H2 international
E-JOURNAL ON HYDROGEN AND FUEL CELLS

H2-international – e-Journal

October 2016

Content

H2 international
E-JOURNAL ON HYDROGEN AND FUEL CELLS

H2 Refills – Part of the Daily Routine or Still a Challenge?

What (Trial) Customers Think

Electric Transportation

During the research accompanying the 50 filling stations program, the Fraunhofer Institute for Systems and Innovation Research ISI, based in Karlsruhe, Germany, used refueling tests and focus groups to determine to what degree hydrogen filling stations have become accepted by experienced users and trial customers. The results show that a hydrogen refill is typically regarded as a safe and simple procedure, although it still represents a challenge – especially for trial customers.

With the 50 H_2 stations program, the German Federal Ministry of Transport and Digital Infrastructure (BMVI) supports the expansion of the H_2 filling station network in Germany. The project is part of the National Innovation Program Hydrogen and Fuel Cell Technology (NIP) and is coordinated by the National Organization Hydrogen and Fuel Cell Technology (NOW). It enables the thorough testing of increasingly market-ready hydrogen filling stations under close to real-life conditions as an important step toward market preparation. Besides user opinions, the research accompanying the program analyzes the ecological, economic, regulatory and technological aspects of the construction and operation of hydrogen refueling stations.

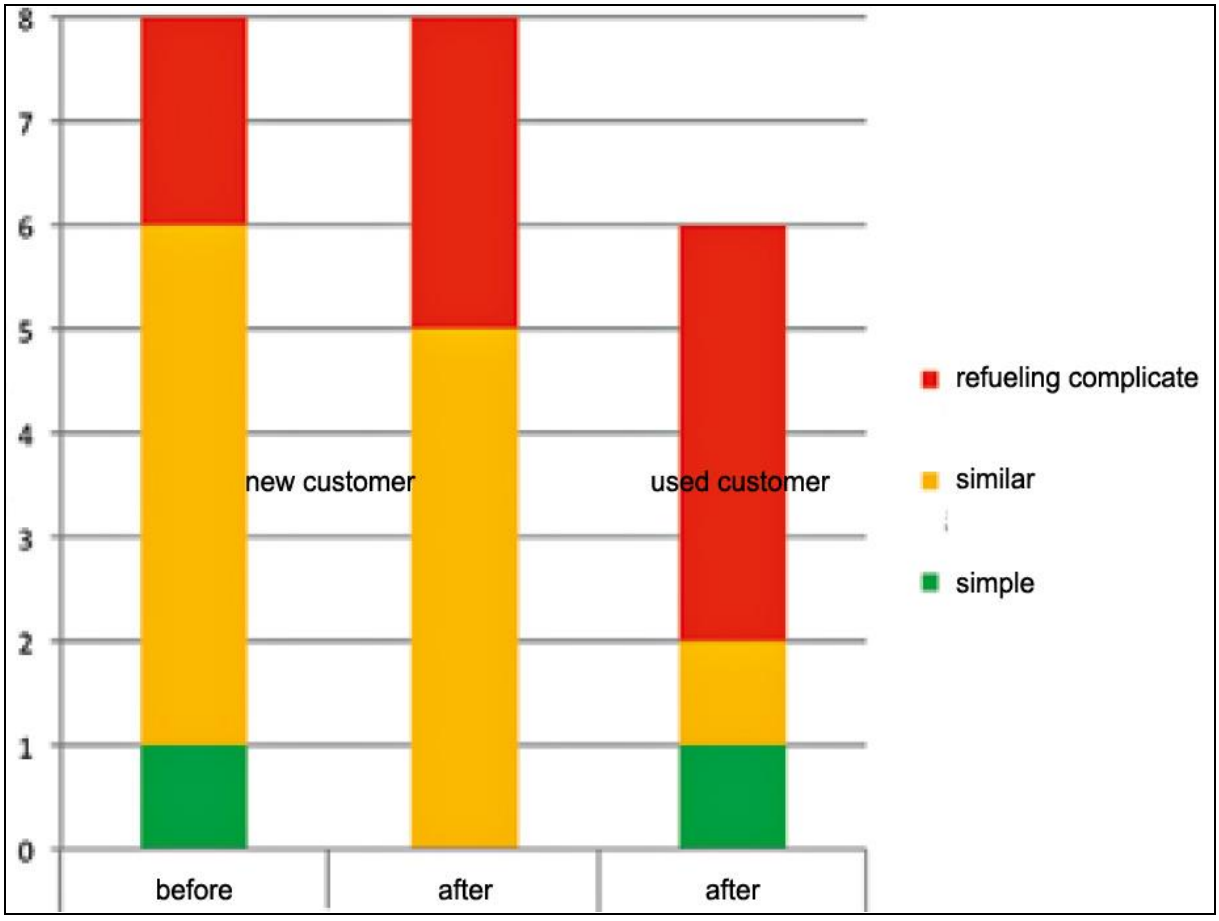


Fig. 1: Perceived complexity of H_2 refueling compared with gas or diesel refills

So far, hydrogen refueling has been available in Germany at around 34 stations, of which 20 are accessible by the public [1]. In large cities, such as Berlin and Hamburg, users can fall back on three to four filling stations, whereas other German regions have been less fortunate. For comparison: Drivers of conventionally operated vehicles were able to refuel their car at over 14,000 gas stations in 2015 [2] and drivers of natural gas vehicles could rely on a network of 850 publicly accessible locations [3]. As a collaboration between industrial companies and with support from the public sector, the Clean Energy Partnership has been the lighthouse project of NIP's transportation division since 2008. The partner companies of CEP have tested the system capabilities of hydrogen and developed technological and economic solutions for daily use scenarios.

In principle, there is no difference between hydrogen and conventional fuels when it comes to filling up a car tank. Refueling takes only a few minutes more compared to gas or diesel. But compared to charging battery-run vehicles, the quick refill period does turn into a crucial advantage. The tank is being filled with hydrogen at around 700 bar of pressure and a temperature of about -40 °C [4], accompanied by a sometimes loud hissing sound. The low temperature of the fuel makes the nozzle cool down considerably. At present, refueling still requires that customers have a special CEP H_2 Card, which is also used for billing. Regarding the planned increase in the number of filling stations and associated technological advancements, one should consider the experiences and wishes of users.

Refueling tests

To examine user acceptance, ISI organized a series of refueling tests at an H_2 filling station in Berlin, Germany. During the course of these tests, each user filled up the tank of a hydrogen vehicle. Prior to it, he or she had received a brochure explaining step by step how to refuel the car. No (further) details were given. During the test, the researchers stood by the entire time to answer questions or provide assistance.

The tests were conducted with two groups of people: One with six who had experience in refueling H_2 vehicles and another one with eight who had no such prior knowledge. All people taking part in the test possessed basic operating knowledge of cars. From the customers who had prior experiences with hydrogen refueling, four owned a hydrogen vehicle at the time of the test, whereas the other two had driven one in the past. The period of hydrogen car use ranged from half a year to two and a half years, whereas all vehicles had been used primarily in Berlin. Three people had the car solely for business purposes; the other ones had a mixed private-business use case. There was a monthly leasing rate paid for the car.

The test was completed by altogether 14 people: Seven women and men each, aged 23 to 72. Nine of them had a college degree.

These participants also received two short questionnaires, one before and one after refueling. The questionnaires made it possible to conduct a before-after comparison of expectations and experiences by the group of trial customers – since the ones with prior knowledge had already refueled hydrogen cars before. During refueling, everyone was asked to “think aloud,” to enable the researchers to record assessments and perceptions immediately.

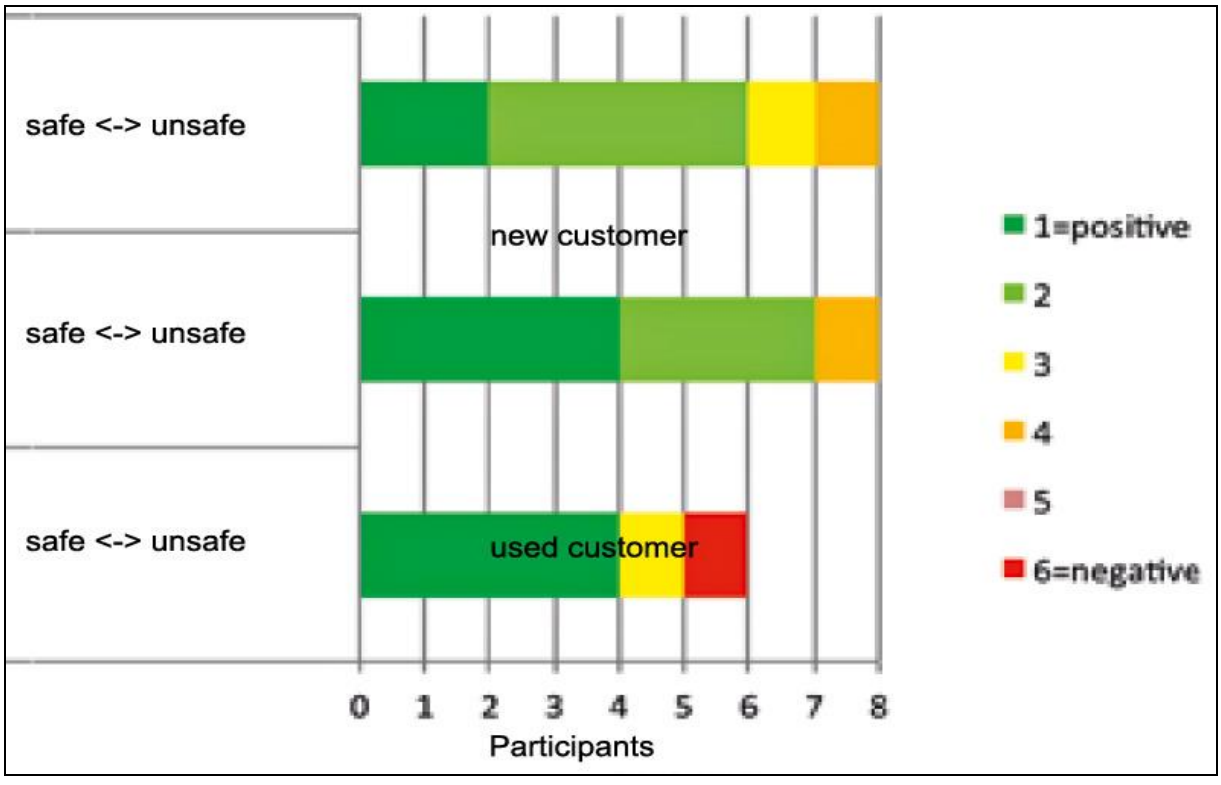


Fig. 2: Safety aspects associated with H_2 refueling

After the refueling tests, the participants were divided into focus groups to discuss the experiences made during refill as well as to provide an overall assessment of the H_2 technology. Focus groups are group debates among three to eight people, moderated by a researcher and based on a discussion guide. The group dynamics make it possible to obtain more profound insights into the thought process than would have been possible during separate interviews.

Rating H_2 refills

All participants successfully completed the hydrogen refill. Two trial customers, who purposely did not read the brochure before refueling, were nevertheless able to complete the task. Several participants, however, turned to one of the researchers during the procedure, as they weren't so sure about some of the steps. It took each participant between five and thirteen minutes from getting authorized at the card reader to putting back the fuel nozzle. With the experienced customers, who had already filled up the tank at this test station, the procedure seemed very routine. They were faster than both the trial customers and the ones without any prior knowledge of refueling the car at this location. Some had problems taking out the nozzle and putting into the fuel fill inlet. Additionally, several participants had difficulties releasing the nozzle after fueling and putting it back, since it is relatively heavy and has to be held at a certain angle.

There were also some technical problems with the price and volume indicators on the filling station display as well as with the button to start refueling. With three of the participants, the pump didn't even start or the procedure was cancelled, making a second attempt necessary. This caused a bit of irritation among some customers, especially among the ones without prior knowledge.

The majority, however, regarded H_2 refueling as a simple and uncomplicated process. Most trial customers rated H_2 refills similar in complexity to conventional ones – both before and after the test. More than half of them were convinced that one could get a good grasp of the system after several times refueling a car. Four of the experienced customers thought hydrogen refueling was more complicated (see Fig. *1*). One possible explanation could be that these customers hadn't been used to this particular filling station – each hydrogen station may require operation in a slightly different manner. The

experienced users may have also had higher expectations of the practicality of the technology in daily use and thus expected a simpler procedure.

During the focus group discussions, the trial customers said that hydrogen refueling was similar to filling up tanks with conventional fuel. They welcomed such parallel approaches. Two customers mentioned that they appreciated the absence of any smell during H_2 refueling compared to typical gas or diesel refills and that the fuel could not dirty up your hands.

Some saw the downside compared to conventional refueling in the cold fuel nozzle and the condensation water resulting from it. Some also criticized the design of the fuel nozzle, which in their view resembled typical gas or diesel interfaces: For example, the trigger lock was unnecessary for refueling, they said; alternatively, they suggested a type of turn lock (similar to LPG refueling), which could better tell the user that both components – vehicle and fuel nozzle – were inextricably linked to each other. Another interface currently used in Germany does meet user expectations in this regard.

The majority rated the time it takes to refuel the car as appropriate. This question again revealed the differences between both groups of users: The experienced customers rated the refueling time a bit worse than the trial customers (after refill). This may also be explained by the former group's daily use of fuel cell cars and their correspondingly high expectations of the technology. Additionally, their judgment may have also been influenced by bad experiences with past refills. Conversely, the trial customers expected a longer refueling period, but were pleasantly surprised by the rather short time it took them.

The majority of the people who took part in the test had no safety concerns while refueling. However, they described their feelings with a certain "respect" for the new technology. The experienced customers said that possible concerns disappeared over time, also because the flammability of gas and diesel could equally pose a risk during refueling. Moreover, the participants showed great trust in German safety standards, so that the high pressures were not seen as a safety concern. The handed-out questionnaires confirmed that the majority did not worry about the safety of the procedure. However, one experienced customer – who encountered technical difficulties while refueling – expressed a negative opinion about the safety of the H_2 refill (see Fig. *2*).

Evaluating the H_2 technology

The participants appreciated in particular the local absence of emissions in fuel cell cars. They welcomed the guarantee of sustainability and rated it as an important prerequisite for the further promotion and expansion of the technology as well as for future use. Especially the experienced customers called for a further expansion of the network of filling stations: The main goal should be to close the gaps primarily found in middle Germany, so that drivers can travel across the entire country. Because of the slow expansion of the network, the technology was currently not an alternative in a daily use scenario. And high vehicle costs ran counter to the idea of private individuals purchasing such cars.

Conclusions about the H_2 infrastructure

All in all, it should be noted that H_2 technology has been well received, albeit there are still some challenges to be overcome before everyday use is deemed practical.

One of the aims in further promoting the technology should be to simplify the use of the fuel nozzle and improve the technical reliability of filling stations. Especially new customers, who have had no experiences with hydrogen refills, could be unsettled by running into technical difficulties.

On the other side, most participants stated that hydrogen refueling was an intuitive learning experience. The new customers welcomed specifically the refill period, which they perceived as taking little time. The experienced customers had higher expectations of the technology's practicality and showed little patience for downtimes and difficulties. They also expected a further reduction in the number of minutes it takes to refuel.

In the end, what remained was the call for an expansion of the H_2 infrastructure and a wide-spanning network of filling stations to allow for a new kind of driving experience across all of Germany.

Literature

[1] ADAC: Entwicklung der Tankstellenanzahl seit 1965 in Deutschland, www.adac.de

[2] Clean Energy Partnership, Live-Karte mit Wasserstofftankstellen, www.cleanenergypartnership.de

[3] Gas Vehicles Report, Worldwide NGV statistics, May 2015, www.ngvjournal.com

[4] SAE International, Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles, J2601_201407, Fuel Cell Standards Committee

Authors:

Uta Schneider
Uta.Schneider@isi.fraunhofer.de

Elisabeth Dütschke
Elisabeth.Duetschke@isi.fraunhofer.de

Both from Fraunhofer ISI, Karlsruhe, Germany

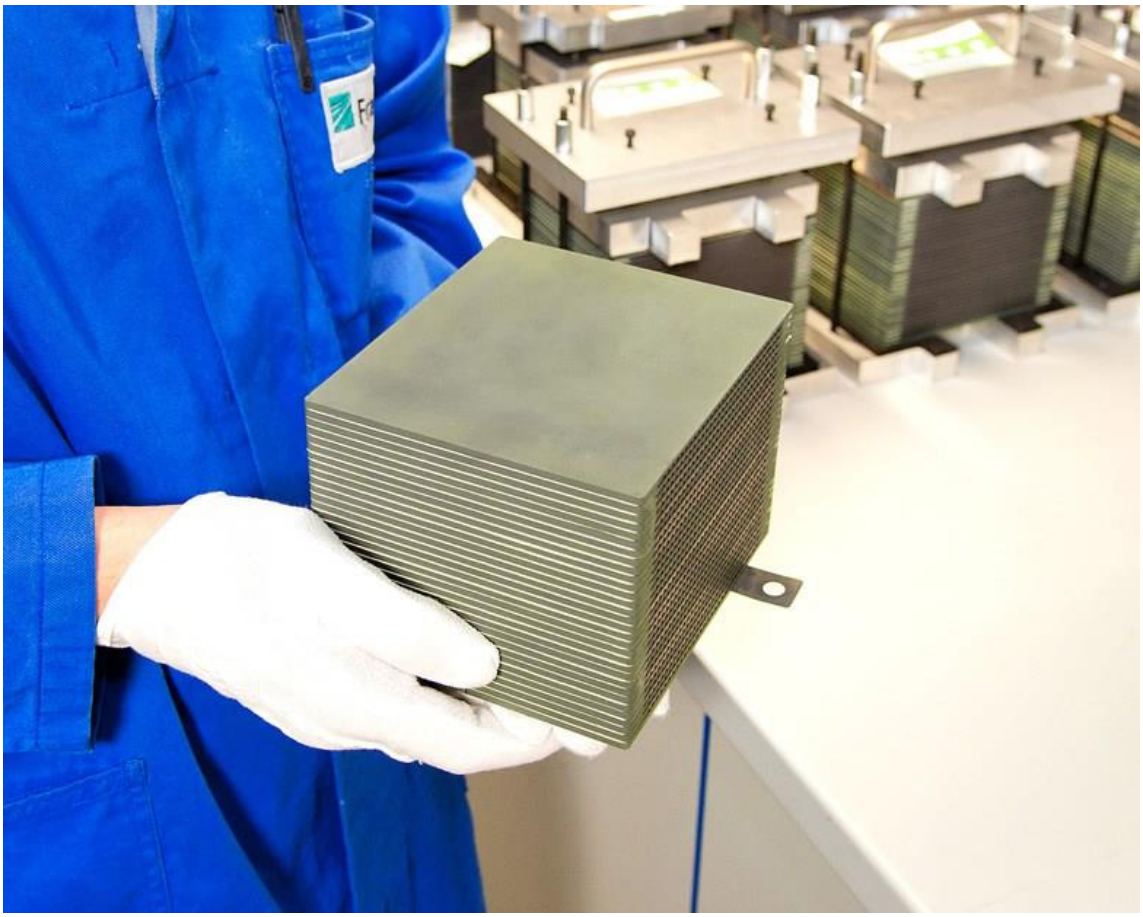
Visions, Engineering Feats, Entrepreneurship

SOFC Systems for Emerging Countries

Research & Development

In the future, high-temperature fuel cells should pave the way for new energy solutions in emerging countries. At least, this is the plan of several Indian investors who founded mPower in November 2015. Trusting in the SOFC know-how of Fraunhofer's IKTS and the interconnects by Plansee, they want nothing less than to set out from Dresden and revolutionize the energy world.

The vision of Siddharth Rajendra Mayur and Amarnath Ashok Chakradeo, the founders of mPower, is to develop efficient, robust, economically feasible and eco-friendly technology solutions that will contribute to the aim of offering clean and green energy at reasonable prices. Mayur said: "My dream is about being able to someday supply the rural regions of my home country and others with electricity, so that each family has access to light, heat and telecommunications all around the clock. The CFY stack is a key technology, which will help me realize my goal. I intend to make it available to everyone who shares my vision of clean energy supply and wants to succeed with a highly efficient product based on this fuel cell technology. mPower will play a considerable and meaningful role in a changing global energy industry."



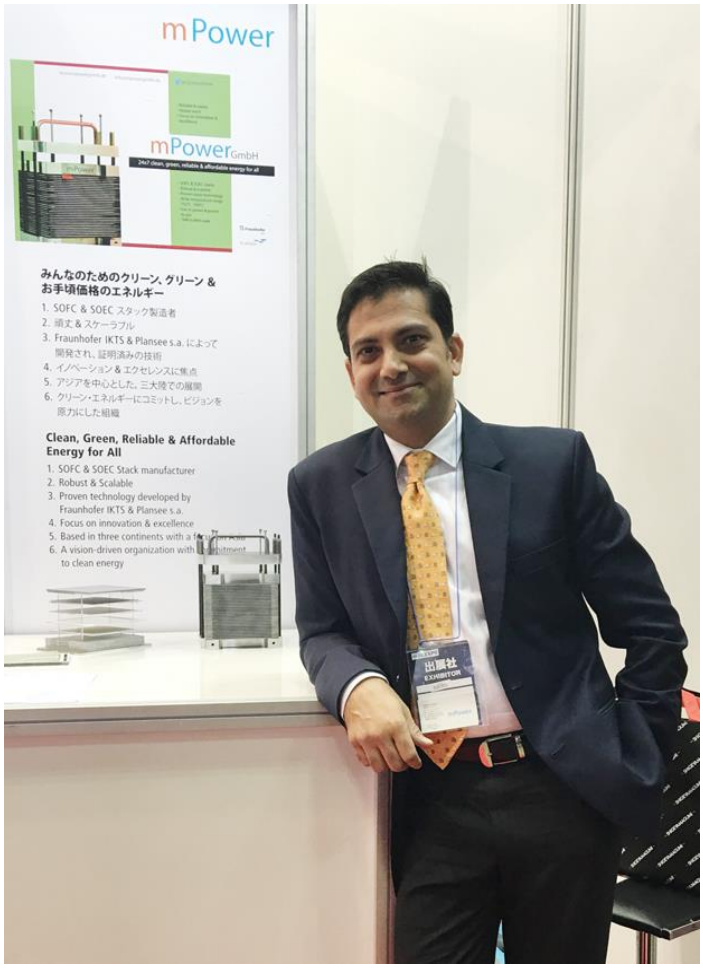
SOFC goes commercial

Together with Bhavana Siddharth Mayur und Sunil Purushottam Mayabhate, the founders of mPower are also the owners of Mayur REnergy Solutions, a company

established in Pune, India, in 2009 and specialized in energy production and supply. Since 2012, it has had a cooperation with the Fraunhofer Institute for Ceramic Technologies and Systems (IKTS). At that time, Mayur (President and CEO) and Chakradeo (CTO) as well as Suresh Sharma und Mahesh Agashiwala founded h2e Power Systems. Even back then, the four entrepreneurs sought to advance the development and distribution of inexpensive fuel cell units for resource-efficient and reliable energy production, especially in emerging countries.

Besides joint research activities, the collaboration with IKTS resulted in the idea of establishing mPower, a company to manufacture SOFC stacks. Little time has passed since then, but the business is said to actually introduce the new SOFC technology to the market by licensing the development, which IKTS and Plansee had had in the making for ten years, from the Saxony-based research institute. Manufacturing and R&D will be done in Dresden as soon as the facilities are ready. The director of the Fraunhofer Institute, professor Alexander Michaelis, said: “Our IKTS team will support mPower by providing top-tier technology in order to set up a manufacturing line for robust, simple, affordable and very efficient stacks. Based on these stacks, we can develop fuel cell systems offering an efficient energy conversion.” Professor Lorenz Sigl, head of Innovation Services at Plansee SE, added: “We are very excited about the foundation of mPower, and we are convinced that Mayur’s vision of making the CFY stack a global industry standard will become reality.”

Fig. 2: Siddharth R. Mayur at the FC Expo



Sources: mPower

CFY interconnects from Tyrol

The SOFC systems are equipped with interconnects by Plansee High Performance Materials (HPM). These interconnects, which have been part of the American Bloom Energy Server™ for years, consist of a chromium-iron base alloy mainly composed of chromium (e.g., 95% chromium, 5% iron and traces of yttrium). Such alloys are typically very brittle, since they can only be created from powdered metal by pressing it into shape and bonding it in a sintering furnace. Still, they are suitable for applications at comparably high temperatures of around 850 °C. Plansee turns this material into so-called CFY interconnects, a name derived from its three chemical components (Cr, Fe and Y). These components create a link between the fuel cell anode and cathode for power and heat transfer and spread the combustion gas and the air across the system – crucial tasks in high-performance cells.

Plansee SE

Plansee has been active in high-temperature fuel cell development since 1997 and owns a pilot-stage manufacturing line in Austria. The line produces around 500,000 interconnects each year. Additionally, Global Tungsten & Powders (GTP) based in Towanda in the state of Pennsylvania operates two large industrial-scale production lines for CFY interconnects for customer Bloom Energy. GTP is a division of the Plansee Group and is one of the biggest processors of tungsten raw material in the Western world.

In February 2016, Plansee opened a new manufacturing line in Mysore, India. It produces highly durable components, e.g., for customers in the automotive and semiconductor industry. CEO Wolfgang Köck said during the inauguration ceremony: “This investment underlines the long-term commitment of Plansee HPM in India.” Besides investing a considerable amount of money in these kinds of production facilities, the Plansee Group has also taken over several companies in India in recent years. The business headquartered in Tyrol, Austria, now employs far more than 700 people in the country. Köck explains the group’s increasing involvement in the Indian market with the country’s comparably low manufacturing costs, a nowadays high technological standard and market potential with a promising growth outlook.

First SOFC system in India

So far, the finished stacks of type MK351 have come directly from Fraunhofer IKTS. But the deputy director of the institute, Christian Wunderlich, explained during the Hanover trade show that the production demand for stacks had gone into the hundreds, meaning lab manufacturing was no longer a sensible solution. In the mid-term, the aim was to have mPower produce an enhanced version of type MK352 on its own and supply it to external customers such as h2e on the global stage. A manufacturing line for the stacks is said to be set up in Dresden before the end of 2016. The first project stage, during which Fraunhofer IKTS developed two SOFC prototype systems for h2e and set them up in Pune for testing, training and demonstration purposes, had already been completed successfully in September 2015. During the second stage, IKTS delivered three additional, enhanced showcase systems to India and initiated the transfer of technological know-how to allow for the establishment of local device production and commercialization.

The SOFC systems can run on natural gas, liquefied petroleum, methane or biogas and currently achieve an electrical output of between 300 and 1,000 W_{el} (net efficiency: 35 to 40%). Over the mid-term, the company is thought to produce

complete fuel cell systems for the Indian market, in the range of 500 W to 5 kW. Thomas Pfeifer, group manager at IKTS, explained: “It is one of the most efficient fuel cell systems based on partial oxidation, meaning without external water supply to increase electric efficiency.”

About the application of his units, Mayur said: “The state-of-the-art h2e® system by Fraunhofer IKTS should be used to supply power to India’s residential and commercial buildings. Additionally, we plan to deploy them in grid-remote use in combination with solar, wind, biogas and fuel cell technologies in rural areas, for example, for telecommunication masts and irrigation systems.” He added: “h2e represents the perfect combination of social vision, German engineering feats and Indian entrepreneurship.”

Besides its above-mentioned activities in the fuel cell market, Fraunhofer IKTS has recently established its Ceragen spin-off, which manufactures the eneramic® system. It has also entered into cooperation agreements with companies such as Vaillant, Sunfire, FuelCell Energy and Convion.

WES – Trial Run for EVS 2017

Trade Shows / Conferences

The World of Energy Solutions will be held this year from in Stuttgart Oct. 10 to 12. It will be viewed as a test case for the 30th Electric Vehicle Symposium (EVS), which will take place in 2017 together with the WES on the trade show premises and is an annual highlight for most electric car aficionados. It’s mere speculation at this point whether some companies are saving their strength for 2017. The only thing certain up till now is that the number of 78 exhibitors one month before the event is far removed from last year’s figure (120) – or even from the one of 2013, when it had been above 150.

The responsibility for this year’s event is now solely on the shoulders of the staff at Peter Sauber Agentur. After the 2015 tradeshow, Landesmesse Stuttgart officially announced it would no longer be available as a co-organizer. In her capacity as an official representative of the Peter Sauber agency, Silke Frank confirmed: “Customer advertising and trade show organization are now entirely in our hands.”

The conference will deal with the usual issues associated with electric transportation and fuel cell technology. In terms of content, the focus is said to be – among other things – on international developments in Asia and the US. For instance, March 2016 was a first for the Japanese government regarding target figures for its own H_2 transportation industry, such as registering about 40,000 fuel cell cars and having 160 hydrogen filling stations in operation by 2020. The pioneer in this field is carmaker Toyota with is unequivocal commitment to hybrid and fuel cell technology and its little enthusiasm for purely battery-driven cars. During the WES, Yuki Maehiro from the Japanese economy ministry METI will report on the country’s efforts to change the face of the national transport industry by advancing hydrogen solutions.

Fig. 1: Franz Loogen, chair of e-mobil BW, partner of the WES

The situation looks somewhat different in China, where high levels of pollution make quick changes all the more necessary. During the four months at the beginning of 2016 alone, the country produced around 78,000 electric and hybrid vehicles. The People's Republic's swift production ramp-up of relevant vehicles has been accompanied by an expansion of the charging infrastructure and the establishment of the necessary political framework. For example, the average consumption of carmakers' fleet vehicles is to be limited further as per the government's China Automotive Technology & Research Center (CATARC), which will force them to include zero-emission cars as part of their product portfolio. Cheng Wang, deputy director of CATARC, will have the details.

Other speakers who are expected to address the audience are Sunita Satyapal, Director of the Fuel Cell Technologies Office, US Department of Energy, and Diarmuid O'Connell, vice president of business development at Tesla Motors. O'Connell will likely also offer specifics on the Gigafactory currently being built in the state of Nevada. The current developments in Europe will be presented by Jorgo Chatzimarkakis, the new chair of industry association Hydrogen Europe based in Brussels.

Free tickets

As a media partner of the WES and the eCarTec, H2-international offers subscribers its annual free-of-charge tickets for the trade show areas of these events. However, both of them require that you be registered for participation. Please contact the editorial board if you're interested.

Let Construction Begin in Switzerland

News

It's getting serious in Switzerland: Swiss utility IBAarau reported in mid-June 2016 that it had taken concrete steps to let the project initiated by H_2 Energy and Coop Mineraloel (see Coop Sticks Around – Axpo Quits) become reality. IBAarau has recently submitted a building application to set up an H_2 production system at the company's hydropower plant in Aarau, Switzerland. The plant is said to provide 2% of its power generation for the envisioned electrolysis system plus compressor station from 2017 on. The compressed hydrogen should then be stored in big gas cylinders before being transported to Switzerland's first public H_2 filling station. This Coop Mineraloel station located in Hunzenschwil has already been in operation; next year, it will have enough hydrogen to supply 170 vehicles.

We're Not Done Yet

Interview with Dr. Klaus Bonhoff from NOW

Policies

Klaus Bonhoff has managed the activities of the National Organization Hydrogen and Fuel Cell Technology (NOW) since its founding in 2008, making him the face of the German H_2 and fuel cell industry. He has travelled around the world, patiently explained strategies and made the case for greater commitment. But he has also had to face criticism whenever projects were not implemented as quickly as had been hoped. H2-international spoke with the chair of NOW during the Hanover trade show in April 2016 about the National Innovation Program Hydrogen and Fuel Cell Technology (NIP 1 and 2), the H2Mobility Conference, the obstacles surrounding the implementation of projects as well what motivates him personally in his work.

H2-international: Mr. Bonhoff, several things have happened recently: First, there was the Callux Closing Conference, then the H2Mobility Conference, followed by the discussions about the new direction of the Clean Energy Partnership and H2 Mobility Germany, and finally the Showcase Conference. I think this would pretty much be the right time to look back at what has been achieved so far.

Bonhoff: Yes, although the actual conference on the results – "What we have accomplished during NIP 1" – is scheduled for the end of this year. It is true that 2016 was a transitional phase. There's a lot going on right now. One can see that the industry is in an optimistic mood. The last one, two years have helped clear up certain things. The industry has a relatively precise idea of where it wants to go next. But, of course, there are still some unanswered questions and open issues about the general framework.

H2-international: You've been managing NOW since its inception in 2008. Just this spring, you renewed your contract for a second time, something that has gone relatively unnoticed.

Bonhoff: Correct. I've been chairing NOW for the past years and am looking forward to continuing my work, putting every effort into advancing our cause.

Fig. 1: Dr. Klaus Bonhoff

H2-international: Was it difficult to push through the program's extension and new direction?

H2-international: And what about the extension of the National Innovation Program as well as the National Organization for Hydrogen and Fuel Cell Technology? Just like NIP, NOW was originally supposed to end in 2016.

Bonhoff: The key issue was the extension of NOW's run time as a program management organization of the federal government. Last December, the managing partner had changed the business purpose in the registration in two instances: One of them was the organization's run time, which has now been pushed back to Dec. 31, 2026. This means that NOW will continue through the end of 2026. The second substantive change was the organization's extended business purpose. We had originally been founded to coordinate NIP, but that changed in 2009 when we were additionally tasked with coordinating battery-electric transportation for the federal ministry of transport. Now, our purpose of business has been broadened again by also covering the program design and implementation in sustainable transport and

fuel cells for road and stationary use. This includes activities such as the accompanying infrastructure expansion, European guideline creation, etc., so that we can and are allowed to advise and support the ministries.

Bonhoff: To be honest, no. The discussion wasn't all that difficult. Of course, it's a process where you need to adhere to formalities, but the political will to further advance the issues through NOW was there all along – both among the members of the board of supervisors and throughout the related political discussions.

H2-international: What's your personal motivation for staying on?

Bonhoff: Personally, I'd like to see that everything we have developed together during the last years has a successful future. We're not done yet. Designing sustainable transportation concepts will remain a decades-long task. I don't want to overstate the importance, but that's my very own motivation to contribute.

H2-international: You document your work at NOW in annual reports. The one from 2015 was as thick as never before. Have you been satisfied with both the quantity and quality of your work so far?

Bonhoff: All in all, yes, I have. Naturally, there are projects which you would have expected more from. Such isolated cases do happen from time to time. We've also had ventures that had to be cancelled prematurely because the make-up of partners changed. That's nothing unusual in an environment that has its ups and downs. You'll have to see that this is exactly the reason why the federal government is supporting the process financially, because R&D always carries the risk of things not working out later on. You can't expect a 100% success rate in everything up to the last detail. Still, we have a very high number of successful projects. But there are additional benefits to the program from the synergy of all these activities, whether it's in lighthouse projects or other structures. And when I take a look at what is being discussed and created in different industries beyond purely technical advancements, then yes, I believe, I can be very satisfied.

H2-international: Some large projects did run into considerable difficulties – for example, Callux: 484 fuel cell heating units in eight years. What could you have done differently?

Bonhoff: I don't quite understand why this should be the only figure to gauge the success of the program. I mean, in total, we have been able to install a thousand units in Germany through Callux and other demonstration projects if EU activities are included. I'm not at all worried that the overall figure wasn't achieved through Callux alone. The higher-level strategic decisions on where to go from there have been made together with all stakeholders, for example, as part of the IBZ. Callux was indeed the largest, the lighthouse project, but it needs to be viewed in conjunction with other efforts. And when I look at what was achieved in cost reduction – especially, the increase in reliability – and that Viessmann, Elcore and SOLIDpower now each have a product on the market and Vaillant says that it will launch a product this year too: Then, you can only conclude that it was a meaningful endeavor. Not least because all of the companies agree that we wouldn't have pulled it off without the sometimes difficult, but successful coming-together during the joint project. Nevertheless, we are indeed lagging behind the Japanese in market deployment. This is still a challenge. Japan is a good example of a market with a gradually lowered economic incentive being right on target when it comes to reducing costs

and getting units onto the market. I'm pleased that we were able to convince the economy ministry during our discussion, so that Germany can gets its own market incentive program soon.

H2-international: So now it depends on if and when the technology rollout program arrives?

Bonhoff: Yes, market ramp-up depends on whether the TEP is coming soon.

H2-international: Could you maybe tell us when there will be a decision regarding the TEP?

Bonhoff: For that, you'll have to ask my colleagues at the BMWi. My understanding is that the announcement will be made at EU level. The BMWi did say that the political will was there. Now, the formalities have to be observed. However, the program should arrive quickly, since the ones at state level have ended and because the things we can still do through contracting models in the framework of NIP, will only have a limited impact. That means I'd rather see it in effect today than wait for it being implemented tomorrow.

H2-international: So still in this legislative session?

Bonhoff: Yes. The decision has been made; that's what the BMWi has publicly announced as well. Now it's only about the formal process that needs to be brought to a conclusion.

H2-international: The next difficult sector: transportation: The overall number of delays has inevitably resulted in the issue being brought to the forefront time and again. Just recently, at the Public Forum, it was mentioned that the aim of 50 H_2 filling stations would be accomplished no earlier than 2017. What's it going to be? Do we get to 50 filling stations this year or do we have to wait until 2017?

Bonhoff: Our lists show even more than 50 locations for which there are contracts available and financing has been secured. This is true for both private business contributions as well as NIP grants. Based on experience, there can be many different reasons for delay at one of the locations, whether there are issues with approval or difficulties not even associated with the hydrogen part of the installation. I expect that we will have 50 filling stations by the end of the year. They may not all be in operation by then, but quite frankly: It's not that big of deal whether they're up and running at the end of the year or at the beginning of the next. But yes, there are delays. They can't just be explained away either. But they shouldn't lead to anger or frustration; they are simply part of the learning curve for the further rollout. And it will stay that way. However, it's not like the hydrogen industry is the only that has to deal with these kinds of uncertainties. At many locations, it's not a hydrogen-related issue either, but it may as well be all about the fact a new installation is set up there. These situations are nothing extraordinary and they won't disappear either.

H2-international: At the moment, it doesn't look as if companies over here are aggressively making a case for H_2 and fuel cell technologies. How could the German automotive and energy industry be persuaded to rethink their approach, so that someone will at last leap ahead, so we see that companies actually want to?

Bonhoff: That the manufacturers want to make fuel cell vehicles – this I think became crystal-clear again recently, at the H2Mobility Conference, where they all agreed: We know that we need fuel cells besides batteries – both complementing each other – to provide sustainable transportation in the future. The realization is definitely there. We in Germany have a special debate around diesel emissions, which I think has given the issue a bit of dynamism. It also shows the seriousness of the situation. We ultimately have come to the realization that improving the existing system will be insufficient to achieve the goals we set out to do. It makes a switch to electrical engines with battery and fuel cells inevitable. Certainly, the challenge for each of us is to look at the timetable and ask ourselves, as I do as the head of a business, when the time is right to introduce which technologies to what extent. Yes, of course: Personally, I'd wish for more visibility of hydrogen and fuel cell engines, no doubt about it. It's the driver for the CEP Ride & Drive events, it's the reason for us, as NOW, to organize the roadshow where we always showcase batteries and fuel cells, and it's why we joined forces with numerous companies and associations in the industry to launch the hydrogen campaign starring Hannes Jaenicke [translator's note: a well-known German actor]. It is no use to complain about things that aren't – you'll have to put the effort in where you can.

H2-international: Tesla's CEO, Elon Musk, can cause a stir in the scene with one single tweet. There, you'll see that he wants to.

Bonhoff: The comparison is difficult insofar as the purely economic prerequisites for a start-up, which gets money to spend most of it, are entirely different from a company which has to report to its shareholders each quarter and make enough to be

profitable. This is exactly the dilemma in which we are: Disregarding all of the aforementioned for a moment, we have all in all not yet been able to translate the aims set and accepted by everyone (see COP 21) into a framework that would actually prompt companies to invest because the economic foundation is there. This is exactly the conflict we need to resolve: Clean energy, clean transportation, which we all want, must be economically feasible.

Fig. 2: Bonhoff praised NIP as a "stabilizing factor"

H2-international: Would it not be the responsibility of politics to set the framework and targets in a way that fuel cell vehicles are being considered more favorably before 2020 or 2023?

Bonhoff: What's clear is that the government has to establish exactly this kind of a framework. I think it's the right move in politics to set even longer-term targets early on. They should indicate a clear path toward decarburization of the energy industry by 2050, since this will be the planning base for the industry. I think it's certainly possible that the industry can respond even to stringent threshold limits – given the appropriate lead time.

H2-international: Okay, let us go back to the NIP lighthouse projects. There was or still is e4ships – which is rather a non-starter. What went wrong?

Bonhoff: I wouldn't call it a non-starter. Instead, I'd recommend taking a closer look before reaching such conclusions. In the shipbuilding industry, it's also about thresholds, port emissions and the advantages of efficient fuel cells, up to the question of "What is the right fuel for ships." That shouldn't be discussed by only one stakeholder but by several or all. This kind of debate in the industry is necessary and is part of e4ships. Indeed, there are R&D project partners which make different business decisions. There are also technological reasons for why another path is chosen later on. That was true for a great number of cases in the shipbuilding industry, which is caused the delays in the end. But when you talk to shipyards and

system integrators nowadays, they feel very confident about having finally found a system set-up that won't be used only for showcases, but which would actually lead to market deployment. It's about global competition and being a leader in technology developments, and the fuel cell is still pretty much "vogue." We're now discussing the continuation of this network, as the partners have realized that a joint effort makes sense.

H2-international: Meaning NIP 2 would also continue e4ships?

Bonhoff: That's what's currently on the table.

H2-international: And the Clean Power Net would continue as well?

Bonhoff: Yes, it would.

H2-international: It has lately been relatively quiet around the latter. Is it really realistic to assume that it could prompt a breakthrough over the coming years?

Bonhoff: The entire industry relies on fuels promising reliability and on fulfilling that promise. Proof is about to be provided: There have been or will be 100 systems installed to power public safety networks. Real-life application will show the benefits of fuel cells, benefits that are on display every time they can bridge the gap during longer backup periods. It's a good starting point for further growth. Germany, however, will not likely be a large and attractive environment for system demand, but emerging markets, such as China, India and also Africa, will be. Here, the question will be how we can develop market instruments to help the industry compete for exports on a global scale. That's where the differences in subsidy programs in Europe, Asia and the US come into play. For instance, if the US grants tax rebates or China provides direct subsidies, German companies will hardly have the edge. We are currently in discussions with the industry about creating an export fund which could make a market ramp-up possible or speed it up. This fund would not be one granting irretrievably lost incentives, but could be profitable over time.

H2-international: Are there any concrete plans regarding such a fund?

Bonhoff: It's mainly about pre-financing. The idea came from CPN and was discussed in different departments and at different events. I think it's an interesting model, as it would help the industry we nurtured to become a global competitor.

H2-international: What about energy storage, say, as the fourth pillar of NIP?

Bonhoff: We were more thinking along the lines of "power-based fuels," as we believe that electrolysis and hydrogen are not storage technologies, but the basic requirement for using renewables as fuel in transportation. If the electrolysis capacity in the fuel sector increases, it will certainly have to meet grid feed-in requirements, so that it has a positive impact on grid stabilization and the volatility of renewable energies. You could say, such is the purpose of electrolysis systems. They must fill precisely this gap. The development of electrolysis systems will create the link between the transport, power and heat markets. The driver for system development, however, is transportation. This means that we don't see storage technology as the key issue, but power-based fuels. You commercialize electrolysis – on a large scale basis.

H2-international: What exactly is planned for NOW at this point? What will remain, what will change?

Bonhoff: On the one side, it's about continuity in R&D; nothing will change there. We hope we can continue to offer a stable framework for research and development in coordination with all stakeholders. The right means for market ramp-up would indeed be a new step, and when they are available, it'd be about their continual improvement. For example, if there is a technology rollout program for fuel cell heating systems, I'd advocate for monitoring. And this wouldn't be just about counting how many systems are online, but it would also mean taking a look at how these systems perform, how cost reductions are achieved and what we can learn from the experience. I consider this kind of active monitoring with a feedback loop on follow-up R&D activities to be crucial. Of course, other examples could be vehicle purchases in public transportation – whether they are buses or trains – and infrastructure, where a balanced and driving force is needed besides normal project support in order to really push things forward.

H2-international: Now to our last question. Which size will a TEP or NIP 2 have? The BMVI has already pledged EUR 161 million for 2016 through 2018. Could that now possibly be followed by an increase to EUR 400 million?

Bonhoff: I would ask you to wait for the official announcements by the ministries. These EUR 161 million show that the BMVI is still committed and is devoting an increasing amount of financial resources to support hydrogen. And the economy ministry has always been unwavering in its commitment to continue supporting research and development as part of its energy research program on par with what it has provided so far.

H2-international: Mr. Bonhoff, my profound thanks for this insightful interview.

NIP 2.0 On Its Way

News

"The paperwork has been finalized." With this statement, NOW chair Klaus Bonhoff announced that NIP 2.0 was about to be ready for implementation. During e4ships' final conference in Hamburg on Sept. 7, 2016, he also told H2-international that the remake of the National Innovation Program Hydrogen and Fuel Cell Technology would still be made available this year. Parts of it have already been made public (see Germany Prepares for Technology Rollout Program and Interview with Klaus Bonhoff from NOW).

H_2 Race Car to Compete Against Fossil Fueler

Electric Transportation

The hydrogen industry isn't new to electric race car development: As far back as 2007, the Delft University of Technology had launched Forze, a project which brought together engineers and students for the purpose of designing and constructing a fuel cell race car. The aim of the project has been to combine racing and clean technologies. Within the past nine years, the team has developed seven prototypes.

Source: TU Delft

Work on the Forze VI was finished in 2013. Even back then, the car boasted numerous improvements: It was six times as powerful and efficient as its predecessors. Its lightweight construction and the changes in aerodynamics also turned the race car into serious competition versus fossil fuel models. Two years after its completion and a most exhaustive list of enhancements, it was taken out for several laps on Nürburgring's North Loop by former Dutch race car and Formula 1 driver Jan Lammers. On May 7, 2015, he set a record for H_2 cars by completing a lap in 10:43:56 minutes. Max Verstappen, the current Formula 1 driver for Red Bull Racing, later showcased the car's capabilities in front of a 100,000-strong audience during the pre-show on Gamma Racing Day in the Netherlands, proving that hydrogen and racing aren't such strange bedfellows after all.

At present, the clock is ticking for preparing the vehicle's seventh generation: The Forze VII concept study was presented in March this year. The race car, which seventy students helped create based on an LMP3 chassis, is planned to compete – and win – against the fossil fuel counterparts on Aug. 6 and 7, 2016, during the Supercar Challenge on Gamma Racing Day. The Forze VII has a 100 kW fuel cell as well as an electric motor with a maximum power of 200 kW. The car's top speed is 210 kph (130 mph) and it needs less than 4 seconds to go from 0 to 100 kph (62 mph).

BeeZero's Fuel Cell Carsharing Offer

Electric Transportation

BeeZero is gas company Linde's new carsharing offer to anyone interested in renting a fuel cell car for a short trip on the road. Linde Hydrogen Concepts, the subsidiary that the technology business founded for this purpose, has acquired a total of 50 Hyundai ix35 Fuel Cell for its first-ever rental location in Munich, Germany. Christian Bruch, Linde board member, said during the presentation of the first BeeZero fleet vehicle in April 2016: "We are confident that operating a fleet of fuel cell cars will provide us with valuable insights to help enhance our hydrogen technologies and further the expansion of an H_2 infrastructure."

Linde also announced that "unless the customer chooses otherwise, the cars will be refueled by BeeZero employees. The hydrogen fuel is sourced exclusively from sustainable production processes, making it completely carbon neutral." Hyundai said that the 50 fuel cell cars had been handed over to BeeZero on June 9, 2016.

The Munich-based company showcased both their new idea as well as the car, wrapped in matte lacquer, during the H2Mobility Conference in Berlin and the industrial trade show in Hanover. During the Hanover trade show in 2016, one attendee remarked: "Linde collaborating with Hyundai – that's not a great sign." It's exactly how Linde's collaboration should be viewed: as a signal to the automotive industry that gas companies are no longer willing to wait until German carmakers finally offer fuel cell vehicles. Instead, Linde has run an aggressive marketing campaign with the tagline: "This time, you can believe the hype."

www.beezero.com

Synergies Between Space Flight, Energy and Transportation

H_2ORIZON – DLR Invests in H_2 Site

Energy Storage

The Institute of Space Propulsion of the German Aerospace Center (DLR) in Lampoldshausen is one of Europe‘s largest hydrogen consumers. The organization primarily uses cryogenic hydrogen to test the main and upper stage engines of Europe’s Ariane 5 rocket. The experiences made during those tests will now be expanded even further: Together with ZEAG Energie, the DLR is planning to implement a regenerative hydrogen process chain. It creates the required hydrogen in a 1 MW PEM electrolysis system, which draws its power from the neighboring wind farm Harthäuser Wald, and makes the hydrogen available on-site for use in space flight, energy and transport applications. This turns the H_2ORIZON project into an entirely new demonstration and research platform for utilizing a wide range of hydrogen technologies.

When the Vulcain 2 main engine is running at test stand P5, it converts about 28 tons of hydrogen into fuel energy within ten minutes. The maximum output is three gigawatts. And that’s not all: The DLR in Lampoldshausen also operates test stands for innovative engine designs using gaseous hydrogen. The amount necessary for these manifold endeavors comes from large-capacity units storing cryogenic and gaseous hydrogen and from a network that transports the fuel from a central storage facility. This fuel is available as both cryogenic and gaseous hydrogen (at 320 or 800 bar, respectively).

H_2ORIZON project

The H_2ORIZON project was launched to meet the DLR‘s aim of making its long-term experiences in hydrogen applications as well as the existing infrastructure available to other industries not associated with space flight. The ultimate goal is to implement a technology transfer that ties the space flight, energy and transport sector to hydrogen as its central component, in order to enable the use of a wide variety of hydrogen technologies on-site while benefitting from the best possible utilization of synergies.

At the same time the DLR was contemplating its options, ZEAG Energie, the local utility in Heilbronn, Germany, was planning to set up Harthäuser Wald, a 42 MW wind farm, in close proximity of the DLR location. In October 2015, the wind farm’s altogether 14 energy systems were brought online.

With the new availability of renewable power nearby and location-specific benefits, especially for industrial-scale H_2 applications, the DLR site enjoyed the ideal prerequisites for implementing a renewable hydrogen process chain, from generating and storing to distributing and utilizing the fuel on-site.

The DLR subsequently invited bids for a project partner to set up and operate the systems of H_2ORIZON. ZEAG Energie’s offer was chosen shortly before the end of 2015.

Cross-sector platform

The three focus areas of H_2ORIZON are:

1) Establish and operate a sustainable, industrial-scale process chain that will generate and supply hydrogen for application in various industries or sectors

2) Guarantee sustainable and secure energy supply of the DLR location with heat and power sourced from natural gas and hydrogen

3) Set up a demonstration and research platform for the use of and research into a wide range of hydrogen technologies beyond the already planned process chain

Fig. 1: Testing the Vulcain 2 at the DLR site

To be able to generate renewable hydrogen in large quantities, the DLR location will have a dedicated power line connected to the wind farm. The transmission output will be as much as ten megawatts. Hydrogen will be created by an electrolysis system with a polymer electrolyte membrane (PEM) and a power rating of one megawatt in the first stage of development. The great capacity that the wind farm has available leaves the door wide open for later plant upgrades. The electrolysis system is a product of manufacturer ITM Power, based in Sheffield, UK.

Because of the high purity requirements in space flight and the fuel cell‘s electric transportation angle, hydrogen is being processed to meet a purity grade of 5.0. Cryogenic LH_2 units store the gaseous hydrogen, which makes it all the more important that there are no other residual gases present. Such residual gas content could turn into ice at the low temperatures of around 20 K (true for all gases, except for helium) and lead to clogged pipes.

After processing, the hydrogen can be compressed at 350 bar of overpressure and fed into tube trailers. Besides on-site usage, the method of compressed storage would also enable third parties to buy renewable hydrogen and distribute it to relevant consumer locations. The DLR and ZEAG have been supported in their joint project efforts to generate renewable hydrogen and supply it to the fuel cell transportation industry by the Ministry of the Environment, Climate Protection and the Energy Sector of the German federal state of Baden-Wurttemberg.

H_2ORIZON also entails an expansion of the existing heating plant, which will not be able to cover future heat demand at the location. Two heat-based gas-run cogeneration plants with combined heat and power (CHP) will cover the site’s base load in the future. This additional thermal power to be installed on-site amounts to 1.5 MW. The plants will run primarily on natural gas. One of the two cogeneration plants, however, will be designed to accept mixtures with hydrogen, up to a hydrogen content of 100%.

Demonstration and research platform

The H_2ORIZON project will be implemented as a demonstration and research platform open to any kind of technology and is planned to be available for third-party use as well.

Provided that the interplay between the components is duly optimized, linking the two energy carriers, hydrogen and natural gas, to electrical energy and heat, and to the demand from space flight, energy and transport applications can create synergy effects and an ideal system load that would not be possible if each sector was on its own. The DLR and ZEAG hope to gain valuable insights into what a renewable H_2 value chain could look like in terms of technology and economic feasibility. Additionally, the project should try and showcase on-site strategies that will offer solutions for a successful energy transformation, for example, by meeting the challenges of peak loads and performance in the power grid, the long-term storage of energy or inexpensive fuel supply for emission-free transportation.

Regional importance and beyond

In Lampoldshausen, the DLR is developing 2.5 hectares (62 acres) to make room for the implementation of H_2ORIZON and allow for possible future expansions of the demonstration and research platform. The land will also be available for new buildings by the DLR and local institutions as well as for new collaborations. The land

development affirms the research center's commitment to grow the location. Additionally, creating renewable hydrogen in Lampoldshausen will shorten supply lines in southern Germany significantly and make it possible to base hydrogen applications in the industrial, energy and transportation sector on renewable sources.

Author:
Andersen.jpg
Thorben Andersen, M.Sc.
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Institut für Raumfahrtantriebe
Thorben.Andersen@DLR.de

read more: www.h2-international.com

Events

- October 5th to 6th, 2016, **California Hydrogen and Fuel Cell Summit**, in Sacramento, CA, USA, www.californiahydrogensummit.com
- October 10th to 12th, 2016, **World of Energy Solutions**, on the Stuttgart Fair Ground, Germany, www.world-of-energy-solutions.de
- October 18th to 20th, 2016, **eMove 360° Europe**, Mobility 4.0: electric – connected – autonomous, in Munich, Germany, www.emove360-expo.com
- November 1st to 2nd, 2016, **Battery Safety & Lithium Battery Power**, Bethesda, MD, USA, www.knowledgefoundation.com
- November 3rd to 5th, 2016, **23. Energiesymposium** - Nutzung regenerativer Energiequellen & H2-Technik, in Stralsund, Germany, www.stralsund.de
- November 8th to 10th, 2016, **gat + wat** - , Conference and Fair for Gas and Water, in Essen, Germany, www.gat-dvgw.de
- November 9th to 11th, 2016, **17. Forum Solarpraxis** - The next energy era, in Berlin, Germany, www.neue-energiewelt.de
- November 21st to 23rd, 2016, **9th FCH JU Stakeholder Forum** - Fuel Cells and Hydrogen 2 Joint Undertaking, in Brussels, Belgium, www.fch.europa.eu

read more: www.h2-international.com/events/

Companies

Electrolyzers

- **AREVA H2Gen GmbH**, Maarweg 137, 50825 Cologne, Germany, Phone +49-(0)221-888244-88, Fax -67, www.arevah2gen.com
- **Diamond Lite S.A.**, Rheineckerstr. 12, PO Box 9, 9425 Thal, Switzerland, Phone +41-(0)71-880020-0, Fax -1, diamondlite@diamondlite.com, www.diamondlite.com
- **Giner, Inc.**, 89 Rumford Avenue, Newton, Massachusetts 02466, USA, Phone +1-(0)781-529-0500, information@ginerinc.com, www.ginerinc.com
- **Hydrogenics GmbH**, Am Wiesenbusch 2, 45966 Gladbeck, Germany, Phone +49-(0)2043-944 141, Fax -6, hydrogensales@hydrogenics.com, www.hydrogenics.com
- **Proton OnSite**, 10 Technology Dr, 06492 Wallingford CT, USA, Phone +1-(0)203-678-2000, info@protononsite.com, www.protononsite.com

Energy Storage

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

- **Hydrogenious Technologies GmbH**, Weidenweg 13, 91058 Erlangen, Germany, Phone +49-(0)9131-12640-220, Fax -29, www.hydrogenious.net
- **MicrobEnergy GmbH**, Specialist in Methanisation, Bayernwerk 8, 92421 Schwandorf, Germany, Phone +49-(0)9431-751-400, Fax -5400, info@microbenergy.com, www.viessmann.co.uk

Event Organizers

- **23rd Group Exhibit Hydrogen + Fuel Cells + Batteries**, HANNOVER MESSE 2017, April 24 – 28, Tobias Renz FAIR, Tobias Renz, tobias@h2fc-fair.com, www.h2fc-fair.com
- European Fuel Cell Forum, Obgardihalde 2, 6043 Luzern-Adligenswil, Switzerland, Phone +41-4-45865644, Fax 35080622, forum@efcf.com, www.efcf.com
- **GL events Exhibitions**, 59, quai Rambaud, CS 50056, 69285 Lyon Cedex 02, France, Phone +33-(0)478-17633-0, Fax -2, www.gl-events.com
- **Peter Sauber Agentur Messen und Kongresse GmbH**, World of Energy Solutions, Wankelstr. 1, 70563 Stuttgart, Germany, Phone +49-(0)711-656960-55, Fax -9055, www.world-of-energy-solutions.de

Fuel Cells

- **FuelCell Energy Solutions GmbH**, Winterbergstr. 28, 01277 Dresden, Germany, Phone +49-(0)351-2553739-0, Fax -1, www.fces.de, Stationary fuel cells for commercial and industry: CHP solutions, hydrogen production and power storage

- **Heliocentris Energy Solutions AG**, Rudower Chaussee 29, 12489 Berlin, Germany, Phone +49-(0)30-340601-500, Fax -599, info@heliocentris.com, www.heliocentris.com

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

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

Fueling-Recirculation and Air-Supply

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

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

Gas Diffusion Layers (GDL)

- **MeliCon GmbH**, Metallic Lightweight Construction, Porschestr. 6, 41836 Hückelhoven, Germany, Phone +49-(0)2433-44674-0, Fax -22, www.melicon.de
- **SGL Carbon GmbH**, Werner-von-Siemens-Str. 18, 86405 Meitingen, Germany, Phone +48 (0)8271-83-3360, Fax -103360, fuelcellcomponents@sglgroup.com, www.sglgroup.com

Hydrogen Distribution

- **Hydrogenious Technologies GmbH**, Weidenweg 13, 91058 Erlangen, Germany, Phone +49-(0)9131-12640-220, Fax -29, www.hydrogenious.net
- **Wystrach GmbH**, Industriestraße 60, Germany – 47652 Weeze, Phone +49-(0)2837-9135-0, Fax -30, www.wystrach-gmbh.de

Membrane and Separator

- **FUMATECH BWT GmbH**, Carl-Benz-Str. 4, 74321 Bietigheim-Bissingen, Germany, Phone +49-(0)7142-3737-900, Fax -999, www.fumatech.com
- **Plansee SE**, Bipolar Plates, Interconnects and Metal Supported Cells, 6600 Reutte, Austria, Phone +43-(0)5672-600-2422, www.plansee.com

Organization

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

Reformers

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

Research & Development

- **Fraunhofer ICT-IMM**, Reformer and Heat Exchanger, Carl-Zeiss-Str. 18-20, 55129 Mainz, Germany, Phone +49-(0)6131-9900, info@imm.fraunhofer.de, www.imm.fraunhofer.de
- **Fraunhofer ISE**, Heidenhofstrasse 2, 79110 Freiburg, Germany, Phone +49-(0)761-4588-5208, Fax -9202, www.h2-ise.de

Suppliers

- **Anleg GmbH**, Advanced Technology, Am Schornacker 59, 46485 Wesel, Germany, Phone +49-(0)281-206526-0, Fax -29, www.anleg-gmbh.de
- **Borit NV**, Bipolar plates and interconnects, Lammerdries 18e, 2440 Geel, Belgium, Phone +32-(0)14-25090-0, Fax -9, contact@borit.be, www.borit.be
- **ElectroChem Inc.**, 400 W Cummings Park, Woburn, MA 01801, USA, Phone +1-781-9385300, www.fuelcell.com
- **HIAT gGmbH**, Schwerin, Germany, CCMs / MEAs / GDEs for PEFC, DMFC & PEM-Electrolysis, www.hiat.de

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

System Integration

- **Deutsche Zentrum für Luft- und Raumfahrt (DLR) / German Aerospace Center**, Institute of Engineering Thermodynamics Energy System Integration, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany, Phone +49-(0)711-6862-672, Fax -747, www.dlr.de/tt, www.dlr.de/tt
- **FLEXIVA automation & Robotik GmbH**, Power Electronics – Hybrid Energy System Solutions, Weißbacher Str. 3, 09439 Amtsberg, Germany, Phone +49-(0)37209-671-0, Fax -30, www.flexiva.eu

Testing

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

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

Valves

- **Bürkert Werke GmbH**, Mass Flow Controllers, Christian-Bürkert-Str. 13-17, 74653 Ingelfingen, Germany, Phone +49-(0)7940-10-0, Fax -91204, www.burkert.com
- **OMB Saleri SpA**, Via Rose di Sotto 38/c – 25126 Brescia, Italy, hydrogen@omb-saleri.it, www.omb-saleri.it

read more: www.h2-international.com/companies/

Do you also want to be part of this **List of Companies on H2-international?**

It only costs US-$ 199 (185 Euro) and includes a free subscription for H2-international e-Journal.

Specials

Free tickets or special discounts only for H2-international subscribers:

- **Special discount for the WORLD OF ENERGY SOLUTIONS**
  Visit the conference – the international meeting place for experts
  from October 10th to 12th, 2016, in Stuttgart, Germany
  www.world-of-energy-solutions.com
  Order your conference ticket via H2-international and get a 10 % discount

- **Free tickets for the WORLD OF ENERGY SOLUTIONS**
  Visit the international trade fair with its three exhibition platforms – BATTERY+STORAGE, f-cell, e-mobility solutions
  from October 10th to 12th, 2016, in Stuttgart, Germany
  www.world-of-energy-solutions.com
  Register for the fair via H2-international and get a free ticket

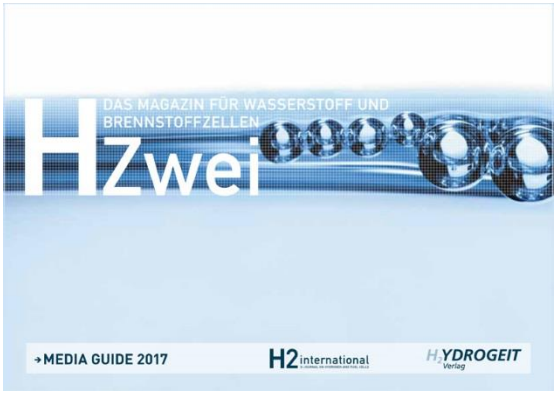
- **Free tickets for the eMOVE360° Europe 2016**
  Visit the international trade fair for Mobility 4.0 - connected, autonomous
  from October 18th to 20th, 2016, in Munich, Germany
  www.emove360-expo.com
  Register for the fair via H2-international and get a free ticket

Please contact *H2-international* for more details.

Literature

Media Guide 2017

HZwei and H2-international



informations for the magazine, the e-journal and the newsletter

print specifications, prices, topics, events

advertisements, print and online

www.h2-international.com

Imprint & Social Media

H2-international – The e-Journal on Hydrogen and Fuel Cells

ISSN-Online: 2367-3931

Publisher: Hydrogeit Verlag, Sven Geitmann, Gartenweg 5, 16727 Oberkraemer, Germany, Phone +49 (0)33055-21322, Fax +49 (0)33055-21320

UID/VAT: DE221143829

Web: www.h2-international.com & www.hydrogeit-verlag.de
Email: info@h2-international.com