehicles are under growing pressure to come up with new options. At the latest since the German transportation minister, Andreas Scheuer, stated in mid-September 2018 that software updates alone would not be enough to fix diesel emissions, the benefits of diesel models have been declining by the hour. Meanwhile, politicians in many regions of the world have been crafting new legislation to bring the era of combustion engines to an end.

While the Green Party is the only one in Germany to call for a total ban on internal combustion engines in new cars, other parts of Europe have gone ahead and passed legislation that, in some regions at least, will translate into a complete ban on diesel technology. Many countries and big cities, and businesses, have already decided to abandon the fuel.

Paris is planning to impose comparatively stringent emissions limits and might bar diesel cars from driving into the city as early as 2024, when it hosts the Olympic Summer Games. Although a decision on the issue has yet to be reached, the city council has already moved to block internal combustion engines from driving on Greater Paris roads by 2030, while the French government intends to end sales of gasoline and diesel vehicles by 2040.

In Italy, the situation is pretty much the same. Rome will, for the benefit of its population and its many historic buildings, hit the brakes in less than a decade and bar privately owned diesel cars from entering the city center starting in 2024. By 2030, drivers of diesel cars will have to deal with driving restrictions in Milan as well.

Brussels aims to get diesel vehicles off its streets in 2030. Whether the city-wide ban will also apply to gasoline-powered cars has yet to be made clear. Since early last year, the city has banned diesel vehicles that are older than 20 years from driving around its low emission zones.

On Spain's Balearic Islands, a ban on gasoline and diesel engines in new cars will take effect in 2025. However, owners of ICE delivery vans will most likely be allowed to register their cars until 2035. To meet COP21 climate targets, fossil fuels will no longer power anything on the islands by 2050.

Last September, Iceland said it would include the phase-out of gasoline and diesel in its 34-item climate action plan. The island country in northern Europe intends to ban sales of new ICE cars by 2030 and be carbon-neutral by 2040. It not only wants to see its charging network grow and electric vehicle incentives increased, but it also intends to promote climate-friendly fuels such as hydrogen and methane. Reportedly, it will even abandon the use of bunker fuel for marine vessels and ferries and instead install renewable energy systems at ports by 2025.

Two years ago, in September 2017, Nicola Sturgeon, the first minister of Scotland, announced that new ICE cars could no longer be registered starting in 2032. The following March, the national Transport Scotland agency set out more detailed plans that show it would allow drivers to register

	ICE ban effective from
Balearic Islands and Norway	2025
China, Denmark, Netherlands, India, Ireland, Iceland and Israel	2030
Scotland	2032
Denmark (hybrids)	2035
Taiwan (motorcycles)	2035
British Columbia, California, France, Spain, the UK and Taiwan (last only passenger cars)	2040
Germany	2050

battery-electric and plug-in hybrid vehicles only. Regular hybrids won't be accepted.

Likewise, many automakers are saying goodbye to the diesel era, including all but one of those based in Japan. Except for Mazda, they intend to stop shipping ICE cars to Europe altogether. BMW is pulling its diesel models from North American markets to focus on plug-in hybrids and gasoline vehicles, while Cadillac is ditching diesel completely to dedicate more resources to vehicle electrification. Among the brands of the Volkswagen Group, Porsche and Bentley have distanced themselves from the discredited technology. PSA has not made any final decision on the matter but has halted development of new diesel cars. And Volvo is now offering only electric motors and hybrid engines. ||

### OPINIONS DIVIDED

"It is true that Volkswagen Commercial Vehicles has succeeded in providing more electric motor options across its product portfolio. However, we believe that diesel engines will remain the backbone of logistical operations in a number of industries and application areas. From both an economic and an environmental standpoint, the latest diesel technology is still better suited for long-distance travel, difficult terrain, building sites and heavy-duty transportation."

Thomas Sedran,  
Volkswagen Commercial Vehicles

"They lack the production capacity needed to meet demand. The real drag on the electric vehicle market is the auto industry."

Erik Lorentzen, Norwegian Electric Vehicle Association,  
as quoted by *kurier.at*

# A CAR THAT'LL MAKE YOU SMILE

## H2-international at Päsler's

Today, few car dealers can give consumers comprehensive answers about electric vehicles. Regardless of the model, an EV is still a curiosity in most showrooms. Either there is none on display or a single one is standing in a faraway corner. On top of this, fuel cell cars are mostly unavailable simply because there are not enough being produced. One exception to common experience is Autohaus Päsler, a dealership located in Hamburg, Germany, where highly competent staff members offer advice on both battery and fuel cell vehicles.

The first time I distinctly remember hearing the name Päsler was last June in Enge-Sande, a small town close to the Danish border, when Oliver Päsler, the store manager of a dealership store in Schwarzenbek, showcased the new Nexo at the local Grünstrom event. While I talked with him, he told me that he specialized in battery-powered cars, whereas his brother, Sebastian, who showed up a few hours later, was the fuel cell expert in the family. During a follow-on visit to Sebastian Päsler's store in Hamburg, he explained to me that he had thought it important to have someone with knowledge of electric vehicles near the car the entire time, which was why both siblings had not minded taking the long trip to Enge-Sande.

Sebastian Päsler shared several more anecdotes with me when I visited him last October. Even though he had a cold, he nevertheless devoted much of his time to speak to interested customers and, afterward, made himself available for an interview. "Reinhard Christiansen was here a few minutes ago," he said. "You just missed him." That would be the Reinhard Christiansen, Germany's wind energy pioneer, who is building an electrolyzer and a fueling station at his wind farm in Ellhöft (see p. 23). I would have liked to chat with him again, but, in any case, he was not the reason why I was here.



Fig. 2: Holger Päsler is always happy to hear customers truly appreciated the advice they received.

That day in October was all about people such as the Päsler siblings, one of few in Germany to sell Nexo cars to prospects. Their commitment has earned them a reputation among many players in the industry, whether they are called H2 Mobility or hySolutions. The latter, by the way, had a representative coming the same day, I was told. Even Jorgo Chatzimarkakis, the head of Hydrogen Europe, had ordered his car at Päsler's.



### 40,000 FUEL CELL VEHICLES A YEAR

Last year, Hyundai produced 800 Nexo cars altogether. This year, the automaker expects the number to rise to 3,000. As per its new road map called "FCEV Vision 2030," yearly production capacity would gradually increase to reach 700,000 fuel cell units in 2030. On Dec. 11, 2018, the corporation broke ground for its second fuel cell factory in Chungju, South Korea. The facility will reportedly produce 40,000 fuel cell systems starting in 2022.

When I asked Sebastian Päsler about current sales figures, he gave few details, out of respect for other Hyundai dealers. At dealerships in other cities, I later found out the reason for his muted response: Not every distributor can get a Nexo model because some simply lack the means and qualification. As a result, a sizable proportion of the 150 Nexo cars imported into the EU have been leased through the Päsler family business.

Likewise, the Päslers have put a lot of effort into becoming an authorized dealer for Hyundai fuel cell cars. They regularly send their entire staff to Offenbach in the state of Hesse to attend fuel cell training courses, which last for up to three weeks. In the meantime, they stay behind to promote the cars and speak to potential buyers. Of course, this means that the brothers have less time to sell bread-and-butter models. I asked him why he carried on regardless. “You can’t earn money with it. But it’s fun,” he replied.

**CLOSING THE DEAL TAKES TIME** Holger Päsler, the father of the Päsler brothers and chief executive of Autohaus Päsler, was also in the store at the time of the interview. A man as eloquent as his sons, he said that he had been selling cars for 47 years and fuel cell vehicles for the last three. He had just come from a test drive and was raving over EVs. He agreed that selling fuel cell vehicles took a lot of time, saying “we need to put in double the effort.” But he has always been one to provide comprehensive and trustworthy advice. More than once, he recommended that customers not choose the model they had thought about buying and many came back thanking him for his bluntness.

Sebastian Päsler said he was selling “cars that I know will make people smile.” He added that most of them had the same questions about the fueling infrastructure and the number of stations. Still, in his experience, “those who buy a Nexo know they’ll have to make compromises.”

Holger Päsler said those “who buy a Nexo car are idealists, disappointed by Daimler’s progress.” Many of them asked for fuel cell vehicles because they were looking for a groundbreaking experience. “And, indeed, this car is something special,” he said while his eyes lit up, leaving no doubt that he wasn’t just saying it to drive sales.

In the eyes of some customers, hydrogen vehicles are still too much of a novelty. The car they will want to take a look at in Päsler’s showroom is the Hyundai Kona, the latest model by the South Korean automaker. Its range is between 279\* and 381 miles (449\* and 613 kilometers) on a single charge. If the conversation turns to more in-depth questions about the car’s battery and range, Sebastian Päsler often recommends that customers visit his brother’s store in the town of Schwarzenbek. In turn, his brother will tell those looking to buy a fuel cell car to drive from his store to Sebastian Päsler’s in Hamburg’s Bergedorf district.

#### HYUNDAI KONA ELECTRIC

Primarily because of a lack of fueling stations in Germany, few people were asking for fuel cell cars at Hyundai dealerships across the country, said Kaufmann Automobile, based in Oranienburg, in the state of Brandenburg. However, there was comparatively high demand for another model named Kona Electric. This battery-electric car offers a range of 279\* miles (449\* kilometers), according to a testing procedure called the Worldwide Light Vehicles Test. The Oranienburg-based store said that, despite a 14-month-long wait for delivery, it had sold, on average, three units a month since the model had been launched in August 2018. If the delivery time were cut, the dealership was sure it could about double its sales per month. The demand was there.



Fig. 3: One difference between the Kona Electric and any Kona with an internal combustion engine is the lack of a radiator grill in the front.

A test driver hired by the German Auto Bild magazine got as far as 381 miles (613 kilometers) on a single charge of the Kona Electric’s 64-kilowatt-hour battery.

This kind of task-sharing among family members and the direction in which they have taken their business may be a bit unusual for the industry. And perhaps it is not as profitable as selling other cars, but the family is not in it for the money. They believe they have found the market they want to be in, even if that means they will have to put in more hours. All three told me in one way or another that “we’ll continue to do what we’ve been doing all these years.” ||

Model	Engine power	Battery capacity	Range	Consumption	Base price
Kona Elektro	100 kW (136 hp) 150 kW (204 hp)	39,2 kWh 64,0 kWh	180* miles (289* km) 279 miles (449* km)	22.4 kWh / 100 mi (13.9 kWh / 100 km) 23.0 kWh / 100 mi (14.3 kWh / 100 km)	34.600 Euro 39.000 Euro
Nexo	120 kW (163 hp)	6,33 kg <sub>H<sub>2</sub></sub>	470 miles (756 km)	0,84 kg <sub>H<sub>2</sub></sub> / 100 km	69.000 Euro

\* Results from WLTP tests were revised downward from 300 miles (482 kilometers) on Dec. 4, 2018.



# POTSDAM MEETS 50-STATION TARGET

*Brandenburg pledges greater commitment*



Fig. 1: Minister Schneider spoke at the opening.

36

The German transportation minister, Andreas Scheuer, was not among those who took a trip to Potsdam, in the state of Brandenburg, to see the opening of the country's 50<sup>th</sup> hydrogen fueling station on Sept. 7, 2018. His absence, however, did little to stop those who came from celebrating this particular milestone. The event attracted over 120 people, including Kathrin Schneider, the state minister for infrastructure, and Jann Jakobs, the then-mayor of Potsdam.

It was a long-awaited moment for some, considering the magical number of 50 fueling stations across Germany was supposed to have been reached by the end of 2015. At least, that had been the aim of Peter Ramsauer, the country's minister in charge of transportation at the time. That it took so long to fulfil the 50-station target was mainly the fault of the ministry itself. Headed by politicians of the Christian Social Union in the past decade, the department missed the opportunity to put automakers' feet to the fire, allowing their actions to go unchecked. Instead of advancing sustainability, it intervened in Brussels to help dial back the emissions targets proposed by the EU. Then, at the height of the diesel emissions scandal, it shied away from taking corporations to task over their shady practices.

Yet, thanks to H2 Mobility, the past months have seen a remarkable increase in the number of fueling stations. The company's young team, led by Nikolas Iwan, has been chipping away at many market barriers and sped up the entire process, fueling expectations that the next 50 stations will be completed much sooner. Iwan himself was visibly proud when he said in Potsdam that "in 2017, more hydrogen stations were being built in Germany than in any other country in the world. In 2018, there will be even more."

Among the attendees at the opening was Bart Biebuyck, the executive director of the Fuel Cells and Hydrogen Joint Undertaking since 2016, as some of the funding for the sta-

tion had been provided via the EU's Hydrogen Mobility Europe project, or H2ME for short. Biebuyck said 1,200 fuel cell vehicles were registered in the EU. He also noted that an entire factory to produce fueling stations had opened in Denmark last fall, something that is certain to have a positive impact on the size of the fueling infrastructure over the next years.

**EU OFFERS SUPPORT** The new hydrogen pump installed at the Total-branded gas station on Horstweg, in the southeast of Potsdam, was designed for filling up the tanks of passenger cars at 700 bars. Additionally, the site has been prepared for the installation of a 350-bar pump to refuel buses. The capacity of the present pump is about 40 fill-ups a day.

The chairman of NOW, Klaus Bonhoff, called the opening a "milestone in the history of fueling stations," adding

At one point, an Oldsmobile vintage car passed the event, following a trip to the neighboring car wash. When its driver intentionally made the vehicle's big engine howl, the only response he got was laughter – and head-shaking pity.



Fig. 2: Hydrogen fuel pump right next to a fuel cell vehicle.

that the testing stage was over, and efforts should focus on building up a nationwide network instead. He went on to say that the “50<sup>th</sup> station may have arrived late but not too late.” Later, Biebuyck said that “we will make use of the know-how gained from H2ME to expand the fueling infrastructure in other parts of Europe.”

**BRANDENBURG WANTS TO DO MORE** Kathrin Schneider, Brandenburg’s minister for infrastructure, said in her speech that the opening of the fueling station was “in line with our policy objectives.” Among them was the aim to create more “sustainable modes of transportation.” She underscored that Brandenburg’s government “closely follows the progress of both battery and fuel cell technology” before pointing to another hydrogen-focused project, in the railroad sector. The idea behind that venture was to make fuel cell railcars part of the Heidekrautbahn line, which ran from Berlin to the Schorfheide region in the north. She then remarked that the state government “would be happy to contribute” to the implementation of those kinds of projects.

She told H2-international she agreed with her colleague Regine Günther, Berlin’s environment senator, about re-opening the main Heidekrautbahn line, which used to go from Berlin’s Wilhelmsruh suburb to Basdorf. Fuel cell railcars could run on those tracks, she stated, and possibly in the region between the Elbe and Black Elster rivers. Everything, however, would depend on how much interest the project would generate. She said that she was “curious whether we will see bids for the venture.” When H2-international asked about the statewide lack of hydrogen and fuel cell projects and if that was going to change in the foreseeable future, she replied, “It will. That’s our plan at least.”

Jann Jakobs, who, after 16 years in office, had decided against seeking another term as mayor of Brandenburg’s state capital Potsdam, said “we are a growing city that needs its bus lines.” Although he has now been replaced by Mike Schubert, who was voted in on Oct. 14, 2018, to manage an area with a population of 177,000, he said he was pleased “talks have started in time,” since the decision to introduce fuel cell buses was still due in 2018. At the same time, however, he pointed to the low number of offerings, calling on manufacturers to “make and supply the buses we need.” He said that those would have to be “articulated buses with a length of 59 feet (18 meters).” In this context, Schneider announced the state would pay 10 percent to 15 percent of the difference in price between a fuel cell model and a conventional one if a city or town chose to buy those buses. ||

#### OFF TO CHINA

At around the same time last September, Brandenburg’s governor, Dietmar Woidke, took a trip to Zhangjiakou, one of the Chinese cities to host the Winter Olympic Games in 2022 and, reportedly, China’s new showcase for renewable energy. The city is currently seeing the construction of the world’s largest hydrogen cluster. Woidke said “if there is one thing that has been crystal clear, it is that all of us need to forge ahead with protecting our environment and our climate [...] Brandenburg is in a good position to take on possible challenges and become a market for ideas to be exported to all corners of the globe.” As for the agreements McPhy and Encon. Europe signed with Chinese partners, he said: “It’s a market with a bright outlook and we want in.”



Fig. 3: The container houses an ionic compressor by Linde, as well as a stationary hydrogen tank (left).

37

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## DOUBLE THE EMOVE360° EXPERIENCE

On Oct. 16, 2018, the eMove360° show in Munich was no longer an event that attracted mainly fans of battery-powered vehicles. For the first time, it featured a conference on fuel cell cars, attended by around three dozen people. However, the main question during this eMove360° Fuel Cell Conference, which took place at the same time as the show, was not whether battery or fuel cell vehicles would make it on the market but if and how the technologies could be combined.

Thomas Grube, who works for the Jülich Research Center and spoke during the conference, recommended the development of both transportation pathways. He said that the cost of each pathway depended mostly on how many vehicles would need to be supplied with fuel. He believes that hydrogen would beat electricity should the number of cars go into the millions. Still, he remarked that both pathways would cost a lot less than other parts of the infrastructure and that both would be needed to shift to more sustainable modes of transportation (see H2-international, April 2018). Jan Michalski, project manager at Ludwig-Bölkow-Systemtechnik, agreed and said that “the optimal solution would be to combine the two pathways, so that we could benefit from synergies.”

Korean carmaker Hyundai showed attendees what the fuel cell vehicle of the future could look like. Besides the Nexso, it presented a concept study of its first fuel cell truck, slated to hit the market in 2019. One person who is looking forward to the new vehicle with great anticipation is Philipp Dietrich, H2 Energy’s chief executive, as his company wants to get a thousand of Hyundai’s hydrogen-powered heavy-duty units onto Swiss roads by 2023. To this end, he formed a rather unusual partnership with Switzerland’s biggest supermarket chains, Coop and Migros, and farmers’ cooperative Fenaco, instead of enlisting the help of automakers and hydrogen producers.

All three businesses operate their own gas stations in Switzerland. Coop had a hydrogen fueling station built in 2016 (see H2-international, September 2016), with the fuel coming from an electrolyzer H2 Energy installed at a run-of-the-river hydropower plant in Aarau. At the event in Munich, Dietrich said that constructing a station paid off if at least ten fuel cell buses or trucks were filled up at it regularly. ||

## GAPS ARE CLOSING

On Sept. 18, 2018, shortly after the hydrogen fueling station in Potsdam was started up (see p. 36), the 51<sup>st</sup> one in Germany, and first in Saxony state, went into operation in Dresden. It is located on Wiener Strasse, at a Total gas station in an easily accessible spot in the midst of the city’s historic core. Its construction was partly funded by EU project Connecting Hydrogen Refueling Stations, or COHRS for short. The state’s second site came online on the very same day. It is also part of a Total gas station, or, more specifically, a truck stop named Poststrasse, near the A14 autobahn. Stefan Brangs, who works at Saxony’s economy ministry, said at the opening ceremony that he was pleased to see “the gaps in the fueling network in east and middle Germany getting smaller all the while the number of publicly accessible stations is becoming larger. The establishment of a densely connected network of stations across Europe will be vital to convincing more people to buy hydrogen vehicles.”

Only three days later, another station opened at Mundorf Tank in Frechen, near the Cologne West interchange, where the A1 and A4 autobahns meet. It was installed by Air Liquide as part of the company’s “Small 4-Wheel fuel cell passenger vehicle Applications in Regional and Municipal transport” project, or SWARM, partly funded by the European Fuel Cells and Hydrogen Joint Undertaking. Another COHRS project saw a symbolic opening on Oct. 23, 2018, at the Fuel Cell Forum in the state of Hesse. The actual pump is located at Weiterstadt’s Shell gas station, near Darmstadt’s interchange between the A5 and A67.

On Nov. 21, two more fueling opportunities showed up on the map, one in Magdeburg and another in Munich. Since the former was the first ever in the state of Saxony-Anhalt, the state’s governor himself, Reiner Haseloff, was in attendance when it came online at a Total truck stop on Glindenberger Weg. Among those invited to the opening of the latter, located on Verdistrasse at the A8 autobahn near Bavaria’s capital, were Christian Bruch, a member of Linde’s board of directors, and Josef Zellmeier, who worked at the state’s transportation ministry at the time. These last two sites pushed the number of operational hydrogen fueling stations in Germany to 55 at the end of 2018. ||

## HYDROGEN TEST FACILITY IN KLEINBURGWEDEL

JA-Gastechnology, based in the German state of Lower Saxony, is planning to open a hydrogen testing lab this spring. The company’s founder, Jens Asmuth, decided it was time to branch out beyond the core business of calibrating emissions testing equipment and focus more on alternative fuel engines. Construction started last summer. It was said that the facility would house a pressure and an environmental test chamber to determine the mechanical strength, exhaust gas behavior and lifetime of tanks and analyze valves and sensors. The nearly 80-strong staff business would also offer training courses and construct tanks themselves, while an electrolyzer would be added to produce renewable hydrogen on-site. One benefit of the busy schedule is the fueling station JA-Gastechnology aims to build at its headquarters in Kleinburgwedel’s industrial area. It would be used to test tanks and fill up the company-owned Toyota Mirai, saving employees a trip to the fueling site in Wolfsburg. The lab would come online in early April to mark the start of this year’s Industriemesse show in nearby Hanover. ||



Source: JAG



# WHAT WILL MOVE US IN THE FUTURE

## *The Clean Energy Partnership is on the move with hydrogen*

Knowing that a successful structural change in the transport sector can make a decisive contribution to a reduction in CO<sub>2</sub> emissions, the Clean Energy Partnership (CEP) works in the field of mobility powered by hydrogen and fuel cells, and has already produced an array of internationally acclaimed results: Fuel-cell vehicles suitable for everyday use are on the road in Germany, the expansion of the infrastructure has picked up speed, the market activation of H<sub>2</sub> mobility has begun. The industrial partnership is dedicated to the H<sub>2</sub> electrification of the heavy-duty sector, the production and logistics of green hydrogen, and the development of an 'RCS (Regulations, Codes, Standards) Platform' that will serve to involve even small and medium-sized companies from the H<sub>2</sub> sector in regulatory decisions in Germany, Europe, and worldwide. The partners consider the entire hydrogen chain, from production to tank.



**HEAVY DUTY – LEARNINGS FROM THE PASSENGER CAR SECTOR** Studies show that hydrogen can play a key role in reducing CO<sub>2</sub> emissions in the heavy-duty sector. In the logistics sector in particular, there is already great demand for emissions-free vehicles; some manufacturers are already developing production-ready hydrogen-powered commercial vehicles. Since H<sub>2</sub> electrification is a global topic in heavy-duty logistics, the CEP is in international dialogue with major players in the H<sub>2</sub> industry. Learnings from the passenger car sector can be transferred to the truck sector, and the existing expertise can be used to help reach an agreement on a global refueling standard.

**GREEN HYDROGEN: PRODUCTION AND LOGISTICS** The electrification of the transport sector is especially sustainable if renewable energies serve as the basis for emissions-free mobility. So another focus of the CEP is the development of solutions for the production and logistics of 'green hydrogen' in the terawatt-hour range. The partners have developed a definition of 'green hydrogen' as a basis for the repositioning of the industry that is needed in this context. The green hydrogen used by the companies meets all the criteria and requirements of TÜV Süd (CMS 70 standards 'Production of green hydrogen' in the version dated December 11<sup>th</sup>, 2017). In addition, it also essentially corresponds to the European CertifHy project's definition of 'green hydrogen'.

**IN DIALOGUE WITH POLICYMAKERS** To leverage synergies, the Clean Energy Partnership cooperates with key associations and institutions across all sectors. In order to realize a holistic H<sub>2</sub> economy, industry needs the unrestricted support of policymakers. The CEP, as an established source of knowledge, is in close contact with political representatives at both federal and state level. The industry partners support the work of the various political actors with consistent lines of argumentation, precise requirements, and important timings. The CEP also participates in the discussion on funding guidelines designed to facilitate research on new technologies and the strengthening of 'hydrogen regions', as well as accelerate market activation.

**RETROSPECTIVE** When the Clean Energy Partnership took up its work in 2002, there were neither H<sub>2</sub> vehicles nor H<sub>2</sub> filling stations in Germany. The clearly formulated goals of the companies involved were to establish everyday suitability of high-performance vehicles; fast, safe refueling; and system capability of accompanying technologies for optimum production, storage and logistics. With this in mind, the H<sub>2</sub> technology was researched and developed, data on vehicle and plant operation evaluated, and knowledge about H<sub>2</sub> mobility expanded bit by bit. The development of a global standard for refueling passenger cars is one of the partners' success stories. These successes were only been possible because the CEP offers something quite unique: a protected framework for cooperation between competitors. ||



### CLEAN ENERGY PARTNERSHIP (CEP)

The partners in the Clean Energy Partnership (CEP) are working across multiple sectors towards the market activation of hydrogen and fuel-cell mobility as part of a sustainable energy transition. Air Liquide, Audi, BMW, Daimler, H2 Mobility, Honda, Hyundai, Linde, OMV, Shell, Total, Toyota, and the Westfalen Group are all involved in the project. In order to make optimum use of resources and synergies as the partners work together towards their goals in the spirit of a shared mission, the project is organized into working groups: Market Activation & Modes of Transport, Car Filling Stations, Green Hydrogen & Logistics, Regulations & Promotion, Strategy Circle, and Communications, with their respective subordinate focus groups.

[www.cleanenergypartnership.de/en](http://www.cleanenergypartnership.de/en)

# RADICALLY NEW MARINE PROPULSION

## Zero Emission Shipping symposium in Hamburg



Fig. 1: A visual representation of the ZES symposium

Environmentalists have had the maritime sector in their sights for some time. Cruise liners in particular emit large amounts of pollutants on route to the world's natural – sometimes seemingly untouched – landscapes, or their diesel generators are running to power onboard systems while they are docked. However, now that shipping companies are switching to LNG, the market could see a change for the better. Fuel cells, too, could soon play an important part in the design of cleaner marine propulsion.

Even though the industry was clearly aware that its strong reliance on diesel generators would need to come to an end someday, it showed little willingness to entertain alternatives. Now, after several years of discussing the pros and cons of liquified natural gas use, the ultracold fuel has become part of a broader push for reducing the emissions from large watercraft. Probably the most prominent example of this shift in attitude is the AIDAnova cruise liner. This LNG-only vessel was christened at Meyer Werft in Papenburg, Germany, on Aug. 31, 2018.

When German environmental association NABU published its yearly list of the cleanest cruise liners last August, AIDAnova was the only ship to be given four green screw propellers and a (limited) recommendation. The chief executive of NOW, Klaus Bonhoff, said about the changes at the top of NABU's rankings that "ships powered by renewably sourced liquid fuels, such as LNG, are especially suitable for longer trips that require lots of energy." At that time, all other cruise liners were still using heavy fuel oil. This type of bunker fuel is cheap but extremely damaging to the environment, which explains why those vessels had been rated much worse.

With the construction of AIDAprima and AIDAprila in 2011, AIDA Cruises became one of the first cruise lines to use LNG to power its ships. They both have dual-fuel engines that can run on the liquid while docked, provided that it is available on-site.

But LNG is not "the panacea for the shipping industry's problems, since it too is a fossil fuel," NABU stated and pointed to a recent study by Transport & Environment. It added that "the benefits of replacing diesel with LNG to protect the climate are negligible at best."

**ENVIRONMENTAL RULES NARROW THE PATH** Similar to what is happening with land-based transportation, there have been years-long efforts to clean up the maritime sector. For example, a decision has been made to allow only fuels that contain 0.5 percent of sulfur or less worldwide starting in 2020. Additionally, the EU is planning to lower the limit from 3.5 percent today to 0.1 percent, the current threshold across Sulfur Emission Control Areas, such as the North and the Baltic Sea. Years ago, when ever-stricter targets were driving up the cost of cleaning the exhaust from ships pow-

The AIDAnova cruise ship is the grey one among the black sheep in the family.

NABU transportation expert Dietmar Oeliger, as quoted by ndr.de



ered by the tar-like sludge known as heavy fuel oil, ship operators likewise began looking for alternatives. That was when LNG started to gain traction.

In comparison to diesel, natural gas requires a relatively large amount of energy to be cooled to below  $-160^{\circ}\text{C}$ , condensed into a liquid and stored aboard a ship. But when it is converted back to gas and burned, it produces 90 percent lower nitrogen oxide and 20 percent lower carbon dioxide emissions. It also cuts particulate matter emissions by around 98 percent and all the sulfur is removed during liquefaction. And yet, like the chicken-and-egg dilemma the fuel cell industry has been faced with on land, there are comparatively few ports offering LNG fueling.

“Upgrading a vessel carrying 1,400 twenty-foot equivalent units of cargo to run on LNG could offset the annual carbon dioxide emissions of 1,500 and the nitrogen oxide emissions of 500,000 diesel-driven passenger cars.”

NOW

**ZES SYMPOSIUM IN HAMBURG** On Sept. 4, 2018, NOW, the organization in charge of implementing the German government’s transportation and fuel strategy, held a Zero Emission Shipping symposium at SMM, an international maritime industry show, in Hamburg to update attendees on recent developments in the market. As in 2016, roughly 150 people came to the event to discuss low-emission alternatives to conventional ship fuels.

The event program was divided into three parts: LNG, batteries and fuel cells. Early on, it became clear that fuel cells needed the most research and development efforts of the three technologies. However, what became just as clear was that many stakeholders in the sector saw significant opportunities for fuel cell use in short-sea and inland waterway transportation and onboard power supplied to a ship at a berth. One current challenge is that while more efficient engines cut fuel consumption, the pollutants that ships do not emit at sea will be produced as soon as generators remain running because of a crowded port.

#### IMO

The International Maritime Organization, a specialized U.N. agency, has a key role in regulating the industry. In all, 174 countries are members of IMO and have agreed to cut greenhouse gas emissions by at least 50 percent by 2050 compared to 2008. As the deadline to submit change requests for 2020 has passed, the objective now is to include fuel cells in Part E of the IGF code, short for the International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels, by 2024. In this context, methanol is also being tested for its viability as a fuel in the sector.

**LNG STORMS THE DIESEL CASTLE** At ZES, Christian P. Hoepfner, the general manager of the Wessels shipping line, gave insights into marine LNG use. With the help of a vessel called Wes Amelie, he demonstrated that the exhaust was “no longer noticeable at any cargo weight. There is no smoke, no soot particles and no smell.” Wes Amelie was converted to run on LNG within 90 days, with 60 percent of the cost paid through the government’s fuel strategy. The upgrade had reduced carbon dioxide emissions by around 31 percent,

Hoepfner said. Even at a methane leak rate of around 25 percent, which had been the latest figure at the time, the ship would end up with lower GHG emissions. And the cost of the liquefied fuel itself could be cut “by 25 percent or more.”

Another intriguing report came from Christian Becker, who gave a presentation on the recently completed LNG PowerPac® devices by HPE Hybrid Port Energy. These con-



Fig. 2: The AIDAprima cruise liner was ranked third by NABU, despite the use of heavy fuel oil.

tainerized systems produce 1.5 megawatts of electric power, are easy to transport and can supply ships with energy while they are in port. Becker said that HPE was planning to “make hydrogen part of our offerings, since Norway and Denmark have requested it.” The 40-foot containers could be put either directly on a quay or, like others, onto a ship, where they would be operational within 30 minutes.

**HYDROGEN ONLY FOR FERRIES?** Gerhard Untiedt from shipbuilder Meyer Werft again stressed that “LNG has become a viable method to power passenger ships,” adding it was “the fuel that will dominate the next decades. We don’t believe bio-fuels will be serious competition, not to mention that their availability is limited.” As for electric propulsion systems, he said that “batteries and hydrogen are not suitable to power ships long distance. We don’t consider hydrogen to be an engine fuel at all, except for ferryboats and similar vessels.”

“The target for 2050 can only be reached by using radically new marine propulsion systems based on hydrogen and batteries.”

*Esben Poulsson,  
chairman of the International Chamber of Shipping*

During the following discussion, the political representatives attending the symposium signaled a willingness to sit down and talk. Thorsten Herdan, who heads one of the energy policy departments at the economy ministry, called on the representatives for businesses and associations who had gathered at the event to present a list of proposals they liked to see being implemented as part of new government regulations. Achim Wehrmann, who heads the transportation ministry’s maritime industry division, said he would cooperate with both the industry and the economy ministry. But he also stated that his division would go it alone if no organization was going to make suggestions. The VDR association of German shipping companies had none. Instead, it said how difficult it was for any ship operator to imagine that something besides heavy fuel oil could power its vessels. ||



# FUEL CELL WATERCRAFT

## *e4ships 2.0 – maritime projects to last*



Fig. 1: Illustration of HySeas III, [Source: DLR]

42

Hydrogen and fuel cells are becoming ever more popular in the maritime industry. After many years spent on research and development, it seems as if both technologies could enter the market soon.

Launched in 2009, the e4ships flagship project had been a way to explore a variety of options for fuel cell use in the shipping market. Seven years later, the venture and all of its subprojects came to an end. Around that time, in September 2016, those involved gathered for a conference to discuss e4ships' successes and failures, finding that the millions of euros the National Innovation Program Hydrogen and Fuel Cell Technology had poured into the endeavor had done little to encourage progress (see H2-international, October 2016 and March 2017).

HyFerry, a subproject with the aim of studying fuel cell ferry operations in the North Sea, was paradoxically one that the industry abandoned quite early on. Nowadays, ferries are among the most promising application areas for the technology in the maritime sector. Just last August, Siemens and PowerCell Sweden inked a cooperation agreement to advance fuel cell-powered marine propulsion. Joachim Hoffmann, who works at Siemens Marine, confirmed to H2-international that Norwegian hybrid ferries in particular are making waves – in a good way.

**DEMONSTRATION PROJECTS CONTINUE** Since many still believed that there was strong potential for growth, the German government set up e4ships 2.0 in 2017. That decision also prompted the creation of several follow-on projects, namely MultiSchIBZ, SchIBZ2, Pa-X-ell 2, RiverCell 2 and ELEKTRA.

The successor to Pa-X-ell again focuses on powering systems and equipment aboard cruise liners. It intends to install methanol fuel cells throughout a passenger ship to ensure that each fire zone is independently supplied with electrical and thermal energy, even when the ship is in port (see fig. 2).

RiverCell 2, launched in April 2017, uses fuel cells made by Serenergy and alternative (low flash-point) fuels to develop and test a hybrid engine that can supply all the energy aboard a river cruiser. The project will run until September and is being supported with EUR 2.1 million.

ELEKTRA was originally part of RiverCell 1 (see H2-international, July 2016). It is the name of both a project and the zero-emission, hybrid-electric towboat that the venture aims to design and build. The vessel is to transport goods across the region and beyond, or, more specifically, between Berlin and Hamburg and farther, to Poland. Reportedly, it will be equipped with three of Ballard's low-temperature FCveloCity®-HD fuel cell modules, NMC batteries manufactured by Hoppesche and a PV system. The modules will have a capacity of 100 kilowatts each, while two batteries will provide 1,025 kilowatt-hours to power the boat and another one 300 kilowatt-hours to supply energy on board. The PV installation will offer an additional 1.8 kilowatts. The hydrogen for the fuel cells will be stored at a pressure of 500 bars inside six 125-kilogram cylinder packs. These packs could be transferred at relative ease from a truck to the boat. Expectations had been that the vessel would be placed in commercial service in Berlin's West Port in late 2018. However, construction has been postponed until the end of this year and test runs are now planned for 2021.

**ELECTRIC YACHT TO RUN ON LOHC** In the meantime, numerous other maritime projects have been launched in addition to e4ships. For example, a Rendsburg-based builder of superyachts, Nobiskrug, is testing the viability of LOHC for storing hydrogen on all-electric motor yachts. Last August, it announced that it was developing an LOHC system in partnership with H2-Industries. Holger Kahl, Nobiskrug's chief executive, said that his company believed "hydrogen will become the energy source of the future. And it can be stored in LOHC fluid." A low-flammable and non-explosive liquid, the fluid had good storage properties: "One advantage of LOHC is that it can be kept and transported in conditions similar to diesel."

Michael Stusch, the founder and chief executive of H2-Industries, said that the vessel would become "the first all-electric watercraft equipped with LOHC technology developed by H2-Industries. It will have a range of over 1,000 nautical miles and a speed of 10 knots." His statement sounded like an announcement the business had made in 2013, when it had partnered with motion code: blue, a ship engineering firm, to build an LOHC-based superyacht. That project, however, never made it past the planning stage.

But now, H2-Industries' aims to go beyond the yacht industry. Together with shipbuilder PortLiner, based in the Netherlands, it wants to become an influential player in the market for zero-emission transportation on inland waterways. The Dutch business is designing all-electric cargo ships drawing energy from so-called Powerboxes. Those boxes are actually containers, which would initially house batteries but might store LOHC later on, it was reported, so

they could offer sustainable, zero-emission cargo shipping on rivers and canals. Last September, at international maritime trade show SMM, both companies jointly presented a plan on how to bring their idea to market.

**WIR! INITIATIVE CAMPFIRE** In northeastern Germany, a project is underway to take advantage of both the region's proximity to the Baltic Sea and its abundant wind resources to create an integrated system based on the idea of "Fuel from Wind and Water – Transforming the Energy and Maritime Markets in the Northeast." In early 2018, a group of businesses and research institutes set up the CAMPFIRE initiative to adapt multiple types of marine propulsion systems for use with zero-emission fuel. Following a thorough discussion about the suitability of several energy carriers, the group's conclusion was that "utilizing surplus wind power to create climate-friendly synthetic fuels by means of thin-film electroceramic membranes is an extremely efficient process that has a long-term future."

At a workshop held on Sept. 11, 2018, in Stralsund's Ozeaneum, Christian Pegel, the minister for energy in the German state of Mecklenburg-West Pomerania, said the development of zero-emission engines for watercraft offered exciting prospects, considering that "electricity generated by wind farms in the state could be used to cut emissions in the shipping sector. As a result, two of our most cherished industries, renewable energy and shipping, could provide greater added value for the region and support the transformation of energy markets."

Accordingly, the 70 representatives that are now partners in CAMPFIRE all agree that a project to turn the area bor-

The CAMPFIRE initiative was launched by the German education ministry as part of WIR! – Innovating Regional Change. It has grown to include 30 businesses, both small and large, research organizations and universities. All of them are based in the country's northeast, in an area extending from Rostock to Stralsund and Greifswald to Neubrandenburg.

dering the Baltic Sea into a haven for zero-emission transportation "can be implemented by 2030 if marine engines are powered by locally produced renewable fuels and the use of those fuels is coupled with innovative energy generation devices either made of electroceramics or based on technologies available on the market." The aim during and after the five-year implementation stage will be to offer new types of propulsion systems and membrane components for sale. Reportedly, another important item on the agenda will be the production of renewable ammonia (NH<sub>3</sub>) from wind power generated in the region.

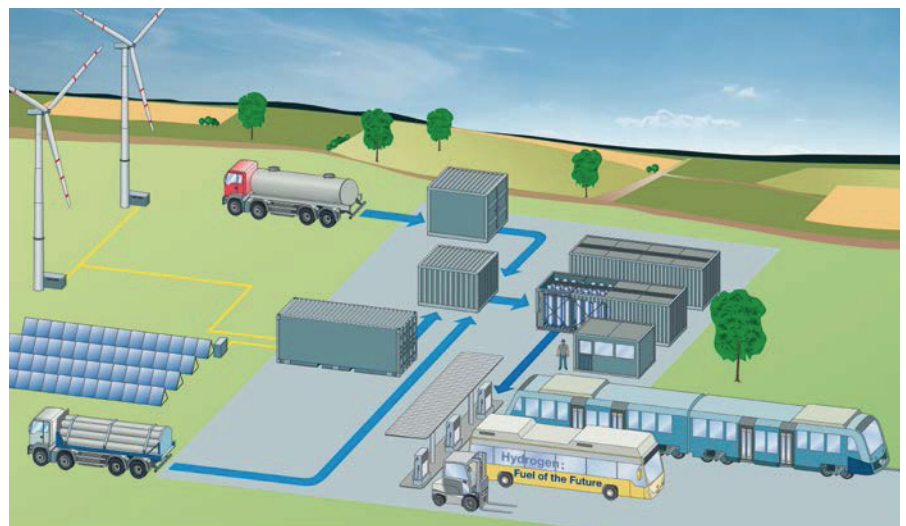
**TEST RUN ON LAKE CONSTANCE** The south of Germany is designing hydrogen watercraft too. Since 2007, researchers at the HTWG university in Konstanz (see HZwei, July 2007) have been steadily making improvements to a hybrid research vessel that goes by the name of Solgenia. Last summer, during a three-day test run, the boat was powered by methanol instead of the previously used compressed hydrogen. It took five years to get a hydrogen fueling station commissioned on one >>

43

# covalion

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side of the Lake Rhine. Now, however, the leader of the research team, Richard Leiner, is concentrating on methanol, which he believes is easier to handle and less expensive.

Following the test, during which the boat traveled 84.5 miles (136 kilometers) at an average speed of 4.6 knots (8.5 kilometers per hour) and consumed 25.2 liters of the liquid fuel, Leiner told H2-international his team was “thrilled by the simple handling of methanol compared to hydrogen.” He added that after “10 years of working with hydrogen, I am now convinced that the technology is not suitable for operating small boats. Methanol, on the other hand, is as easy to handle as gasoline and diesel, which is why I think boat owners will be more likely to accept it as a substitute.”

Additionally, the EU set up a project named Maranda. It has brought together European companies in an effort to test a fuel cell hybrid engine on board a research vessel called Aranda. Equipped with PowerCell MS-100 fuel cells, the system was manufactured by Hyon, a joint venture between Nel, Hexagon Composites and PowerCell Sweden. Last June, certification body DNV GL greenlighted the business’s use of modular fuel cell solutions for watercraft.

**SCOTLAND’S BIG HIT** In Scotland, the focus is again on ferryboat operations. As part of the Big Hit project, plans are to adapt a high-sea ferry running between the Orkney islands of Mainland and Shapinsay to use hydrogen instead of traditional options (see H2-international, September 2016 and July 2018). By 2021, a fuel cell made by Ballard is expected to replace diesel aboard Ferguson Marine’s HySeas III. It was reported that the hydrogen required for the ferry would come from renewable sources available nearby.

The German Aerospace Center, also known as DLR, has been supporting the project by providing economic and environmental assessments and estimating the potential market. Thomas Vogt, who heads the energy systems analysis department at the organization, said that “we intend to show if and how a hydrogen ferry like the one running between two of Orkney’s islands could be used in other regions of Europe.” HySeas III, launched July 1 last year, is being funded by the European Union and will cost an estimated EUR 12.6 million (see fig. 1).

**ON TO NORTH AMERICA** In late June 2018, Canadian stack manufacturer Ballard and the ABB Group, a multinational corporation, signed a memorandum of understanding with the aim to develop a fuel cell system for powering maritime vessels. The module is to provide a capacity of 3 megawatts but be equal in size to a fossil fuel engine.

Peter Terwiesch, who heads ABB’s industrial automation division, said the next generation of watercraft would be electric, connected and data-driven. “We are excited to collaborate with Ballard Power Systems on driving the development of fuel cell technology that will power the vessels of the future,” he noted.

Rob Campbell, Ballard’s chief commercial officer, added that “the rapidly evolving marine market represents an exciting growth opportunity for zero-emission fuel cell technology.” Through creating and delivering megawatt-scale containerized PEM fuel cell systems that had been put up on land, Ballard had gained the experience and knowledge needed to ensure effective collaboration on the design of clean energy solutions for key uses in the maritime market. In the meantime, ABB has teamed up with the Norwegian SINTEF research institute to model a multi-megawatt engine based on two 30-kilowatt stacks by Hydrogenics.

The Water Go Round project in the United States wants to start operating its first fuel cell vessel in September, when it expects to have Hydrogenics fuel cells supply two 300-kilowatt electric motors on Catamaran Zero (see magazine cover). Reportedly, the watercraft will be equipped with Hexagon-made 250-bar tanks that can store 264 kilograms of hydrogen and allow the watercraft to go for two days without refueling. The catamaran’s keel was laid on Nov. 8, 2018.

Its design originates with Joseph Pratt, who had created several drafts of a hydrogen-powered vessel during his time at Sandia National Laboratories. He proved the viability of his ideas by publishing a paper titled SF-BREEZE, or “San Francisco Bay Renewable Energy Electric Vessel with Zero Emissions”, together with Lennie Klebanoff. Today, Pratt is the chief executive and co-founder of Golden Gate Zero Emission Marine. Tom Escher, president of San Francisco’s Red and White Fleet, said what Pratt had thought up was a “game changer. We can eliminate pollution from ships.” He also said that it “could have a major impact on every shipyard in the country.” Paul Jaenichen, the former head of the U.S. Maritime Administration, remarked that the prospect of pollution-free transportation had seemed like science fiction not too long ago. SF-BREEZE, however, had made it possible to turn that prospect into a reality.

Another Sandia-born idea was the design of a coastal research vessel called Zero-V, a 10-knot ship with a range of 2,400 nautical miles. The ship was to be refueled with liquid hydrogen at four ports of call on America’s West Coast. The project resulted in five commercially viable concepts of passenger ships running on fuel cells only.

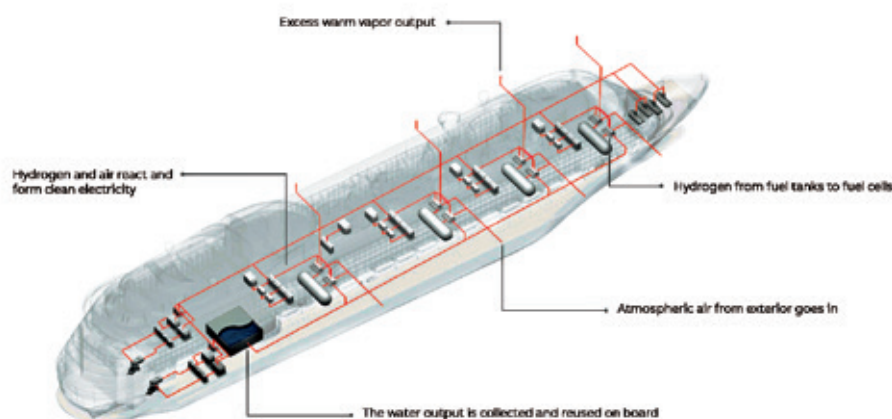


Fig. 2: Energy supply aboard a cruise liner, [Source: ABB]



GE Jenbacher was acquired by General Electric in 2003. Last June, however, the U.S. corporation sold its entire distributed power business to financial investor Advent International for USD 3.25 billion.

Additionally, two electric catamarans using solar energy and hydrogen are sailing around the world, the Energy Observer and the Race for Water. In November 2017, H2-international had already reported about the former's journey around the globe. The Race for Water catamaran is also equipped with PV panels and batteries, as well as a fuel cell system manufactured by Swiss Hydrogen.

**HYDROGEN IN COMBUSTION ENGINES** Another, entirely different, technological pathway was chosen for a marine research project launched last July. Called HyMethShip, it goes beyond renewable hydrogen production, adding carbon dioxide to create methanol. This carbon dioxide is later removed from the fuel in a membrane reactor, also known as a methanol reformer, and stored temporarily in a tank. Hydrogen produced via the process is then burned in a reciprocating engine. When the ship is in port, the carbon dioxide in the tank is again used to create methanol, completing the cycle.

Perspectives for the  
Use of Hydrogen as Fuel  
in Inland Shipping



"Perspectives for the Use of Hydrogen as Fuel in Inland Shipping" is available for download at [www.hydrogeit.de/study-marigreen.pdf](http://www.hydrogeit.de/study-marigreen.pdf)

November 5, 2018, marked the publication of a new feasibility study examining the outlook for hydrogen use in inland waterways transportation. Commissioned by Mariko and FME, it was part of an EU-funded project called MariGreen and was written entirely in English. Its author, Sören Tinz, chairs the combustion engine department at RWTH Aachen University. He writes that the use of hydrogen for inland waterway vessels is often technically feasible but has not yet become economically viable for ship operators. In his eyes, the main barriers to growth are the substantial cost of producing renewable hydrogen and the high prices for converting the watercraft. To eliminate these barriers, he recommends initiating, developing and promoting demonstration projects to prove the technical feasibility of those systems in a real-world setting.

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# PLASMALYSIS TO TREAT WASTEWATER

## Graforce unveils demonstration system in Berlin

Plasma physics plays only a minor role in research in Germany. There are some niche market applications for it, such as coating plastic bags or cutting electrically conductive material. But the daily work of most German engineers and technicians doesn't involve the fourth state of matter. Now that Graforce unveiled a new unit called plasmalyzer at a press conference on Oct. 17, 2018, in Berlin, interest in this field of physics may be on the rise again. The system, which uses wastewater as a reagent, produces hydrogen with the help of ionized gas, with the product reportedly being capable of driving LNG vehicles. So, how does it work?



Fig. 1: Jens Hanke explaining the workings of the Plasmalyzer® container.

Plasma is not a solid or a liquid. But it is not a gas either. In a phase diagram, it will show up at the point where all three states of matter meet, which is why it is sometimes referred to as the fourth state of matter. Probably the most well-known example of it is the sun, which is essentially an ionized, extremely hot ball of plasma. High pressure is what keeps the star from turning into a cloud of gas. But what exactly does plasma or a plasmalyzer do?

**WHAT IS A PLASMAZYLER?** Plasma is a mixture of charged particles, such as ions and electrons. To generate it artificially, a high voltage can be applied between an electrode and a liquid, resulting in a strong electric field. Particles are excited across the field when they collide. "Millions of times per second, there will be a change from negative to positive and back again," Jens Hanke, Graforce's founder and chief executive, said at the press conference. A particle that hits the molecules in the upper layer of the liquid will break the molecular bond between two atoms if its kinetic energy exceeds

The name Plasmalyzer® and the terms "plasma electrolyzer" and "plasmalysis" were coined by Hanke himself. Strictly speaking, no electrolysis is taking place.

the electrostatic force that binds them together. According to Graforce, the strong electric field was completely harmless, since it was shielded by a metal casing.

The receivers, as Hanke calls his plasmalyzer units, did not have specific input requirements. They could process both ordinary and distilled water, and even wastewater. This approach is markedly different from, for example, that of electrolysis, which needs deionized water. Chlorine or sulfur, however, should not enter the system.

Plasmalysis splits water, as well as its nitrogen compounds, such as amino acids, nitrates, ammonium and urea, into individual N, H and O atoms, so they can form new bonds. The resulting gases, nitrogen and oxygen, are, in this case, discharged into the atmosphere, whereas the purified water can be reintroduced to the natural water cycle. Graforce, however, did not disclose at what pressure level and temperature it operates the receivers.

While breaking hydrogen bonds in liquid water requires comparatively large amounts of energy, as in  $H = 486$  kilojoules per mole, the ammonium ( $NH_4$ ) enthalpy of formation is between 91 kilojoules and 390 kilojoules per mole, depending on the ratio of ammonium to ammonia. As breaking the bonds between N and H atoms needs less energy than breaking up those between H and O atoms, plasmalysis produces much of the hydrogen, that is, 90 percent of it, from ammonium compounds and much less, about 10 percent, from the water.

At the right pH value, the concentration of ammonium is equal to that of ammonia in an aqueous solution. The former is an important component of centrate, that is, reject water from anaerobic digestion. A liter of centrate typically contains between 1,000 and 1,500 milligrams of ammonium. The plasmalyzer breaks up this  $NH_4$  so as to turn a brownish liquid into almost clear water. The gases created during that process would be directed from the receivers to a separator, said Sascha Knist, a plasma physicist working at Graforce. A colleague of his, Marc Dünnow, added that the "dissociation of  $H_2O$  will prompt the covalent bonds to transition from the liquid to the gas phase, greatly increasing the pressure level inside the receivers." The hydrogen would then be compressed and stored in a gas cylinder pack at 300 bars. The purified water would go into a storage tank.

"The procedure will not create harmful waste products but only purified water and oxygen. Based on a price of EUR 0.08 per kilowatt-hour of electricity, the cost of producing hydrogen using the plasmalyzer come to around EUR 3 per kilogram."

Graforce





Fig. 2: The silver boxes (left) contain three receivers, whose interior, including the blue shimmering plasma, is shown on screen.

The fundamental difference between this process and electrolysis is that the electrodes do not come in contact with a corrosive material during plasmalysis. It is why inexpensive aluminum can be used to manufacture them.

**BERLIN CITY COLLABORATION** It is still unclear whether this kind of wastewater cleaning has a future. To test the project's economic viability, Berlin's water utility is participating in the venture. At the press conference, its chairman, Jörg Simon, seemed confident about the prospects, saying the utility would "build a larger system." It is currently running six large wastewater treatment facilities in and around Berlin, and Graforce units could be installed at all of them.

**AUDI INDUSTRIEGAS JOINS THE EFFORT** While Graforce has been working on its wastewater treatment idea since 2010, it intends to do more than just clean wastewater and produce hydrogen. The 20-staff startup is also planning to use the hydrogen produced in this way to power vehicles. More precisely, with the help of the hydrogen gas, Hanke aims to create a new fuel that could be used in compressed natural gas vehicles. It was said that the project would "not only convert the pollutants in the wastewater into valuable energy resources but also reduce harmful vehicle emissions, such as CO<sub>2</sub>, CO, HC and NO<sub>x</sub> by between 20 percent and 70 percent." Nitrogen oxide emissions, too, would fall by "up to 60 percent," he said. And, compared to CNG, the new gas promised a 5 percent higher vehicle range.

The business has partnered with Audi Industriegas, which has, in principle, expressed interest in the project. Its chief executive, Hermann Pengg-Buehrlen, who is likewise the head of the renewable fuels division at Audi, was scheduled to talk about the collaboration at the press meeting but was unable to attend for health reasons. He later told H2-international that Audi Industriegas had been "in talks with Graforce about setting up projects in Werlte" to treat wastewater and produce hydrogen from it. However, there

had been no conversations about the possible use of a CNG-hydrogen blend in natural gas vehicles.

#### DEMONSTRATION SYSTEM

**OPERATIONAL** After presenting the project, Graforce demonstrated the practical application of its technology by operating a pilot system and refueling a CNG car. This installation is located at the Renewable Energies and Photovoltaics Center, also known as ZPV, where the business has had its office on the fourth floor since 2013. It comprises a plasmalyzer container that houses three receivers, and a second container, in which hydrogen is blended with biogas. The green gas produced in this way can be used to fill up vehicles at a conventional CNG fueling station, attached to the second container.

Hanke said the demonstration system could produce 5 kilograms of hydrogen per day. It drew electricity from a rooftop PV installation with a generation capacity of between 40 kilowatts and 60 kilowatts. The plasmalyzer was capable of treating around 12 gallons (45 liters) of wastewater per day.

Hanke also remarked that the device was technologically advanced enough to be offered for sale. The price for the container solution, including the fueling station, would be EUR 400,000. Larger systems would cost around EUR 750,000 per megawatt. ||



Fig. 3: Jörg Simon

#### What are those for blue sparks?

Marc Dünow, project manager at Graforce: "We apply an electric current across a fluid, so it becomes ionized. Then, high kinetic energy will strip away electrons from their atoms. As a result, you get two groups of ionized particles: positively charged nuclei and negatively charged, free electrons. What you see as little blue sparks on the water are electric discharges caused by the process."

#### Could you tell us something about the efficiency of the system?

Dünow: "Based on initial estimates, it is between 23 kilowatt-hours and 41 kilowatt-hours for one kilogram of hydrogen. It depends on the type of water used and the percentage of ammonium and organic carbons."

## INTERNATIONAL NEWSLETTER

ABOUT HYDROGEN AND FUEL CELLS

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# TURBULENT TIMES

## Sven Jösting's stock market analysis

Considering the many possible uses of fuel cells, the market for them won't go up in a straight line. Nor will the large-scale production of cheap renewable hydrogen be a goal that can be accomplished overnight. Still, new hydrogen fueling stations will be added at a steady pace, and it will only be a matter of time until mass-produced fuel cell cars are available for sale. Stock market analysts take all these developments into account before recommending what to buy and what to sell. Some breaking news stories could send the market into turmoil and every company featured below has ample experience with stock volatility. Despite this, outlook and potential remain unchanged: Fuel cells are the future.

## GOOD AND BAD NEWS FROM BALLARD POWER

48

Ballard (Nasdaq: BLDP) had its very own October surprise, which caused the stock to take a nosedive. Though worse than expected, the USD 0.03 net loss per share and revenues of as little as USD 21.6 million weren't to blame for the slump. Neither was the company's low cash level of USD 23.2 million, reduced by inventory and AFCC asset purchases, nor the 2018 revenue target, revised downward to somewhere between USD 90 million and USD 95 million. What caught the market flat-footed was Ballard's decision to remove the remaining value of a multi-year contract with joint-venture partner Guangdong Synergy from its backlog, which dropped from more than USD 280 million to around USD 120 million. Since the contract was worth north of USD 138 million, it couldn't have been an easy choice to make, albeit other key factors, such as the sale of Protonex assets and deliveries already made, need to be included to figure out how much of an impact this had on the company.

The contract value was removed because of Synergy's inability to meet its purchase commitment regarding membrane electrode assemblies, apparently for a variety of reasons. It seems as if the Chinese government hadn't been fast enough to grant funding for fuel cell buses, and some communities are reportedly taking a long time to invite bids. Plus, the fueling station network might not be growing as rapidly as expected.

**WEICHAI BUYS INTO BALLARD** Another point, with more profound consequences, is that, through a capital raise, a Chinese corporation called Weichai, which manufactures around 600,000 engines a year, purchased a 19.9 percent ownership position in Ballard for USD 163 million. The decision could pit two of the business's shareholders against each other, since Ballard and Weichai have announced plans to offer LCS stacks for trucks, buses and other vehicles to customers sometime this year. According to Ballard's most recent conference call, however, the company is speaking with both Weichai and Synergy, which could mean all three



Fig. 1: Historical prices of the five companies covered in this issue. [Source: wallstreet-online.de, Retrieved Dec. 22, 2018]

may enter into partnership. Weichai is also a bus maker, so the idea isn't that far-fetched. In a best-case scenario, Ballard could regain the backlog it lost.

That Weichai, the world's biggest manufacturer of diesel engines, has purchased Ballard stock is the best piece of news the fuel cell producer could hope for. The Chinese corporation, which generates revenues topping USD 23 billion a year, owns 45 percent of Kion, with 200,000 units produced annually the number two forklift truck manufacturer in the world. At around the same time, Broad-Ocean paid USD 20 million to prevent the dilution of its 9.9 percent ownership stake in Ballard.

Broad-Ocean produces around 50 million engines a year. It has partnered with Ballard to manufacture fuel cell stacks for trucks and other vehicles in China.



Fig. 2: FCgen®-LCS stack [Source: Ballard]

Weichai intends to become one of the People's Republic's leading companies in the market for heavy-duty fuel cell applications. Its commitment to build and supply 2,000 fuel cell modules for commercial vehicles is further proof of that. The corporation was also reportedly contemplating investments in producers of electrolyzers and hydrogen fueling stations to become a one-stop source for all of its customers' fuel cell needs. The money from Weichai and Broad-Ocean upped Ballard's cash reserves to USD 200 million, or around 40 percent of its market cap.

At the IAA Commercial Vehicles, it was said that Ballard's latest fuel cell stack generation, called LCS or liquid-cooled stack, for trucks and forklifts would be available in 2019. The company has a lot of experience in materials handling not only because of its partnership with Plug Power but also because of its collaborations with the number one forklift truck manufacturers in the United States and the world, Hyster-Yale and Toyota Tsusho, respectively.

Another thing already hinted at was Ballard's sale of Protonex assets that no longer benefit the company. What the manufacturer, however, kept of its Protonex subsidiary were those fuel cell technologies relating to drones. It is said that the sale will pour over USD 16 million into Ballard's coffers – not a bad deal, as the company paid as little as USD 17 million, some of it in the form shares, to buy Protonex in the first place.

Regarding the question of whether Ballard is becoming too dependent on China, I would argue that without its Chinese partners, it wouldn't be able to realize some economies of scale and expand as much as it has. To my knowledge, Ballard likewise retains the global distribution rights to some of the stacks. And China is the biggest market, by far, for the company's products used in vehicles. If, as expected, the People's Republic zeroes in on fuel cells, Ballard will be certain to profit from it.

## POWER PLANT DEALS BY FUELCELL ENERGY

Power purchase agreements are a central part of FuelCell Energy's new corporate strategy. These agreements allow for long-term community purchases of electricity and energy. Not too long ago, the company concluded several contracts to that effect. One example is a 14.8-megawatt site in Derby, Connecticut. Meanwhile, it has been adding fuel cell power plants to its inventory as well, as it did last November when buying the Bridgeport fuel cell park from Dominion Energy. The 14.9-megawatt installation, for which the company is also the service provider, came with a price tag of USD 36.6

million and is being financed through USD 15 million of previously restricted cash, plus loans. FuelCell Energy (Nasdaq: FCEL) expects the park to generate a revenue of more than USD 15 million and an impressive EBITDA margin of over 50 percent.

In light of the above, the company's stock price is a real head-scratcher. It dropped below USD 0.7, possibly as the result of an announcement by its South Korean partner, Posco, which said that it would end the projects on which it collaborated with FuelCell Energy in the red and sell its remaining 2.9 percent stake in the business. At first, it seemed like Posco had sold all its shares on the market or by private placement. Then, in October, Posco said it intended to abandon its fuel cell business but without presenting a timetable. The announcement leaves room for speculation about whether FuelCell Energy's stock has traded so low because someone intends to get Posco's share at a cheap price. I think the business may have already written off its investment a long time ago, so that it might accept any offer for sale. By contrast, there are those South Korean energy suppliers that have just started to invest in fuel cell power plants.

In short, all available data on cash reserves, credit facilities and backlog, as well as the company's technologies, are in stark contrast to the current stock price. Do other market players know something is up or do they want to keep the price down for the time being? Have shares been sold based on convertible preferred stock? A high number of call options this month could be interpreted in more than way. I believe that the collaboration with Exxon will start to bear fruit this year. It has already led to pilot projects and prototypes, both of which form a solid foundation for further development. Let BlackRock, a fund that has bought additional FuelCell stock and now owns more than 5 percent of the company, be an example for others. Why shouldn't it?

49

## THE UPS AND DOWNS OF HYDROGENICS

Hydrogenics (Nasdaq: HYGS) seems to be facing similar headwinds in China, mostly with regard to funding, bid requests and grant approval. It said the country offered >>



Fig. 3: Dominion Energy in Bridgeport [Source: FuelCell Energy]



Fig. 4: Carrefour's Still forklift trucks equipped with Plug Power systems [Source: Still]

excellent prospects; everything was just moving along a bit more slowly than expected. At the very least, backlog at Hydrogenics added up to USD 132 million, more than half of which originates with Alstom contracts for fuel cell trains. Thirty trains have already been ordered and more are said to follow this year. The company had also submitted bids for projects with a total contract value of more than USD 100 million. In Norway, it won a contract for installing a 2.5-megawatt system that is to store electricity generated by a 45-megawatt wind farm. In Germany, it was chosen to construct a power-to-gas system in Wuppertal.

Third-quarter results weren't up to standard, with the company posting a loss of USD 3.4 million, that is, minus USD 0.22 per share instead of minus USD 0.07, as expected, and revenues of USD 7.7 million. High fluctuations between quarters were the norm, company management said, considering FuelCell Energy carried out projects with multi-quarter deliveries. None of it, however, would influence long-term outlook, since interest in fuel cell technology was on the rise and Hydrogenics had strong, diversified product platforms, valuable patents and the expertise needed to make it in the industry.

A quick look at Weichai's strategy (see above) suggests that, in theory, companies will soon want to branch out into other areas by buying into businesses that produce electrolyzers or fueling stations. If my prediction comes true, Hydrogenics could be a candidate for this kind of acquisition. Take Nikola Motors for example: Not only is it planning to sell fuel cell trucks, but it also has partners build hydrogen fueling stations and has been ordering electrolyzers from Nel Asa. Toyota has been doing the same, building power plants in partnership with FuelCell Energy to produce hydrogen for its vehicles and setting up fueling stations in partnership with energy suppliers.

The lack of stations is a challenge that manufacturers have begun to address themselves without waiting on gas station managers to add hydrogen pumps, which they probably won't do until they see enough fuel cell cars on the road. Now, all of the above benefits Hydrogenics. Its stock price, lowered by third-quarter results, presents another opportunity to buy shares, provided shareholders see the small-cap company as having the outlook I described and are considering investing long term.

## NEW FUNDS SECURED BY PLUG POWER

Plug Power (Nasdaq: PLUG) has again received an infusion of capital, by offering convertible preferred stock in the amount of USD 35 million. It was priced at USD 2.31 per share and will have to be redeemed in 13 monthly installments at 105 percent the face value, or USD 2.69, should shareholders decide not to convert or the stock drop below the conversion price. I can't see any upside to this. I've also heard that the company sold parcels of more than 20 million shares to investors that I am not familiar with.

In the third quarter, gross revenue increased to USD 55.3 million, at a net loss of USD 15.2 million, or USD 0.07 per share, around two cents better than expected. Plug managed to open several fueling stations and convert 1,483 forklift trucks. It anticipated 12-month gross revenues to be between USD 175 million and 190 million, which would bring it one step closer to profitability. Because of larger factory halls, manufacturing capacity was now at 20,000 units annually.

Plug sees great promise in China, where it is looking for business partners, and customers such as FedEx, which are working to convert their courier vans to run on fuel cells. The technology has already undergone a series of tests at the courier service, similar to what Ballard and Hydrogenics have done in partnership with UPS. While I am closely following Plug's progress, I see the better opportunities at Ballard, as it focuses on integrating stacks during vehicle production instead of offering to convert trucks at a later date. But when the time is ripe for fuel cell shares to grab the spotlight, every market player, including Plug, will stand to profit from it.

## THE ROLLERCOASTER THAT IS TESLA

The sky's the limit, you might have been thinking, when Tesla's stock jumped from USD 240 to about USD 340 in few days. On Oct. 23, 2018, a short while before the company said that it would preschedule the publication of third-quarter results, a well-known short seller named Andrew Left, of Citron Research, changed his outlook on Tesla (Nasdaq: TSLA). In what seemed like a 180-degree turn from his previous position, he stated that Tesla stock had become a long-term investment option. Other analysts followed his lead. At that time, the consensus estimate was a basic loss of USD 3.12 per share, down from USD 6.83 previously, and even a profit of USD 5.79 in 2019.

Analysts' assessments were based solely on the third-quarter, when Tesla posted a profit of USD 312 million, or a basic loss of USD 1.82 per share. Strong sales meant cash reserves totaled USD 3 billion. Revenue skyrocketed thanks to more expensive Model 3 variants. The cars – priced between USD 49,000 and USD 78,000 – increased earnings by more than 130 percent to USD 6.8 billion in one quarter. What came as a bit of a surprise were the lower investments in research and development and reduced expenses for selling, general and administration, both of which affect profits. The cancellation rate for Model 3 was at 20 percent, however, based on 455,000 reservations from 2017. Tesla has so far chosen not to disclose the number of existing reservations.



That's it about the numbers. My skepticism remains, since one quarter is hardly enough to make any long-term predictions. In those three months, Tesla only delivered more expensive Model 3 variants, as they promise high profit margins. It would be interesting to know how many cars will still be sold for USD 50,000 or USD 70,000 – the USD 35,000 base version isn't making any money according to online statements by Tesla's chief executive, Elon Musk, himself.

In my opinion, the company's market cap of more than USD 58 billion is not reflective of current developments. In the next two years, around 200 electric variants by all kinds of manufacturers will become available, creating some serious competition that previously did not exist. In Norway, Jaguar has already succeeded in driving Tesla from the top spots by bringing its I-Pace to market.

Where Tesla seems one step ahead is in China. The electric carmaker has obtained a fifty-year lease on around 9.3 million square feet, or 860,000 square meters, of land in the greater Shanghai area for building a factory to produce batteries and vehicles. The company said that it foresaw no difficulties with realizing the USD 2 billion project in China. How liability would be managed in-house seems unclear.

**THE MORE THINGS CHANGE, THE MORE THEY STAY THE SAME** I don't see Tesla's new chairwoman, Robyn Denholm, as being the one for a clean break from company history, since she has been with Tesla since 2014, in the role of independent director. She is very knowledgeable, I will give her that, but her elevation to chair doesn't seem to change much of the equation or might even be seen as a strategic maneuver, considering how long she has been working for the carmaker. The change meets the U.S. Securities and Exchange Commission's requirement that Tesla needs a new chair, but this should have meant a fresh face not previously affiliated with the business. Plus, many high-level managers are still leaving.

In short, good quarterly results have had people's imagination running wild. The fourth quarter will most likely bring more good news and, possibly, a windfall profit because of the inclusion of further zero-emission vehicle credits. After that, times will get tough: This year, Tesla will have to pay back several loans, Solar City's among them, which will have an influence on liquidity and capital raises. Also, the competition is starting to catch up. On top of this, the USD 7,500 tax incentive per vehicle is running out: Like GM and others, Tesla has exceeded the limit of 200,000 cars, after which the grant is phased out over six months. Building new factories in China and Europe and bringing new car models to market will cost much money and can't be done overnight.

The number of new hydrogen-powered cars, in the form of fuel cell and hybrid vehicles, expected to arrive this year may still be quite low. However, a breakthrough could occur in 2020, when the first mass-produced ones come to market and have an impact on electric car buys thanks to a larger network of hydrogen fueling stations and prices approaching those of combustion-engine and battery-only cars. It is a vision in line with what Toyota has said will happen. China may be the single biggest influence on outcomes if the country begins prioritizing fuel cells over purely battery-powered solutions.

All of this will have consequences for Tesla – not today, but tomorrow. Plus, multiple class-action suits are still pending. And the FBI has been reviewing Musk's statements on Model 3 production figures dating to 2017. His comments didn't match the actual numbers but led to a highly volatile stock price.

All in all, 2019 promises to be a very interesting year for Tesla – in more than one way. Its market cap accounts for any positive developments the next quarter may bring but not for negative ones. Can Tesla resist the global downturn that is happening in the automotive sector? Why would the company be immune to its effects? I expect the stock price to fall below USD 200 within two years. Let's see what happens. ||

#### RISK WARNING

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# HYDROGEN AND FUEL CELL OPPORTUNITIES IN THE UK

## *Great promise despite Brexit*

Since the government passed the Clean Growth Strategy at the end of 2017, the UK's hydrogen and fuel cell sector has been picking up speed. Despite Brexit headaches, politicians, business executives and researchers see the technologies as a great chance to set up key value chains across the country and turn it into a leading market for hydrogen-based heat. The UK's BEIS department, which is in charge of implementing the strategy, has likewise been promoting the use of hydrogen to generate heat and power means of transportation.



Fig. 1: Red hydrogen bus by Wrightbus in London

Besides sourcing the gas from renewable energies, the United Kingdom has focused on producing hydrogen by reforming natural gas, including carbon capture, utilization and storage. But demonstration projects especially will have to manage without funding from Brussels soon, considering the impending Brexit.

At present, the country's universities, research institutes and businesses are involved in dozens of EU projects to promote hydrogen and fuel cell technology, either as coordinating organizations or partners in a consortium. The government, however, has already announced it would make up for the lack of EU funding in research and infrastructure build-up, so that all currently running ventures would not have to be stopped. What has not been clear yet is whether the same funds going into the establishment of a market, that is, all efforts to demonstrate hydrogen and fuel cell technologies, will continue as well. It is one issue where UK firms are at risk of no longer being able to commercialize their ideas.

**HEAT UTILITIES TURN TO HYDROGEN STORED IN NATURAL GAS** For the UK to be able to meet its climate targets, it will have to transform its heat market above all else. Nearly all of the thermal energy and over one-third of electricity is generated by burning natural gas, with greenhouse gas emissions to match. More than 80 percent of residents, from a total population of 66.5 million, use natural gas for cooking

and heating. Gas boilers are part of most of the 27 million households, as well as offices, stores and commercial property. These wall-hung devices provide a reliable and low-cost supply of space heating and hot water in little time and with little noise. It is one feature that distinguishes the country's heat market from probably any other in Europe.

To control the emissions levels that accompany gas burning, the government passed a heat strategy in 2013. It is focused on making the sector run on electricity and renewable energies. Alternative options such as electric heat pumps, district heating and biomass burning, as used in other countries at a large scale, have yet to make a discernible impact in the UK. Compared to gas burners, the aforementioned alternatives are pretty expensive and disadvantageous to British users, as they would need more space or more efforts to manage the systems.

It is no surprise, then, that the UK has difficulties producing clean heat. There is a lack of simple and attractive options to make use of the climate protection and energy efficiency potential offered by more than 1.2 million replacement devices a year.

Stricter climate protection targets – but, most of all, studies such as H21 Leeds City Gate (see H2-international, September 2018) – have prompted the government and the natural gas industry to float the idea of converting the natural gas network to hydrogen. The long-term objective is to increase the percentage of green hydrogen in the pipeline system until it eventually substitutes all the natural gas. By slightly adapting the existing gas grid and the consumer devices, the use of both would continue at reasonable cost.

Only time will tell whether that wish can become a reality. At least, Northern Gas Network, the business behind the publication of the Leeds study, will receive an additional GBP 10.3 million from private sector investors and energy regulator Ofgem, the Office of Gas and Electricity Markets, to build upon the momentum. More projects that receive funding from the UK government and its agencies to showcase the advantages and the feasibility of hydrogen to produce heat include HyDeploy managed by Keele University in Staffordshire, Hydrogen 100 by Scottish gas network operator SGN and HyNet by the Liverpool Manchester Hydrogen Cluster.

Even though the current focus is on the continued use of natural gas pipelines and boilers, suppliers of heating systems do see opportunities for fuel cell CHP devices. As early as 2014, the Hydrogen and Fuel Cells Supergen Hub, comprising government and business representatives, as well as hydrogen and fuel cell researchers, had published a white paper, titled "The role of hydrogen and fuel cells in providing affordable, secure low-carbon heat," in which they conclude that the UK has a good chance to develop a hydrogen and fuel cell industry that could be leading other markets in heat production.

**HYDROGEN-POWERED CITY FLEETS** As nearly everywhere else, national and international climate change legislation and, above all, the increasingly deteriorating air quality in cities, >>



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is forcing the country to switch to electric vehicles for transporting passengers and goods. At the latest in 2040, the UK wants to abandon fossil fuel engines completely (see also p. 33).

As part of its Modern Industrial Strategy, the government launched the Faraday Challenge in 2017. The aim, to make the UK a showcase for innovative battery technology, will be supported by an estimated GBP 246 million. The government will likewise offer a total of GBP 23 million in support of hydrogen and fuel cell transportation, to reward the purchase of fuel cell vehicles and the construction of hydrogen fueling stations. These programs have been complemented by local and regional initiatives such as BIG HIT (see H2-international, July 2018) on the Scottish Orkney Islands and the Hydrogen Hub.

The aim of the hub is to ensure that as many fuel cell vehicles as possible are used in participating regions, from delivery vans and mass transit buses to garbage trucks, and to create a fueling infrastructure. So far, there have been two of these hubs, one in Swindon since 2016 and another in Oxfordshire since last year. As for the latter, the city of Oxford is expected to become the first zero-emission zone in the UK.

When it comes to mass transit and fuel cell buses, the UK is one of those countries that are leading the world. Since the early 2000s, different types of zero-emission fuel cell buses have been running in London. Aberdeen in Scotland is likewise relying on hydrogen buses for its mass transit system. The two cities currently own 20 of them. It is said that another 26 will follow soon.

As part of two EU projects, JIVE and JIVE2, Dundee and Birmingham will reportedly buy fuel cell buses as well. Transport for London is coordinating the purchase of 88 units altogether. Additionally, to ensure that London still features its hallmark red double-decker buses, manufacturer Wrightbus based in the northern Irish town of Ballymena showcased precisely such a model two years ago. It is said that the first of these will soon be driving on the streets of the capital.

Even if UK cities and businesses will no longer receive money from EU funding pots, government programs such as the Ultra-Low Emission Bus Scheme will continue to exist and promote the use of clean buses, as well as add to the EU's fuel cell projects in London and Birmingham on a national level. ||

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Category: Global | Author: Uta Mummert |

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## ALL SET FOR HULOT'S HYDROGEN ROAD MAP

### *French Hydrogen Days in Toulouse*

54

In 2013, France's government began cooperating with the national Afhyac association on holding Journées Hydrogène dans les Territoires, that is, Hydrogen Days in the Regions, each year in another one of them. Last September, it was Occitanie's turn to invite people to Toulouse.

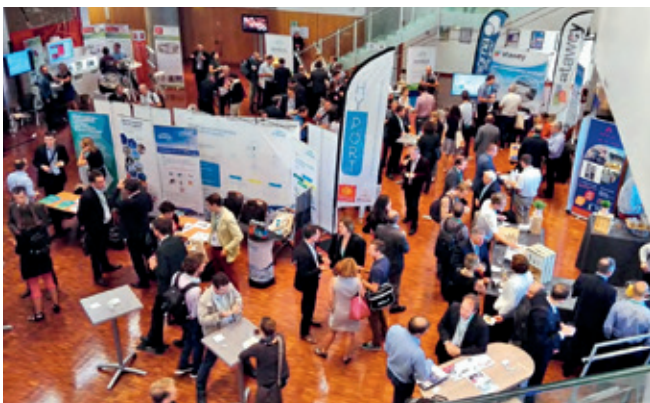
Around 440 people came from all over the country to the annual meeting of hydrogen professionals, that time in the capital of Occitanie, created in 2016 from the regions of Languedoc-Roussillon and Midi-Pyrénées. It was an event mostly by the French for the French, however. Few had arrived from somewhere outside the country, albeit those who attended were a more diverse group than at some other events and included a relatively high number of women, many young engineers and staff from startups, and more than one-third of all participants were a highly interested and committed group of public sector officials from France's regions, cities and towns. Also in attendance were manufacturers and energy suppliers, of any type and size, such as

Areva, Atawey, EDF, Engie Cofely, Haffner, Mahytec, McPhy, Michelin, Plastic Omnium, Powidian, Pragma Industries, Safran, Stäubli, Symbio FCell and Toyota. Representatives for the CEA had arrived as well, though researchers were clearly in the minority.

Those seeking information about local efforts could listen to, for example, regional or city representatives, who talked about ongoing projects, or energy businesses, which explained their corporate hydrogen strategies. The event was also the first opportunity for France's environment ministry, as well as agency Ademe, to inform the public about the requirements projects need to meet to become part of the hydrogen road map set up by the former French minister for the environment, Nicolas Hulot. At the same time, the exposition rooms had been made available to anyone who wanted to discuss ventures with partner organizations.

The focus of the event was on hydrogen production via electrolysis and its use mainly in public transportation, with the railroad industry being the most favored one. That French manufacturer Alstom's first fuel cell railcar, Coradia iLint, had taken its maiden run in Germany shortly before the event was a matter of some pride for the French hydrogen community. Still, the nagging question was, "Why didn't it run in France?" In some way, then, the demonstration of the train's capabilities has given the community a push to start these kinds of projects at home.

Plans are to open the first hydrogen bus line in the country in Pau at the end of 2019. Because of France's law on the transformation of the energy industry, mass transit companies have come under pressure: From 2020 on, at least half of the buses they buy need to be equipped with clean engines. In 2025, each newly acquired bus needs to be a low-emission one. Goodbye, diesel!



In late September, Occitanie's regional government and energy supplier Engie founded the HyPort association, which will manage a project bearing its name. Its aim is to test the use of hydrogen in all kinds of vehicles used at the Toulouse-Blagnac and Tarbes-Lourdes-Pyrénées airports.

**FUNDING IS AVAILABLE** One reason for the lack of discussion about storage options and problems, and fuel cell technologies, was that the projects showcased in Toulouse have already been well-adjusted to the funding regulations of the EUR 100 million hydrogen road map. Half the money will reportedly be spent on electrolyzer systems and the other half on a set of measures designed to achieve milestones of the road map. This year, Ademe will start with the first EUR 100 million. The initial project call is being drafted and its managers are merely waiting for the ministry to give the green light.

After one-and-a-half days filled with networking opportunities, as well as one information event about projects, strategies and funding regulations after another, the event ended with tours of one of three sites in the region, namely a research facility called PACAERO-CEA, a hydrogen-powered waste-to-energy plant named VaBHyoGaz at Trifyl, and SaFra, a business that doesn't just refurbish hydrogen buses but designs and builds its own, branded Businova.

One thing was clear thereafter: France's regions, communes and businesses are all set to turn Nicolas Hulot's hydrogen road map into a reality. The 7th Journées Hydrogène dans les Territoires will take place this year in Marseille. ||

Written by Uta Mummert, who went to Toulouse on behalf of Peter Sauber Agentur Messen und Kongresse GmbH.

Category: Global | Author: Sven Geitmann

## LINZ' HYDROGEN INITIATIVE

### *Outline of a European hydrogen strategy*

Hydrogen has finally entered the halls of power: Last September, the gas, as well as storage, was a key topic at the meeting of the EU countries' energy ministers in Linz. Austria, which, at the time, held the presidency of the EU Council, had put the creation of a Hydrogen Initiative on the agenda, inviting all ministers to sign a joint statement called the Hydrogen Declaration. Thomas Bareiß, who works at the German economy-slash-energy ministry and attended the meeting on behalf of his government, put his signature on the document as well.

The declaration states that the ministers had gathered in Linz with the aim of maximizing "the great potentials of sustainable hydrogen technology for the decarbonization of multiple sectors," as well as the energy system, and ensure long-term energy security in the EU. The 12-page document also underlines the large "potential of renewable hydrogen as an energy storage solution, as well as a sustainable climate-neutral energy carrier and feedstock." The green gas was capable of guaranteeing "reliable and timely access to renewable energy, thus offering new opportunities to increase energy security and reduce the Energy Union's dependency on fossil imports."

One objective was to create synergies by promoting "regional and multilateral cooperation regarding the exchange of technological expertise, data, results and best practices." Later on, the declaration states that to make use of the gas to provide "efficient, safe and clean energy for all users throughout Europe, research and innovation in the field of hydrogen technology must be further intensified."

When Austria's minister for energy, Elisabeth Köstinger, of the ÖVP party, spoke before 250 experts at the High Level Conference in Linz, she said that "the hydrogen declaration has been an important pledge by all member states to invest in the technology and work together to advance it further. That 25 countries, and the European Commission, have signed the document is, quite honestly, more than we had hoped for." The UK, Denmark

and Norway did not participate, although five European regions, such as Heide in Germany, as well as 85 public and private organizations, did.

Köstinger then remarked that "hydrogen can be one of those important and sustainable technologies for both engines and storage. Above all, it is a very good addition to all-electric vehicles." ||



Fig. 1: Group photo of all Hydrogen Initiative members

"We support the Hydrogen Initiative. [...] Green hydrogen offers great opportunities for decarbonizing Europe's economy. The European Commission is very pleased with the founding of the initiative, especially because it is promoting innovation across the continent."

*Miguel Arias Cañete, the EU's commissioner for climate protection and energy*

"The Hydrogen Initiative is the first project where we see an outline of a European Hydrogen Strategy. We fully support the commitment all members have made to developing hydrogen as a net-zero energy carrier that will play a key role in transforming Europe's energy market. Acknowledging its contribution toward climate-neutral manufacturing and transportation and its promise for long-term storage are big steps forward."

*Thomas Hüwener, vice president of DVGW's gas division*

## EVENTS

**February 13 to 15, 2019**

**H2 meetings by HyVolution**  
Side event of BePOSITIVE  
in Lyon, France  
[www.bepositive-event.com](http://www.bepositive-event.com)

**February 27 to March 1, 2019**

**FC Expo – International Hydrogen & Fuel Cell Expo**  
Tokyo Big Sight, in Tokyo, Japan  
[www.fcexpo.jp](http://www.fcexpo.jp)

**March 12 to 14, 2019**

**IRES – International Conference and Exhibition for the Storage of Renewable Energies**  
in Düsseldorf, Germany  
[www.eurosolar.de](http://www.eurosolar.de)

**March 12 to 14, 2019**

**Energy Storage Europe**  
in Düsseldorf, Germany  
[www.energy-storage-online.com](http://www.energy-storage-online.com)

**March 19, 2019**

**Hydrogen and Fuel Cells**  
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in Birmingham, UK  
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**March 28 to 29, 2019**

**11th Green Vehicle Convention 2019 (GVC)**  
in Beijing, China  
[www.cdmc.org.cn](http://www.cdmc.org.cn)

**April 1 to 5, 2019**

**Hannover Messe**  
Group Exhibit “Hydrogen, Fuel Cells, Batteries” and MobiliTec  
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Hannover Messe, [www.h2fc-fair.com](http://www.h2fc-fair.com)

**April 2 to 3, 2019**

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**April 24 to 26, 2019**

**Hypothesis XIV – HYdrogen POWer THEoretical & Engineering Solution International Symposium**  
in Itaipu, Brazil, [www.hypothesis.ws](http://www.hypothesis.ws)

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in Stuttgart, Germany  
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**Hydrogenics GmbH**, Am Wiesenbusch 2 – Halle 5, 45966 Gladbeck, Germany, Phone +49-(0)2043-944-133, Fax -146, [powersales@hydrogenics.com](mailto:powersales@hydrogenics.com), [www.hydrogenics.com](http://www.hydrogenics.com)



**iGas energy GmbH**, Cockerillstr. 100, 52222 Stolberg, Germany, Phone +49-(0)2402-9791600, [info@igas-energy.de](mailto:info@igas-energy.de), [www.iGas-energy.de](http://www.iGas-energy.de)



**Nel Hydrogen**, 10 Technology Dr, 06492 Wallingford CT, USA, Phone +1-203-9498-697, Fax -016, [info@proto-nonsite.com](mailto:info@proto-nonsite.com), [www.NelHydrogen.com](http://www.NelHydrogen.com)

**thyssenkrupp Uhde Chlorine Engineers GmbH**, Vosskuhle 38, 44141 Dortmund, Germany, Phone +49-231-547-0, Fax -2334, [info-uce@thyssenkrupp.com](mailto:info-uce@thyssenkrupp.com), [www.thyssenkrupp-uhde-chlorine-engineers.com](http://www.thyssenkrupp-uhde-chlorine-engineers.com)

### ELECTRONICS



**Prüfrefx Innovative Power Products GmbH**, Egersdorfer Str. 36, 90556 Cadolzburg, Germany, Phone +49-(0)9103-7953-0, Fax -55, [www.pruefrefx.com](http://www.pruefrefx.com)

### FITTINGS, REGULATORS, VALVES



FLUID CONTROL SYSTEMS

**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](http://www.burkert.com)



**Eugen Seitz AG**, Leading H2-solenoid valve technology from 10 to 1,000 bar, Spitalstrasse 204, 8623 Wetzikon, Switzerland, Phone +41-44-9318190, [h2info@seitz.ch](mailto:h2info@seitz.ch), [www.seitz.ch](http://www.seitz.ch)



**OMB Saleri SpA**, Via Rose di Sotto 38/c – 25126 Brescia, Italy, [hydrogen@omb-saleri.it](mailto:hydrogen@omb-saleri.it), [www.omb-saleri.it](http://www.omb-saleri.it)



Phone +49-2174-748-722, [mail@ptec.eu](mailto:mail@ptec.eu), [www.ptec.eu](http://www.ptec.eu)

**PTEC – Pressure Technology GmbH**, pipelines, screw connections, filters, valves, regulators, TPRD, Linde 11, 51399 Burscheid, Germany,

### 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](mailto:info@becker-international.com), [www.becker-international.com](http://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](mailto:info@buschcleanair.com), [www.buschcleanair.com](http://www.buschcleanair.com)



**Haskel International, LLC**,  
100 E Graham Place, 91502 Burbank,  
CA, USA, Phone +1-818-84-34000,  
Fax -14291, [www.haskel.com](http://www.haskel.com)



**Mehrer Compression GmbH**, Rosenfelder Str. 35,  
72336 Balingen, Germany, Phone +49-(0)7433-2605-0,  
Fax -7541, [www.mehrer.de](http://www.mehrer.de)



**sera ComPress GmbH**, sera-Str. 1,  
34369 Immenhausen, Germany,  
Phone +49-5673-999-04, Fax-05, [info-compress@sera-web.com](mailto:info-compress@sera-web.com),  
[www.sera-web.com](http://www.sera-web.com)



**Vairex air systems**, 3048 Valmont  
Road, Boulder, CO, 80301, USA,  
Phone +1-303-994-2047,  
[info@vairex.com](mailto:info@vairex.com), [www.vairex.com](http://www.vairex.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](http://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](mailto:fuelcellcomponents@sglgroup.com), [www.sglgroup.com](http://www.sglgroup.com)

## INTEGRATION



**Deutsches Zentrum für  
Luft- und Raumfahrt  
(DLR) / German Aero-  
space 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](http://www.dlr.de/tt)



**Framatome GmbH**,  
Paul-Gossen-Str. 100,  
91052 Erlangen, Germany, Contact: Mrs. Gemmer-Berk-  
bilek, Phone +49-(0)9131-90095221, [www.framatome.com](http://www.framatome.com)

## MEMBRANES AND SEPARATORS



**FUMATECH BWT GmbH**,  
Carl-Benz-Str. 4, 74321  
Bietigheim-Bissingen, Germany,  
Phone +49-(0)7142-3737-900,  
Fax -999, [www.fumatech.com](http://www.fumatech.com)



**Plansee SE**, Bipolar Plates, In-  
terconnects and Metal Support-  
ed Cells, 6600 Reutte, Austria,  
Phone +43-(0)5672-600-2422, [www.plansee.com](http://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](http://www.dwv-info.de)

**hySOLUTIONS GmbH**, Steinstrasse 25, 20095 Hamburg,  
Germany, Phone +49-(0)40-3288353-2, Fax -8,  
[hysolutions-hamburg.de](http://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](http://www.now-gmbh.de)

## ORGANIZERS (EVENTS)



Hannover, Germany  
April 1-5, 2019



Salt Lake City, UT, USA  
September 23-26, 2019



Shanghai, PR China  
October 23-26, 2019

**Hydrogen + Fuel Cells NORTH AMERICA**,  
Solarpower 2019, September 23-26

**Group Exhibit Hydrogen + Fuel Cells + Batteries**,  
Hannover Messe 2019, April 01-05

Tobias Renz FAIR, [tobias@h2fc-fair.com](mailto:tobias@h2fc-fair.com), [www.h2fc-fair.com](http://www.h2fc-fair.com)



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



**Peter Sauber Agentur Messen und Kon-  
gresse GmbH, f-cell**, September 10 to 11,  
2019, Haus der Wirtschaft, Willi-Bleicher-  
Str. 19, 70174 Stuttgart, Germany,  
Phone +49-(0)711-656960-55, Fax -9055, [www.f-cell.de](http://www.f-cell.de)

## REFORMERS



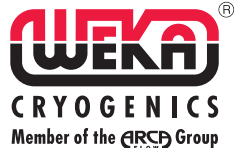
**WS Reformer GmbH**, Dornier-  
strasse 14, 71272 Renningen,  
Germany, Phone +49-(0)7159-  
163242, Fax -2738, [www.wsreformer.com](http://www.wsreformer.com)

## RESEARCH & DEVELOPMENT



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GmbH**, Karl-Heine-Str. 109/111,  
04229 Leipzig, Germany,  
Phone +49-341-2457-113, [www.dbi-gut.de](http://www.dbi-gut.de)

**Fraunhofer Institute for Microengineering and Microsys-  
tems IMM**, Reformer and Heat Exchanger, Carl-Zeiss-Str.  
18-20, 55129 Mainz, Germany, Phone +49-(0)6131-9900,  
[info@imm.fraunhofer.de](mailto:info@imm.fraunhofer.de), [www.imm.fraunhofer.de](http://www.imm.fraunhofer.de)

**Fraunhofer****Fraunhofer ISE**,  
Heidenhofstrasse 2,79110 Freiburg, Germany, Phone +49-(0)761- 4588-5208,  
Fax -9202, [www.h2-ise.de](http://www.h2-ise.de)**STORAGE****GKN Powder Metallurgy**, GKN Sinter Metals, PO Box 55,  
Ipsley House, Redditch B98 0TL, Worcestershire, United  
Kingdom, [www.gkn.com/sintermetals](http://www.gkn.com/sintermetals)**Hexagon xperion GmbH**,  
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Germany, Phone +49-561-58549-0,  
Fax -29, [www.hexagonxperion.com](http://www.hexagonxperion.com)**HEXAGON****HPS Home Power Solutions GmbH**, Carl-Scheele-Str. 16,  
12489 Berlin, Germany, Phone +49-(0)30-5169-5810, [mail@homepowersolutions.de](mailto:mail@homepowersolutions.de),  
[www.homepowersolutions.de](http://www.homepowersolutions.de)**Hydrogenious Technologies GmbH**, Weidenweg 13,  
91058 Erlangen, Germany, Phone +49-(0)9131-12640-220,  
Fax -29, [www.hydrogenious.net](http://www.hydrogenious.net)**MicrobEnergy GmbH**,  
Specialist in Methanisation,  
Bayernwerk 8,92421 Schwandorf, Germany, Phone +49-(0)9431-751-400,  
Fax -5400, [info@microbenenergy.com](mailto:info@microbenenergy.com), [www.viessmann.co.uk](http://www.viessmann.co.uk)**Worthington Industries –**  
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[www.worthingtonindustries.com](http://www.worthingtonindustries.com)**SUPPLIERS****Anleg GmbH, Advanced Technology**, Am Schornacker 59,  
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-29, [www.anleg-gmbh.de](http://www.anleg-gmbh.de)**Borit NV**, Bipolar plates and intercon-  
nects, Lammerdries 18e, 2440 Geel,  
Belgium, Phone +32-(0)14-25090-0,  
Fax -9, [contact@borit.be](mailto:contact@borit.be), [www.borit.be](http://www.borit.be)**ElringKlinger AG**, Max-Eyth-Str. 2,  
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Oxide Cells, Glass Tapes, Koppe-  
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884-30, Fax -90, [www.kerafol.com/sofc](http://www.kerafol.com/sofc)**Pajarito Powder, LLC**, 3600 Osuna Road NE, Suite 309, Al-  
buquerque, NM 87109-4427, USA, Phone +1-505-2-935367,  
Fax -448040, [www.pajaritopowder.com](http://www.pajaritopowder.com)**WEKA AG**, Schuerlistr. 8,  
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Phone +41-(0)43-833434-3, Fax -9,  
[info@weka-ag.ch](mailto:info@weka-ag.ch), [www.weka-ag.ch](http://www.weka-ag.ch)**TESTING****JA-Gastechnology GmbH**,  
Albrecht-Thaer-Ring 9, 30938  
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5107, [H2Team@maximator.de](mailto:H2Team@maximator.de), [www.maximator.de](http://www.maximator.de)**Resato International B.V.**,  
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Duitslandlaan 1, 9400 AZ Assen, Netherlands, Phone +31-  
(0)501-6877, [h2sales@resato.com](mailto:h2sales@resato.com), [www.resato.com](http://www.resato.com)**SMART Testsolutions GmbH**, Röttestrasse 17,  
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85748 Garching / Munich, Germany,  
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[info@h2-test.net](mailto:info@h2-test.net), [www.h2-test.net](http://www.h2-test.net)**TEST STANDS****AVL List GmbH**, Hans-List-  
Platz 1, 8020 Graz, Austria,  
Phone +43-316-787-0, Fax -400,  
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