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Content

Fuel Cell Buses Speed Ahead

Fuel cell double-decker, © Wrights Group

Fuel cell buses emit no air pollutants or environmentally harmful gases. They can run an entire day without the need for refueling and offer operators the same flexibility as diesel vehicles. Fifty-four fuel cell buses and nine hydrogen filling stations were tested in day-to-day operation during the Clean Hydrogen in European Cities project from 2010 to 2016. The results were presented in London at the Zero Emission Bus Conference on Nov. 30, 2016.

The CHIC project (see also HZwei issue from January 2014) was the first to employ fuel cell hybrid buses in small fleets in regular operation. The vehicles possess a battery or a supercapacitor that makes it possible to use the fuel cell at low output and make the ride more efficient, e.g., by through regenerative braking systems. The energy amount that can be stored from it is much smaller than the capacity of the hydrogen tanks.

Models came from five different manufacturers. They were primarily smaller buses of 12 or 13.2 meters or around 39 to 43 feet in length – the latter with three axles – but there were also some articulated buses (18 meters or 59 feet). Their range was up to 400 kilometers (almost 249 miles) and they were used up to 20 hours a day. Most locations were subsidized by the Fuel Cells and Hydrogen Joint Undertaking (see figure).

The project results have been documented and published as part of various reports evaluating different aspects of the project [1]. These reports include recommendations for future projects, a study on the acceptance of fuel cell buses among public transportation users and a rating of their sustainability. Additionally, the project led to the establishment of a dialog with critics of hydrogen and fuel cell technology. All figures mentioned in the following are based on project progress at the end of June 2016.

H_2 filling stations

The buses were refueled around 61,750 times, which consumed more than 1,220 tons of hydrogen. It was possible to speed up refueling: Most of the time, it took fewer than 10 minutes to fill up a tank with on average 20 kilograms of hydrogen after one day of regular operation.

The hydrogen filling stations had an average availability of 97 percent. The lowest value at a location was slightly above 94 percent and the best was at 99.8 percent. The target of the project was 98 percent at each location. These values are a considerable improvement over the ones of the previous project, HyFLEET:CUTE (see HZwei issue from January 2010), when mean availability was at 90 percent and the lowest value was 61 percent.

As in previous projects, more than half of the downtime could be attributed to problems with the hydrogen compressors. Their impact varied throughout the cities taking part in CHIC: One location, which received its hydrogen supply in 500-bar high-pressure tanks from an external source, did not require a compressor and could avoid difficulties altogether. In other cities, there was downtime despite redundancies in place, meaning although two compressors were used at the same time. One reason was the contamination of hydrogen in the compressor and the subsequent components (partly even the bus tanks), which led to downtime for cleaning.

Fuel cell buses

The vehicles racked up more than 9.3 million kilometers or around 5.8 million miles. Their efficiency was notably greater than in the last generation, for example, because of the hybrid design. The 12-meter buses used 26 percent less energy than comparable diesel models. Whereas the 12-meter CHIC fuel cell buses required on average 9 kilograms of H_2 on 100 kilometers or 62 miles (300 kWh/100 km), the vehicles employed during HyFLEET:CUTE had needed more than twice as much with around 18 kilograms.

Mean availability was at about 70 percent, missing the 85 percent mark by a pretty wide margin. A variety of components caused difficulties during operation, but the fuel cell only played a minor part in it. Additionally, the on-site maintenance and repair crews had not always been sufficiently trained from the beginning and were not familiar enough with the properties of hybrid and fully electric vehicles. Another problem – which impacted all manufacturers – was the inadequate supply chain for spare parts.

The challenge of spare part supply

Overall, the vehicles and filling stations have successfully mastered the test stage. But if there was downtime, repairs took longer than expected, as replacement required special components for which demand has yet to pick up and which suppliers often have not in stock. A few examples are the DC-to-DC converters and the valves in buses, filling stations and compressor heads, and the H_2 sensors. Sometimes, there was only one manufacturer available and this one was based outside Europe no less, which caused further delays because of customs checks, etc. All in all, the supply chains for essential components are still insufficient.

As with vehicles and filling stations (without cars no filling station and without a filling station, no cars), the situation may lead to the proverbial chicken-and-egg dilemma: Long waiting times for spare parts will cause delays in introducing new technology to the market, and low demand means that production and availability will not pick up.

Sustainability

A sustainability analysis has shown that the 12-meter fuel cell buses make it possible to reduce CO_2 emissions by 85 percent compared to diesel units during their entire life cycle (manufacturing, operation incl. H_2 generation / supply, maintenance and recycling). To achieve this degree of efficiency, it is essential that the hydrogen is generated entirely based on renewable sources.

Studies estimate the direct life cycle costs of a fuel cell bus to remain above the ones for a comparable diesel version even in 2030 [2, 3]. However, the use of a diesel bus is associated with indirect health costs because of the emitted pollutants. Considering those, both vehicle types are at about the same cost per kilometer based on an estimate that was part of the sustainability analysis. The indirect costs, however, will be borne by all of society and not only by the bus company or its passengers.

Outlook

CHIC has shown the feasibility of fuel cell hybrid buses for transit services and the suitability of the current generation of hydrogen filling stations. The barriers to the commercial viability of vehicles and filling stations have been identified and measures are being taken to remove them. This offers the opportunity of zero-emission public transportation on the road.

The CHIC buses are planned to remain in use during a new project called JIVE or “Joint Initiative for Hydrogen Vehicles across Europe” (see Diesel Exit – Global Advance of Electric Buses), which was launched in January 2017. Additionally, it will put more than100 new vehicles on the road, 50 of them in Germany. A joint purchase strategy of the bus companies is thought to contribute to decreasing the cost per vehicle further. A bid invitation for another project of similar size is expected in early 2017 too.

CHIC conference in London, © EE/CTE

Zero Emission Bus Conference

The conference provided indications of how the future of the technology could again be not in Europe but in the east of Asia. A representative of Hyundai Motor Group unveiled 2020 plans to create a fleet of several hundred fuel cell buses in the region around Korea's capital Seoul alone. In comparison, some attendees were rather disappointed by the sometimes very cautious fuel cell-related announcements that European manufacturers made. At least, there was the showcase of a fuel cell double-decker prototype in front of the event location, London's City Hall.

Acknowledgements

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Diesel Exit – Global Advance of Electric Buses

Fuel cell bus in Bolzano, © STA

An increasing number of German cities follow the example of Hamburg and stipulate the use of only zero-emission buses in public transportation starting in 2020 – Berlin's senate among them. The transit authorities of the German state were instructed to purchase only buses without combustion engines from 2020 to ensure that the state government can meet federal and EU climate protection goals throughout the next decade.

Numerous transit authorities have shown interest in sustainable transportation, but the range of suitable product offerings has been somewhat limited. Berlin and Hamburg are now contemplating to create a purchasing association to prompt bus manufacturers to get more involved. If several transportation companies join forces and clearly state their requirements for low-emission vehicles, hopes are that demand will rise and unit prices fall.

In November 2014, five European bus manufacturers signed a corresponding memorandum of understanding, in which they announced the construction of between 500 and 1,000 fuel cell buses by 2020. Around 30 European cities and regions have expressed interest in their products. Back then, Hamburg's First Mayor Olaf Scholz said: "The expressed aim is to have fuel cell buses in regular use by the end of this decade and have them become economically viable in public transportation as well."

In Berlin, the situation doesn't look as promising: The buses that ran on hydrogen were decommissioned years ago, and the latest utilization figures on the four electric units driving passengers of line 204 between Zoo Station and South Cross were between 70 and 80 percent.

Düsseldorf's cleanup

Düsseldorf, however, intends to use vehicles such as hydrogen buses to exert more control over the city's pollution levels. The Social Democrats in the city government are planning to have ten fuel cell buses on the road by 2018 – like the pioneers from Hamburg and their Innovation Line 106 (see HZwei issue from January 2015). In 2020 and beyond, only electric buses are to be purchased. The reason for the initiative by the head of the city's Social Democratic Party, Andreas Rimkus, was that Rheinbahn had bought 80 diesel buses for EUR 18.5 million (EUR 231,000 apiece) in the Netherlands last fall, a move that prompted irritations in political circles.

Rimkus explained: "I believe that particularly vehicles with heavy city use, such as buses and commercial fleets, should be upgraded to receive zero-emission engines as soon as possible. Since Düsseldorf is one of several places which far exceed the threshold values for nitrous gases, I call for Rheinbahn to share in the available federal subsidy programs and advance toward zero-emission bus transport."

A question of costs

A fuel cell bus costs about twice or three times as much as its diesel equivalent. Rimkus: "Two years ago, a fuel cell bus still cost EUR 1.6 million; today, the figure is down to EUR 800,000." The target is EUR 300,000 to 350,000 for a 12-meter (39-foot) vehicle.

The battery-electric bus used in Berlin, the Urbino 12 electric by Solaris, costs around EUR 700,000, as it contains an induction charging system which is still being tested.

Demand on the rise

Another transport company intending to go "green" in bus operation, albeit from 2030, is Cologne's Regionalverkehr Köln. The four H_2 buses that have already been in use at RVK are planned to be complemented by another 16 with fuel cell hybrid technology by 2020. Similarly, the public utility in Münster aims to buy another two fuel cell vehicles this summer, in addition to the five it is using now and which have so far run up 22,000 kilometers (13,670 miles).

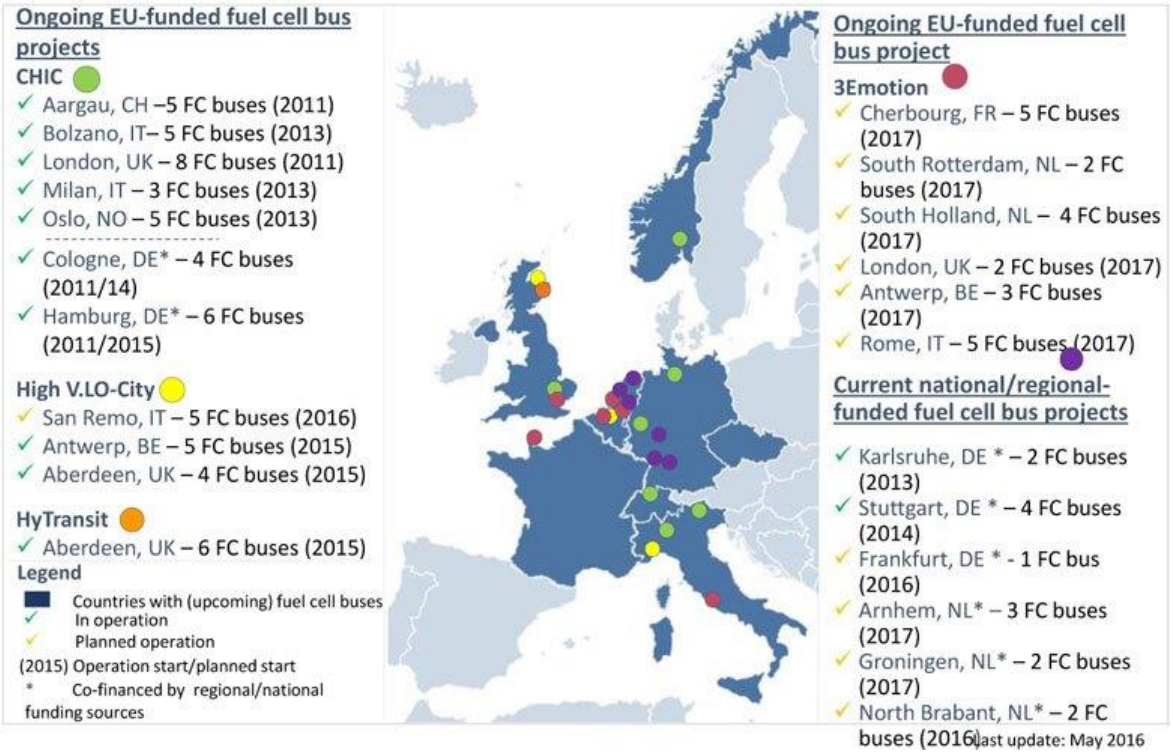
The transport companies of Mainz, Frankfurt and Wiesbaden also plan to use hydrogen buses to reduce pollution and noise levels, but are waiting on a response by the EU about funding support. Their plans would lead to the purchase of eleven fuel cell buses (four in Mainz, four in Wiesbaden and three in Frankfurt) and the construction of a hydrogen filling station by 2018 if Brussels approves. H2Bus Rhein-Main is part of EU project Jive, the Joint Initiative for Hydrogen Vehicles across Europe, in which several other regions take part as well.

Fuel cell buses in Europe

In late 2016, the mayor of London, Sadiq Khan, announced during the International Zero Emission Bus Conference and Summit (see Fuel Cell Buses Speed Ahead) that only emission-free models were to be selected from 2018 when buying single-decker buses for the inner city. And regarding the double-decker version, the acquisition of hybrid buses instead of diesel vehicles is planned for 2018 and beyond (see double-decker). London has long been a pioneer in this field: In early 2016, Transport for London signed a contract with Van Hool about the delivery of two hydrogen buses (type A330 with FCvelocity-HD7 module by Ballard).

Khan explained: *"*I want London to become a world leader in hydrogen and electric bus technology. I'm implementing hard-hitting measures to clean up London's toxic air and it's great that more cities are getting on board to phase out the procurement of pure diesel buses, which sends a clear signal that only the cleanest technologies are wanted in our cities*."* The mayor of Copenhagen, Frank Jensen, added: *"*In Copenhagen, all new buses will be based on zero-emission and low-noise technologies from 2019*."*

The governments of eleven big cities (Amsterdam, Cape Town, Copenhagen, Los Angeles, New York, San Francisco and others) responded to Khan's call and have decided to stop purchasing diesel-only buses by the end of 2020. Madrid, Mexico-City and Paris assured that they will remove any diesel version from their cities by 2025. All in all, the number of fuel cell buses in use Europe-wide is said to increase to around 300 to 400 in the next years. South Tyrol alone intends to buy ten to fifteen new hydrogen buses after CHIC has run out. The state government has already approved the EUR 8.5 million needed for the project.



EU-funded fuel cell bus projects

Activities abroad

Meanwhile, Japan is sparing no effort to prepare thoroughly for the 2020 Olympics. One hundred hydrogen-driven buses are thought to be running in Tokyo by then. The first two will reportedly be in use in early 2017. The buses, which are said to have the same fuel cell system as the Toyota Mirai, store fuel in ten high-pressure tanks adding up to 600 liters.

The situation is different in Switzerland, where transportation provider PostAuto is ending its fuel cell bus operation after a five-year test stage (see Fuel Cell Buses Speed Ahead). PostAuto has used five units from Mercedes-Benz in public transport since 2011, racking up 1.2 million kilometers or 745,645 miles in total. In 2013, the project received the Watt d'Or prize from the Swiss Federal Office of Energy in the category Energy-Efficient Mobility. The last of the five vehicles, however, is said to be decommissioned early this year.

"Currently, manufacturers lack the incentive to put fuel cell buses on the market."

Heinrich Klingenberg, hySOLUTIONS, during the NIP conference

The Tesla Among Trucks

On Dec. 1, 2016, Nikola Motor Company presented its first hydrogen truck. Founder and CEO Trevor Milton unveiled the Nikola One in front of 600 invited guests at the company's headquarters in Salt Lake City, Utah. The truck is a concept study of an electric semi equipped with a large lithium-ion battery pack and a fuel cell.

The hydrogen vehicle shown by NMC, of which the American business was convinced it could mark the beginning of the "end of diesel engines," is reported to have an output of 735 kW or 1,000 hp. Its range is said to be around 1,500 kilometers, whereas refueling would take 15 minutes only. The battery pack of the truck consists of 32,000 individual cells and is reportedly able to store 320 kWh to drive an 800-volt AC engine. Further details about tank size, the type of fuel cell used or development partners have not been made available yet. The only other two things that were revealed was the fuel cell's output – 300 kW – and the fact that it charges the battery during the ride.

Milton said: "Nikola will build a world-class advanced manufacturing facility, which will create thousands of new jobs." Where the factory will be built will reportedly be announced in the first half of 2017. Sales as well as repair and maintenance services are said to rest on the shoulders of business partner Ryder System, which boasts more than 800 service locations across North America.

NMC also presented utility vehicle Nikola Zero, which has a 107 kWh battery pack and provides a range of 500 kilometers or almost 311 miles. Milton was convinced that "our lithium battery packs, which should be available next year, are more energy dense and weigh less than any vehicle production pack in the world. To give you an

idea, we believe our pack could propel a BMW i3 over 400 miles on a single charge and still fit within the i3 chassis."

Unveiling event, © Nikola

Similarities to Tesla

What's interesting about all of this is that there seem to be some similarities between electric truck manufacturer Nikola and electric car producer Tesla. First, both businesses use part of the name of electric engineer and inventor Nikola Tesla. Second, both Elon Musk and Trevor Milton have built a reputation for being innovative and dynamic visionaries. And they both appeal to customers by advertising free electricity or hydrogen. For example, one of the announcements Milton made was that Nikola would set up 300 hydrogen filling stations from 2018 in the United States and Canada ("*Nikola* will have the largest *hydrogen network* in the world."). It is said that – similar to Tesla's Model 3 – there have already been numerous reservations for the Nikola One. The contract value is reported to be USD 3 billion, although no price has been set for the H_2 truck (advance payment: USD 1,500). Manufacturing, however, seems to start no earlier than 2020 anyway.

H&FC Letter Archived

The collected works of Peter Hoffmann, the editor of The Hydrogen & Fuel Cell Letter, have now been preserved for posterity and are available as part of the Hydrogen and Fuel Cell Archives. This database contains all newsletters that Hoffmann published jointly with his wife, Sarah, from 1986 up till his untimely death in April 2014 as well as the information gathered by Fuel Cells 2000 and the newsletters by the International Association for Hydrogen Energy. The archives were made possible by the University of Tennessee, represented through Matthew M. Mench, and the Richard Lounsbery Foundation, which supported the project financially.

http://hfcarchive.org

e4ships – Heavy Fuel Oil Is a Thing of the Past

The transportation sector is moving forward again: After a years-long debate and much reporting about fuel cell use in passenger cars, a breath of new life has been given to maritime, railroad and aviation applications. Especially many of the stakeholders in the maritime industry see great market potential for fuel cell units, as environmental regulations are gradually putting pressure on the oft-used diesel technology.

“We need a transformation.” These were the words used by Winfried Hermann, transportation minister of the state of Baden-Württemberg, during the WES conference to stress that there needs to be a change in both the energy and the transportation sector – not only on the road, but across all segments.

The first fuel cell cars and buses have already made it onto the roads. The situation is much different in aviation. Hydrogen used by airlines in big passenger machines is likely to remain just an idea in people’s heads for a long time to come; attempts to turn zero-emission, fuel cell air travel into a reality have so far been restricted to regional projects (see Fuel Cell Passenger Aircraft for Medium-Distance Flights). The attempts in the railroad industry are similarly timid, although big corporations have at least publicly announced their unwavering commitment to demonstration projects after years of stagnation (e.g. in Hesse and Lower Saxony; see Hydrogenics, Alstom and H2 Trains).

Meagre results after seven years

The shipbuilding industry has seen a much firmer pledge to fuel cell systems over past years, but accomplishments have been equally few. The NIP showcase project e4ships that was to test fuel cells in the maritime industry has run for seven years. However, veritable attempts at sea or even meaningful results on which to base further research have yet to materialize.

The start of e4ships was July 1, 2009 (see HZwei issue from October 2009) on the steamer AIDAluna in Rostock-Warnemünde, Germany. Back then, it was the third showcase project after the Clean Energy Partnership and Callux under the auspices of the National Innovation Program Hydrogen and Fuel Cells Technology (NIP 1.0), with 22 project partners. Then as now, Bernard Meyer, managing director of Meyer Werft, is telling the story of his great ancestor and how he successfully managed the transition from wood to iron ships (see box).

In those days, an opponent of the transition from wood to metal grabbed an iron bar, threw it into the water and asked in an angry voice: “And that’s what you want to build ships with?” Meyer’s great grandson can at least now provide the answer to that provocative question, as Meyer Werft is the only one of 20 shipyards in Papenburg to have existed from 1920 until today.

Bernard Meyer

What is left of four subprojects

Three of the previously four subprojects remain. HyFerry, which was to ensure propulsion of a North Sea ferry by fuel cell and to which almost half (EUR 24.9 million) of the e4ships budget had been allocated, was terminated early. NOW’s chair, Klaus Bonhoff, explained that the decision to discontinue the program was made by the industry. The reason for the early end was that one participating company went bankrupt – for “non-technical reasons,” he stressed.

The other subprojects are still running. One of them, Toplaterne, is primarily focused on the definition and specification of rules and standards and has a budget of EUR 1.2 million (48 percent funding rate).

Enormous delays

Pa-X-ell (initial budget: EUR 13.8 million; increased to EUR 24 million) deals with the onboard energy supply of cruise ships. The aim is to integrate about half a dozen of these methanol-run units in a decentralized way into a passenger ship, so that the different fire zones can be supplied separately with clean power and heat – even at the port, to reduce not only emissions, but also dockage fees.

The first stage of Pa-X-ell was scheduled to end in 2012 and include the development and testing of a 500 kW fuel cell module under real-life conditions. This objective has, in fact, never been achieved until today, even if it was said at the final conference in Hamburg (see below): “The use of fuel cells on ships has been successfully demonstrated.” The main problem was that the Tognum Group (formerly, MTU Friedrichshafen), which had intended to provide their HotModules as central energy supply units for the project, had left the fuel cell industry at the end of 2010. FuelCell Energy did acquire some of the company’s know-how in 2012, but the module based on molten carbonate was no longer available. The entire e4ships strategy had to be revised.

Consequently, the output target was lowered to a significant extent and Serenergy became the new partner in the consortium. Several 5 kW_{el} high-temperature PEM fuel cells manufactured by the Danish company were connected to build a 30 kW prototype and test it in stationary use on land. Meyer: “A demonstration system set up a while ago on the premises of Meyer Werft has been used for initial tests of reliability and aptitude regarding maritime applications. The first test at sea was conducted with a 90 kW system installed in addition to conventional energy supply on board the ferry MS Mariella, which runs between cities in Scandinavia.” Its installation took place in summer last year.

In subproject SchIBZ, which had EUR 10.5 million allocated for testing fuel cell systems on yachts, but will ultimately have EUR 13.7 million available, a solid oxide fuel cell by sunfire was chosen as an alternative to the HotModule. The project team had originally favored an SOFC module by Topsoe Fuel Cell, but the Danish business owned by the Topsoe Group was closed down in 2014. Keno Leites, project manager at ThyssenKrupp Marine Systems, explained: “The focus is on developing a diesel-run, hybrid fuel cell system with a scalable output of 100 to 500 kW for seafaring vessels. To see how well the system works in practice, we built a 50 kW container unit that is being tested on the MS Forester to supply energy to the onboard system under real operating conditions at sea. The fuel used is low-sulfur diesel. The medium-term goal is to use natural gas as an alternative energy source.” When asked by H2-international, however, Leites acknowledged that there had been no “experiences made at sea” with the technology at the time of the conference (see also HZwei issue from October 2014).

Final conference in Hamburg

The consortium members, whose number has meanwhile increased to 18, informed about the activities and accomplishments of the past seven years on Sept. 7, 2016, in Hamburg. At the same time the International Maritime Trade Fair took place, 80 attendees met for the closing conference of the project. They deemed the result a

positive one, although the aforementioned delays had meant that fewer targets could be met than originally planned during the program run (April 1, 2009, through Dec. 31, 2016).

An important success, however, may have been achieved in the area of regulations. For example, there was an information exchange and a close collaboration with the U.N. International Maritime Organization. Reinhard Lüken, managing director of the German Shipbuilding and Ocean Industries Association, explained: “Shipbuilding and transport are highly regulated around the globe. The results of e4ships have now been incorporated successfully into the relevant IMO instruments. This creates a cross-national foundation for the commercial use of fuel cells.”

Switch to LNG

Ship owners, however, are much more focused on liquid natural gas than on hydrogen. The Maritime Environment division of the IMO decided on Oct. 28, 2016, to ban fuels containing more than 0.5 percent sulfur globally from 2020. At high sea, ship operators have so far been allowed to burn sources containing 3.5 percent of sulfur. The permitted maximum is even lower regarding the North and Baltic Sea: Since the start of 2015, the sulfur content has had to be 0.1 percent or below. Faced with IMO’s decision, Ralf Nagel from the German Shipowners’ Association said to Süddeutsche Zeitung: “This decision basically marks the end of today’s era of heavy fuel oil in maritime application. […] The new limit on sulfur content will advance the clean liquid gas LNG and alternative fuels in maritime propulsion.”

Fittingly, Meyer announced that his company “is building seven ships running on LNG.” He added: “Heavy fuel oil is a thing of the past.” State transportation minister Hermann had already pointed to the existing LNG terminal in Rotterdam during the World of Energy Solutions in early October 2016 and remarked that shipping companies would switch to liquid natural gas within the next thirty years, as it did not contain sulfur, which made for a cleaner combustion process.

Gerd-Michael Würsig, e4ships spokesperson, sees other potential alternatives for ship propulsion in methanol, low-flashpoint diesel and also hydrogen, although the latter would only be suitable for smaller ships, if at all.

The government’s bible

All parties agreed that e4ships should continue during NIP 2.0. Achim Wehrmann from the federal transportation ministry used the opportunity to state that “the coalition agreement is something like the government’s bible.” In light of the general election this fall, it was important to incorporate the issue of “maritime fuel cells” into the next agreement as well.

“In contrast to battery cells, fuel cells give us the opportunity to become a manufacturing force that is to be reckoned with.”

Klaus Bonhoff

Example of a Fuel Cell Heating Consultation

© Elcore

Although numerous critics had hardly thought it possible anymore because of years-long delays, fuel cell heating systems have entered the market. Several manufacturers of heating appliances have added power and heat units running on natural gas to their portfolio. One of them is Thermondo, a young heating installation company operating across Germany, which has been offering condensing boilers since last year.

Nowadays, an increasing number of people get their information online – even about the heating industry. One of the first (German) hits in the most common search engines will be Thermondo: The startup founded in 2012 in Berlin employs over 100 master tradesmen and has had collaborations with Viessmann, SOLIDpower and elcore (see: Device list in H2-international issue from November 2016).

Thermondo's employees will offer prospects systems based on their individual needs. For example, Galileo 1000 N by Viessmann has been designed for a comparatively high gas consumption, which makes it a more apt choice for two-family or multi-family properties. Conversely, Vitovalor 300-P is a better match for energy requirements between 9,000 and 25,000 kWh per year and is priced at EUR 19,500 (net; minus EUR 9,300 in subsidies) in online stores. It is relatively big and requires a room height of 2.25 meters or 7.38 feet. A much smaller and model better suited for single-family homes is elcore 2400 (see figure). The net price of EUR 25,000 includes a

peak load boiler, buffer storage and the installation work. After subtracting various subsidy amounts, you get to a total cost of around EUR 14,000.

Compared to condensing boilers (around EUR 8,000), that is quite a lot of money to pay, but a Thermondo consultant said that the investment would amortize after around 15 years, as operating costs were lower. Customers would save more than EUR 2,000 annually starting with the sixteenth year, since the efficient on-site generation of cheap power trumped having to buy it from utilities.

Increasing digitization

However, it is not quite as simple as it sounds: Criticism about the new sales channel has been mounting in recent months, as communication with customers has increasingly shifted toward online stores. When Vaillant created its new heizungonline platform, the Central Association of Sanitation, Heating and Air Conditioning, ZVSHK, railed against the direct sale to consumers, which had been contrary to the way things were done in the industry. It accused Vaillant of a one-sided decision to terminate the market partnership with the tradesmen. During the member assembly in Berlin, it passed a resolution that was approved by (all) 17 state associations and called on Vaillant to return to its traditional ways.

Meanwhile, Vaillant is said to have devised the new strategy because tradesmen in the sanitary, heating and air conditioning business were no longer surviving as individual enterprises in an increasingly digitized world. This statement, however, only exacerbated the situation. Elmar Esser, formerly managing director of ZVSHK, told the German Handwerk Magazin: “The biggest danger is in the role of the trade being reduced to installation work only.” The tradesman would become a “human screwdriver for hire.”

Wary installers

Würzburg-based installation company DESD caused a further uproar on the market by accusing Thermondo of having installed fuel cell heating systems in an unprofessional or even chaotic manner; sometimes, the customer had even ended up with a flawed installation. In fall 2016, Si Magazine quoted from a DESD email: “We sold the power-generating heaters allegedly distributed by Thermondo and only contracted the company with their installation.” Furthermore, Thermondo confirmed that it “had already entered into a collaboration agreement with DESD about the sale of fuel cell heating systems in November of 2015.” But this collaboration had been terminated by the Berlin-based business in March 2016. Additionally, the services that were part of the agreement did not only consist of installation work, but also included the supply of systems and materials as well as part of project management. And whereas DESD said that Thermondo had made mistakes during installation, the accused responded by saying that DESD’s consultations were below standard.

Thermondo put out a statement to clarify that the consultancy contract was not with DESD GmbH & Co. KG but DESD Vertriebs GmbH. In turn, Karolina Balthasar from DESD said to H2-international: “I was also managing partner and managing director of DESD GmbH & Co. KG until the end of March [2016; editor’s note]. I sold the business at the end of this March [in 2016; editor’s note] and handed over

management of the company to the new owner." Balthasar, a designer, who states in her XING profile that she had studied art and art history at the University of Zielona Gorá, founded DESD Vertriebs GmbH in March 2016. She confirmed to H2-international that she had filed charges of willful misrepresentation, fraud and attempted large-scale subsidy fraud against two Thermondo managing directors on Nov. 25, 2016. She explained: "For one, Thermondo is touting a sale of around 160 fuel cell systems in the first half of 2016. This figure is false, because they were sold by us, DESD, and Hamburg-based Amnis Energie, in which I have stake too."

Manfred Stefener, managing director of elcore, which manufactured some of the devices, told H2-international: "DESD sold devices for us until the end of 2015 – not a very larger number, maybe 15. The cooperation was then terminated." He also confirmed that Thermondo and DESD had meanwhile gone their separate ways, probably because "the guy from DESD" felt he was treated unfairly. Stefener said about the collaboration with the Berlin-based business: "In our view, Thermondo is doing a good a job – far above average." Their employees had gathered enough experiences after having done numerous installations, so that "you won't have to worry." Viessmann likewise told H2-international that there were no issues with Thermondo, which had installed more than a hundred fuel cell devices on behalf of the family business.

Some in the heating industry, however, harshly criticized DESD and Karolina and her husband, Wolfgang Balthasar. Philipp Pausder, one of the managing directors of Thermondo, made the following statement to Si: "The charges that Karolina Balthasar has filed include claims without any basis in fact. Considering the baselessness of her charges, we choose not to comment on the matter."

Thermondo

Founded four years ago by Philipp Pausder, Florian Tetzlaff and Kristofer Fichtner and supported by venture capitalist Global Founders Capital as well as E.ON, Thermondo terms itself the "market leader in heating system replacements for single- and two-family homes with 300 staff" and has advertised the fact that it received the TÜV SÜD's Customer Satisfaction Award for the best customer ratings.

Power-to-Gas for Homeowners

Demonstration system with switchboard, © Exytron

Reusing carbon dioxide over and again in a closed process would be an optimal solution for protecting our environment. A demonstration system doing exactly what is needed has been running in one of Exytron's showrooms at Rostock Port since September 2015. About 50 meters or 164 feet away from the wharf at the Unterwarnow, the river flowing through the old part of this Hanseatic city, you will find the headquarters of a young business that won the Start-up GreenTec Award at the end of April last year. But what was more important than the EUR 10,000 endowment which came with the prize was the attention Exytron received – for itself and the catalytic process it developed in-house, the patented SmartEnergyTechnology.

The first commercial power-to-gas system by Exytron is ready and waiting to be delivered to Alzey. The small city has a population of around 18,000 and is located 50 kilometers (31 miles) to the northwest of Mannheim, Germany. The building permit for the row house complex in the state of Rhineland-Palatinate had already been

submitted in November 2015. Plans are to supply partially off-grid and almost emission-free energy to all in all 37 residential units. That was the clear-cut requirement set by the principal contractor, Deutsche Reihenhaus. The temporary delay is the result of an improper inspection of the former Deutsche Bahn premises, which will make an environmental site assessment necessary. In the meantime, the winter is causing another months-long postponement of civil engineering work. “Our energy supply system has been ready for delivery since 2016; we’re basically waiting for the go-ahead,” said Klaus Schirmer, sales and project manager of 2013-founded Exytron.

Based on current planning, the project is scheduled for completion in spring 2017. By then, the 37 residential units are thought to be supplied by eco-power as well as heat energy through a district heating grid. However, the focus of this pilot project has not been on economic feasibility. The main issue was CO_2-neutral living. An Exytron simulation showed a 99.3 percent reduction in carbon dioxide emissions compared to similar residential developments. Almost emission-free living seems possible.

The heart of the supply system is its mechanical room, which has the size of around three-and-a-half car garages. It contains the electrolyzer, methane reformers, condensing boilers, CHP plant, hot water storage and central control unit. This room will supply the houses with electricity and with heat from a district heating system. Remote monitoring makes it possible to check whether everything is running smoothly.

The alkaline electrolyzer has a capacity of 40 kilowatts. It primarily uses power sourced from a PV system (125 kW). Additionally, eco-friendly electricity is bought off the grid, as the solar energy is not enough to provide heat and power to the entire residential complex. This makes the project partially grid-independent.

Designated a biogas system

“Right now, we are taking advantage of the regulations in place, which term our methanization system a biogas plant,” Schirmer said. Having their plant designated a biogas production facility means they benefit from cheaper grid power for electrolysis and methanization, as there will be no electricity tax or grid fees added. This reduces power prices to between 10 and 11 euro cents.

The system’s USP is its CO_2-free output. The CHP part and the gas boiler have been modified to separate the environmentally harmful gas from the other exhaust fumes. Afterward, the captured carbon dioxide can be used to produce methane by using a catalyst. “The recovery is what differentiates this plant from common methanization systems. It’s the reason you can use the power-to-gas plant at any location, meaning decentralized, and provide businesses with heat directly at their facilities,” the project manager said.

Waste heat recovery improves system performance

In contrast to conventional power-to-gas processes, the focus is not on the production and storage of methane. The system that Exytron designed prioritizes heat transmission through methane synthesis, and most of the energy is used on-

site. “It increases the system’s overall efficiency compared to centralized power-to-gas systems, which don’t use this heat or only a small part of it,” Schirmer said.

The process was developed in close collaboration with the Rostock-based Leibniz Institute for Catalysis, one of the biggest publicly funded organizations to research catalysis for industrial purposes in Europe. What’s special about this concept is the focus on thermal energy created through converting hydrogen into methane. The exothermic reaction produces the best results between 300 and 400 °C and the research team of Professor Matthias Beller has optimized the catalytic process to produce as much usable heat as possible – at least, enough to heat a building.

“We were successful in expanding the heat range. Catalysis is done in an environment in which we can make efficient use of the generated heat,” Andreas Martin summed up the research findings. The project participants tested a variety of catalysts, pipe sizes and carrier materials (see box). The aim was to use a “packed bed” to have heat released across the largest possible surface, i.e., to avoid heat being concentrated in a certain “hot spot” only.

How to get to 80 percent efficiency

The production output of hydrogen and synthetic natural gas fluctuates because the control unit provides different fuel quantities based on individual calculations of current and forecast demand. The system can create up to 10 Nm^3 of hydrogen and 2.5 Nm^3 of synthesis gas per hour.

Excess eco-power will first be used to split water into hydrogen and oxygen inside the electrolyzer. With the help of a catalyst specifically designed for this task by the Rostock-based Leibniz Institute, hydrogen will be directly converted into methane by adding CO_2 (Sabatier reaction) stored in a natural gas tank. If required, the methane

can be burned and the subsequently released CO_2 fed again into the closed process and reused for methanization. The modified combustion process does not release any nitrous gases, which could harm the environment.

“Our plant has no steady system or utilization efficiency; both will fluctuate based on the mode of operation, consumption and energy sources,” Schirmer explained. Simulations show efficiency values ranging between 70 and 80 percent. They could still be improved by increasing the heat transfer from pumps and compressors, but that would not make much sense economically right now, he explained, as 80 percent efficiency was enough. In a decentralized system, the overall design of energy supply was more important than efficiency, he said.

There is still more R&D work to be done before intelligent controls can be used for the entire system, something that is still a novelty and technically challenging. It requires the consideration of many parameters (energy supply, storage and energy input). Differing consumption values, weather patterns and forecast figures play their part too. Exytron intends to learn from the pilot project in Alzey what it can to enhance the productivity and manageability of the system.

No added costs

This all will be of little concern to the users living in the residential units. They pay no extra charges, but – as per Schirmer – less than the cheapest price for electricity they can find on online portal Verivox. Heat is said to cost around EUR 1.30 per square meter and month. After all, power-to-gas systems for homeowners must remain economically feasible once subsidies run out. Schirmer knows that: “It is what we strive for.” He added that the technology’s possible scaling in quantity and size could already reveal a notable cost-cutting potential throughout the next projects.

“The system is technologically mature,” Schirmer said. “The biggest challenges domestically are the many regulations governing energy supply. Right now, we are primarily planning projects for larger residential units and apartment complexes or blocks.” In the German state of Bavaria, negotiations are taking place about building a power plant equipped with Exytron’s technology. Implementing the project would create the world’s biggest power-to-gas system.

Schirmer said that businesses from many industries had shown interest in the new technology: From lodgings to owners of single-family homes and multi-family buildings who want more grid independence and customers who have no or only limited access to the grid, such as in remote areas in Africa and Central Asia – or on certain islands, where power is still being produced by diesel generators. Even across Germany, there is still much untapped potential: As many as 19.3 percent of the around 40 million households use natural gas for heating.

The EUR 2.4 million project Chemical Energy Storage for Decentralized Supply was subsidized by the economy ministry of the German state of Mecklenburg-Vorpommern through the European Regional Development Fund.

Author: Niels Hendrik Petersen

H2FC Goes Overseas

This year will be the twenty-third in the history of the joint booth Hydrogen + Fuel Cells + Batteries at the Hannover trade show (April 24 through 28). And since the industry meeting has proved to be a good networking platform, Tobias Renz FAIR and Deutsche Messe will also organize a similar booth at the American trade show this year. The Hydrogen + Fuel Cells North America will take place from Sept. 10 to 13 during the Solar Power International in the Mandalay Bay Convention Center in Las Vegas, Nevada.

Renz told H2-international: “We believe it’s about time for hydrogen and fuel cells to enter the American energy debate at a large, established trade show. We think that with the Solar Power International and the Energy Storage International, we have found the perfect environment for advertising the global H_2 and fuel cell industry in the United States.” With 650 exhibitors and 18,000 attendees, SPI is said to be the largest solar energy trade show in North America. Benjamin Low, head of the Energy division at Deutsche Messe, explained: “Hydrogen + Fuel Cells NORTH AMERICA is therefore a perfect fit for Solar Power International. The respective technologies covered by the shows are closely interrelated and growing in importance.” It is the first energy event for Deutsche Messe in the United States.

Asked what drives him to expand the reach of the industry, Renz said: “There are only two large H_2 and fuel cell trade shows globally, one in Tokyo and one in Hanover.” From time to time, a conference and an accompanying exhibition would show up in the United States or Canada, but these were typically events for H_2 and fuel cell specialists only. He was looking for events dealing with renewable energy and storage in general.

www.h2fc-fair.com/usa/

FC Expo Now in Osaka Too

From March 1 through 3, 2017, the FC Expo will again be held in Tokyo, Japan. This year will be the ninth time that Peter Sauber Agentur Messen und Kongresse organizes a German pavilion at the International Hydrogen and Fuel Cell Expo. Bearing the slogan "Hydrogen and fuel cells made in Germany," the pavilion will offer German businesses and institutions a joint booth of around 100 square meters (1,076 square feet) for networking opportunities in the Asian country. According to Silke Frank, official representative of Peter Sauber, the pavilion has been "the biggest of this trade show for years." The FC Expo is organized each year by Reed Exhibitions on the premises of the Tokyo Big Sight. Reed will hold the second edition of another, newer FC Expo in the Japanese city of Osaka, 500 kilometers or 311 miles southwest of Tokyo, from Sept. 20 through 22.

www.fcexpo.jp

Electric Truck Only in 2020

Even at the IAA Commercial Vehicles from Sept. 22 to 29, 2016, electric transportation was talked about – albeit not very much. For example, Volkswagen presented his e-Crafter concept study, which even EU Commissioner Günther Oettinger and federal transportation minister Alexander Dobrindt paid a visit during their trade show tour. Delivery of the first units of this electric transporter with a top speed of 80 kph (50 mph) is expected for this year.

In Hanover, Daimler presented – or rather, "unveiled" for the first time –a solution for a city's short-radius distribution: Urban e-Truck. However, the electric vehicle weighing up to 26 tons will be sold only at the beginning of the next decade. But another Daimler project unveiled at the trade show, the third generation of the Fuso eCanter, is said to be available for purchase over the coming months. Wolfgang Bernhard, who had been Daimler Board member and head of the Trucks & Buses division until he was placed on leave in February 2017, explained: "So far, manufacturers have made very limited use of electric engines in trucks. Meanwhile, costs, performance and charging times have changed so rapidly that we see a turnaround in short-radius distribution. We believe it is very likely that electric engines will be available on the heavy-duty distribution market at the start of the next decade."

Hyundai's H350 Fuel Cell Concept, Source: © Hyundai

When it comes to hydrogen, Hyundai was for the most part the only carmaker on the entire tradeshow premises to present a new vehicle based on the technology: The H350 Fuel Cell Concept is a fuel cell bus in the gross vehicle weight category of up to 3.5 tons. Its high-pressure tanks hold 175 liters of hydrogen (7 kilograms) – enough for up to 422 kilometers (262 miles) on the road. Its top speed is 150 kph or 93 mph.

EQ – New Daimler Brand for Electric Vehicles

The Paris Motor Show seemingly went all-out electric: There hadn't been so many electric vehicles at one single trade show for a long time. From Oct. 1 to 16, 2016, Opel showcased its Ampera-e (500-kilometer or close to 311-mile range; priced at EUR 39,000), the "currently hottest rod from Germany," as car blogger Fabian Messner put it. Renault showed the Zoe with a large 41 kWh battery. And VW announced a battery storage unit for its e-Golf with an increased capacity.

Daimler announced in France that its electric vehicles will be sold under a new brand in the future: EQ. The name is said to stand for “electric intelligence” and, at the same time, make people think of the words “emotion” and “intelligence.” In marketing speak, this reads as follows: “EQ offers a comprehensive electric mobility ecosystem of products, services, technologies and innovations.” To be able to show attendees what this means for the Swabian-based company, the German carmaker presented its Generation EQ concept study in Paris. Ola Källenius, Daimler board member and head of the Mercedes-Benz Cars Marketing and Sales division, said: “The future belongs to the electric engine. […] The new brand combines our entire expertise in intelligent electric transportation under one roof.” The first mass-produced EQ targets the SUV segment and is said to be available this decade. When asked by H2-international, a Daimler spokesperson replied: “Our large fleet of plug-in hybrid vehicles and future models with fuel cell drive will, of course, be part of the electric transportation division of Mercedes-Benz and thus of EQ.”

DWV Chair Werner Diwald Tells His Side of the Story

Last year, the German Hydrogen and Fuel Cell Association celebrated its 20th anniversary. The occasion prompted the editor of H2-international, Sven Geitmann, to use the editorial of last year’s November issue to paint a picture of the association’s progress over the past two decades. To complete this picture, the chair of the DWV, Werner Diwald, recently sat down with H2-international for a short interview about the current state of affairs and the association’s plans for the future.

Diwald: I agree with one of the things you said in your editorial “Quo vadis DWV?”: The association has changed and will continue to do so. But I don’t concur with your assessment that we have strayed from our ideals or, as you put, from our “path.”

H2-international: Could you please elaborate?

Diwald: Gladly. DWV’s constitution reads: “The objectives of this Organization are: (A) to promote and prepare the widespread market introduction of hydrogen as an energy carrier mainly based on renewably sourced primary energy; (B) facilitate pathbreaking activities and coordination, such as when establishing a relevant regulatory framework; (C) contribute to an eco-friendly resolution of future energy

supply difficulties and the conservation of our natural resources; (D) support science, research and climate protection activities in this field."

Based on this constitution, the efforts by the DWV have had a significant impact on the ability of hydrogen technology to contribute to sustainable energy production. Our efforts, however, would have been in vain and not in line with the spirit of our constitution if we had not also called for a timely market introduction. This alone will allow us to achieve the objectives we set forth in our constitution and help us to find an eco-friendly solution to our energy problems and protect our natural resources.

H2-international: What exactly do you think are your tasks here?

Diwald: The focus and development of the energy industry is an issue that concerns everyone and requires politicians to act responsibly when designing a regulatory framework. It would be grossly negligent to leave development to market forces alone, considering the profit-focused strategy of private businesses and the subsequent risks to the overall economy, energy supply and the public health of future generations. By the way, all technologically advanced countries hold similar views and approach the issue accordingly.

Thus, it is essential that the representatives elected by the people direct the growth of the energy industry in a responsible manner while considering the interests of private businesses. The DWV believes its role is to make politicians aware of the benefits of

introducing hydrogen technologies to the energy market as soon as possible. Additionally, professional lobbying in a positive sense has nothing to do with, as you say in your editorial, paying “for the implementation of one’s own interests.” Rather, we believe it is our responsibility to provide political decision makers with the facts about hydrogen output and core functionality in the energy industry in 2050. It is our contribution to the success of the energy transformation.

H2-international: What, then, is your primary goal?

Diwald: Our aim is to establish hydrogen technologies in the energy industry, since we are firmly convinced that an efficient energy transformation will only be possible with hydrogen as the energy source. It’s not about managing a balancing act, but about steady progress in activities and years-long efforts to find an efficient and effective solution for meeting the objectives of the German Hydrogen and Fuel Cell Association. We are certain that this is what our members expect of us and that they will continue to accompany and support us in the times ahead.

Argument About P2G System in Grenzach-Wyhlen

There has been a steady rise in the number of power-to-gas plants in Germany. Systems at several dozen locations are now producing hydrogen based on eco-power. Despite some bureaucratic hurdles and technical complications that developers may face, planning and construction are typically uneventful processes. Not so in the German town of Grenzach-Wyhlen: There, the future neighbors of a planned power-to-gas system founded a citizens’ initiative to prevent it from being built.

Grenzach-Wyhlen is situated in the Lörrach district of the Rhine Valley, east of Basle, in the tri-border area of Switzerland, France and Germany. One highlight of the town of 14,000 is the Wyhlen hydropower plant set up in 1912, “Germany’s first hybrid renewable power plant.”

The operator of the system, EnergieDienst, intends to set up a 1 MW power-to-gas facility on 32 hectares (79 acres) of company premises in direct vicinity to the historical building and immediately next to a bird conservation area. Two of the objectives of this project are to test a 300 kW electrolyzer by McPhy and devise a guide for the efficient operation of P2G systems. The partners of the main project coordinator, the Center for Solar Energy and Hydrogen Research Baden-Württemberg, are the Institute of Engineering Thermodynamics of the German Aerospace Center, the Fraunhofer Institute for Solar Energy Systems and the DVGW research division of the Engler Bunte Institute at the Karlsruhe Institute of Technology.

EnergieDienst is owned by Energiedienst Holding, a Swiss-based business supplying eco-power, e.g., to private households under the NaturEnergie brand. Sixty-seven percent of this parent company is owned by EnBW.

Citizens debate

The project has faced much criticism over the past months: In mid-October 2016, residents founded an initiative that was initially called “BI gegen Chemie” or Citizens’ Initiative Against Chemical Pollution and directed “against the use of potentially highly dangerous technology in a residential area.” Michael Kempkes, spokesperson of the initiative, is especially worried about how close the chemical plant is planned to be built to the small settlement in which he lives and which directly borders the company premises. This settlement consists of ten houses with around 40 people living in them, of which “five to six” can be considered “core members of the initiative,” as Kempkes told Badische Zeitung in late October last year.

He explained to H2-international that his family’s home was fewer than 100 meters (328 feet) away from where the plant is to be built and that he fears the hydrogen could explode, since these kinds of incidents cannot be ruled out. Additionally, he indicated that he is worried about the property value of the plots that have so far offered a picturesque sight. He also was wary about the potential “strain on traffic through hazmat transports in Grenzach-Wyhlen.”

M. Kempkes on the balcony of his home, © Kempkes

Last but not least, he was not at all satisfied with the information policy of the future operator: “Our fears and concerns remain, since EnergieDienst does not seem to be an apt candidate for operating a chemical plant and because no one was able to fully answer the questions we had.” On the website set up by the citizens’ initiative – bi-wasserkraftwerk-am-altrhein.de – Kempkes summed up what he thought was the most important thing to take away from all of this: “We are typically for developing and testing new technologies, but this should be done at a suitable location.” The initiative had been unsuccessful in convincing EnergieDienst of the alternative site it suggested.

The foundation of the citizens’ initiative has now made the public aware of the entire problem. Since then, regional and national news outlets have reported about the deadlock, with headlines such as: “Hydrogen turns up the heat.” Despite the negative press, the city council decided on signing a building contract with EnergieDienst when the council members met on Oct. 25, 2016. Some of them, however, criticized EnergieDienst’s PR work: “There would have been no reason for the citizens’ initiative had ED informed residents earlier.” The project initiators expressed their utmost regret about the entire issue having “taken a wrong turn somewhere.”

Unsuccessful information event

The information event originally scheduled during the summer time took place shortly thereafter – when the building application had already been submitted. On Nov. 14, 2016, experts from the operating company, the TÜV, the manufacturer of the electrolyzer and Freiburg’s regional authority held a joint presentation with the coordinator to provide a variety of background information, which was met with great interest by the more than 100 attendees. When asked by Kempkes during the event, Irene Knauber, the project’s manager and board member of EnergieDienst Holding, acknowledged that the capacity of the system may be increased at a later date. Before that exchange, she had tried to alleviate the worries of residents by saying that the residential zone next to the plant was already well-protected by the existing buildings on the company premises. Friedrich Haas from planning office HaasEngineering, who had helped design the H_2 filling station in Freiburg, said as per Badische Zeitung: “The noise level won’t be high either. It will be six decibels below the limit of 45.”

The newspaper also reported that Kempkes had read to the audience a list of questions from which you could infer that “he had doubts about almost all of the statements made.” Furthermore: “Kempkes renewed his objections and said he got involved that much to prevent the plant from being built there.” Knauber, however, said: “We expect to be able to start construction early next year.”

Even if EnergieDienst considered the information event a success, the minds of citizen initiative members remain unchanged. Kempkes told H2-international: “Neither side is ready to approach the other.” There is ED, which put an extensive FAQ page online before the event and thinks it has done everything possible to shed light on the issues, and then there is the citizens’ initiative, which has meanwhile renamed itself Citizens’ Initiative on Hydropower Plant at Altrhein and had collected around 200 signature until the end of last November against the project. Particularly the way in

which ED is beating time is garnering “much ill will” among the initiative’s members. Currently, there doesn’t seem to be a solution that would satisfy all parties involved.

Mediation

Hardly any property owner wants to wake up one morning only to look out the window and see nothing more than industrial facilities, even if they are used for eco-friendly purposes. It is a phenomenon aptly described by the phrase “Not in my backyard.” In a situation like this, it seems as if one party reaped all the benefits pushing through a certain item on the agenda, whereas the other would have to expect things only getting worse because of it. It makes little sense when discussing the item in question to bombard each other with “facts.” Attempts at persuasion cannot be successful because if roles were reversed, both parties would simply trade places and opinions. These kinds of “fact-based” discussions can only lead to entrenched opinions. It would make more sense to try and work out an agreement despite contrary opinions, even if a consensus seems far-fetched at first. One possible solution could be to get a mediator involved.

Fuel Cell Passenger Aircraft for Medium-Distance Flights

Prof. Kallo presented HY4

Professor Josef Kallo has been working for years on realizing his dream: the use of zero-emission fuel cell aircraft in passenger transport. On Sept. 29, 2016, he came a huge step closer to his vision, when the first flight of a four-seat, propeller-driven and hydrogen-run airplane was completed successfully. During the World of Energy Solutions, Kallo talked about the flight, the technology used and presented “his” HY4 to all interested attendees.

Ten years ago, the German Aerospace Center (see Launch of Emission-Free Passenger Aircraft Hy4https://www.h2-international.com/2016/02/04/launch-of-emission-free-passenger-aircraft-hy4/) took the lead in developing small fuel cell-driven airplanes. Since then, Josef Kallo, coordinator of the Energy Systems Integration Group at the Institute of Engineering Thermodynamics, has been pursuing the goal of making air travel by fuel cell available to as many people as possible.

The mid-section of the Pipistrel aircraft houses a low-temperature PEM fuel cell (45 kW) by Hydrogenics. The tanks, which store up to eight kilograms of hydrogen gas, are located in the back of the two passenger cabins and supply enough energy for around 750 kilometers or 466 miles. A high-performance lithium battery – likewise installed behind the passenger sections – supplies additional power during peak loads (e.g., during start or descent). The fuel cell-battery combination provides the aircraft with an acceleration speed of up to 200 kph or 124 mph.

Energy recovery ups efficiency

Similar to electric cars on the road, the HY4 is to be the first aircraft to use energy recovery. This means that the propeller still turns in the same direction, but slows down the airplane to allow for the electric motor to generate power. The HY4 project manager believes that the overall highly efficient propulsion system is one the aircraft’s distinct advantages which make this way of travelling so attractive. Assuming a consumption of around 400 grams of hydrogen for each person on 100 kilometers or 62 miles, total fuel cost would be a mere four euros per person at current price levels.

Kallo, who is also head of the Institute for Energy Conversion and Storage at Ulm University, intends to test the technological platform over the coming years before the target will be upped to six or eight seats. He explained: “Recent studies on commercial aviation show that there are indeed feasible propulsion designs for regional air travel with up to 40 seats and a range of 700 kilometers or below, even though the technical challenges are significant. […] In our view, electric aircraft are particularly suited for air taxi use to improve the links between regional airports or between regional and large ones. In both cases, the airports may be one to two hundred kilometers apart.”

read more: www.h2-international.com

Events

- March 14th, 2017, **Hydrogen & Fuel Cells into the Mainstream**, The 13th International Hydrogen and Fuel Cell Conference #CCSHFC2017, NEC, Birmingham, United Kingdom, www.climate-change-solutions.co.uk
- March 14th to 16th, 2017, **Energy Storage Europe - IRES**, in Düsseldorf, Germany, www.energy-storage-online.com, www.eurosolar.de
- March 15th, 2017, **Power-to-X for Europe's Energy Transition**, at Messe Düsseldorf, Germany, www.otti.eu
- March 22nd to 26th, 2017, **eMOBILITY WORLD**, Friedrichshafen, Germany, www.e-mobility-world.de
- April 4th to 6th, 2017, **Electric & Hybrid Vehicle Technology Conference Europe**, in Sindelfingen, Germany, www.evtechexpo.eu/
- April 20th, 2017, **Klimamobility**, Fiera Bolzano, Italy, www.fierabolzano.it
- April 24th to 28th, 2017, **Hydrogen + Fuel Cells + Batteries Group Exhibit**, part of HANNOVER MESSE, in Hannover, Germany, www.h2fc-fair.com
- May 8th to 12th, 2017, **10th Energy Storage World Forum**, in Berlin, Germany, www.energystorageforum.com
- May 10th to 11th, 2017, **Electric Vehicles**, Berlin, Germany, www.idtechex.com
- May 31st to June 1st, 2017, **International Hydrogen and Fuel Cell Expo**, at Tokyo Big Sight, Japan, www.fcexpo.jp

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

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

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

System Integration

- **Areva GmbH**, Paul-Gossen-Str. 100, 91052 Erlangen, Germany, Contact: Mrs. Gemmer-Berkbilek, Phone +49-(0)9131-90095221, www.areva.de
- **Deutsche Zentrum für Luft- und Raumfahrt (DLR) / German Aerospace Center**, Institute of Engineering Thermodynamics Energy System Integration, Pfaffenwaldring 38-40, 70569 Stuttgart, Germany, Phone +49-(0)711-6862-672, Fax -747, www.dlr.de/tt, www.dlr.de/tt

Testing

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

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

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

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