



## H2-international – e-Journal

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## Fuel Cell Market: Transport Sector Is Growing Rapidly

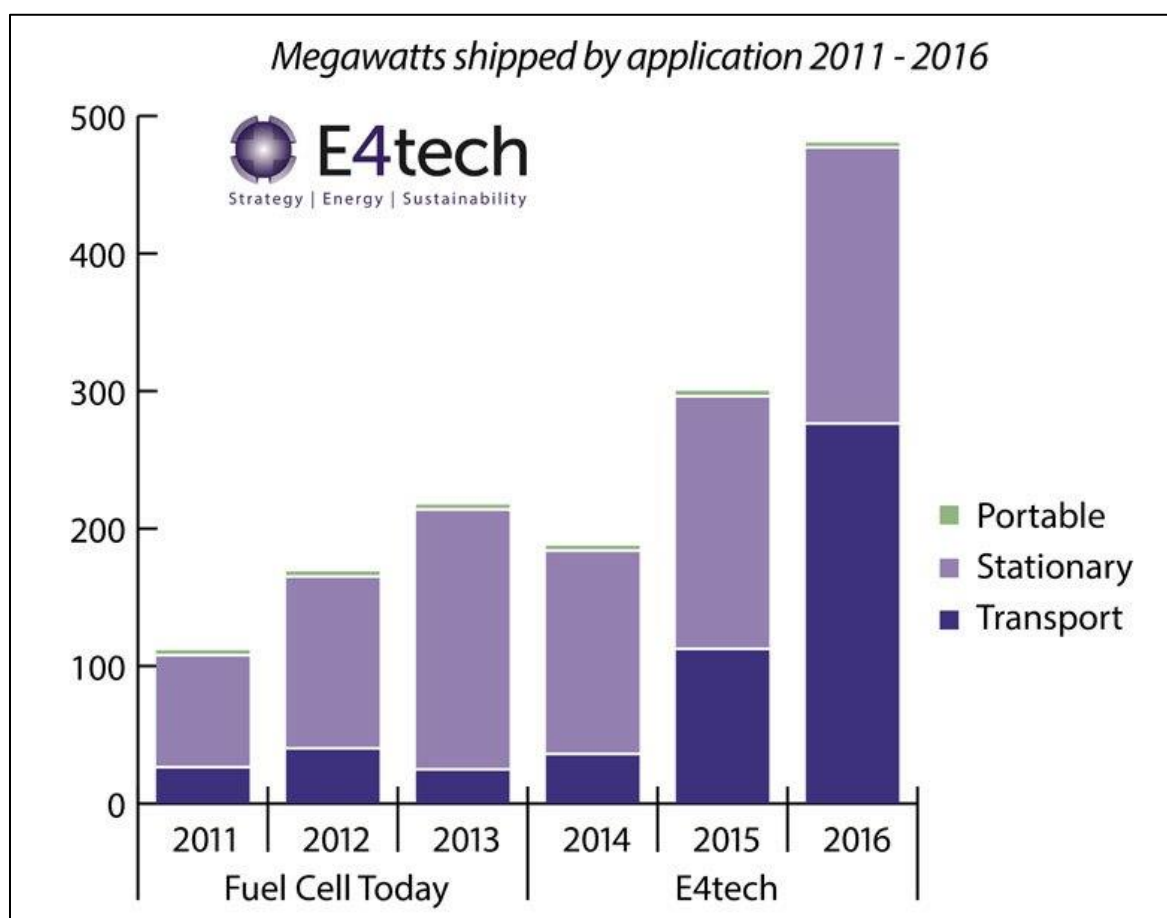
*Fuel Cell Industry Review by E4tech*

### Global Market

In November 2016, E4tech published data and analyses on the fuel cell industry in its latest edition of Fuel Cell Industry Review. Since 2014, it has contacted businesses in the industry and aggregated their shipment figures to capture the most recent market developments. The following sections will present some excerpts from this review and explain the changes to the preliminary 2016 figures published last November.

In many respects, 2016 was a successful year for the fuel cell industry. The fuel cell capacity shipped worldwide added up to around 480 MW, a considerably higher number than the 300 MW of 2015. Much of the industry's growth in recent years was a result of increasing production capacities and sales in the vehicle segment, which has – for the first time – climbed to the top spot on the ranking of the most important fuel cell markets of 2016. This trend will only get stronger in the coming years.

*Fig. 1: Capacity shipped per year, by type of application from 2011 through 2016 (in megawatts)*



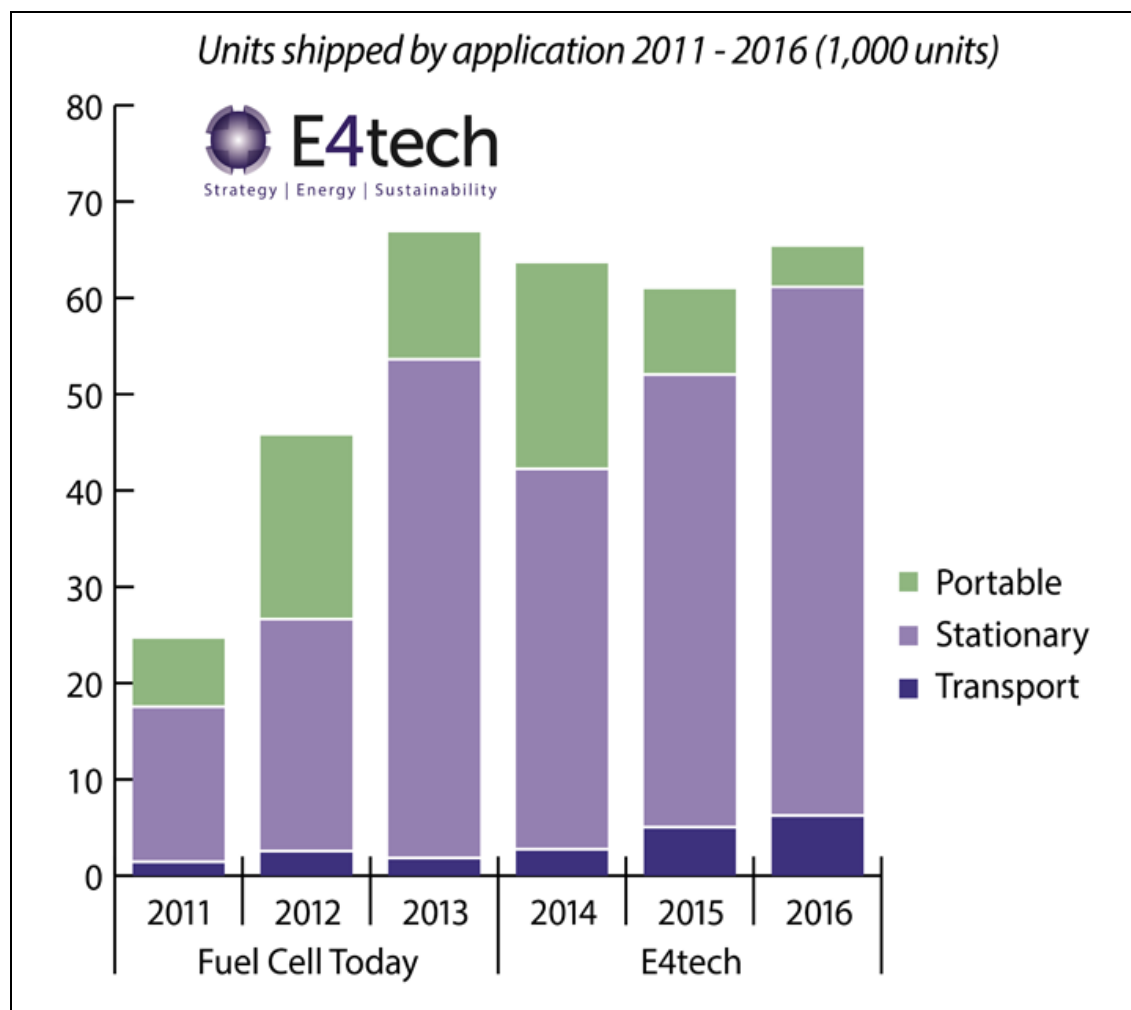
Hyundai's ix35 is still in a good position and even Honda has entered the contest with its new Clarity model, but it is Toyota which sold by far the most fuel cell cars in one year for the second time in a row. The Mirai has basically made the Japanese carmaker the global leader in fuel cell manufacturing within just a few years. Most of

the industry's 2,000 new fuel cell cars were shipped to Japan and California; Europe came in third place. Fuel cell capacity varies between 100 kW and 130 kW depending on the model, greatly bolstering the megawatt total.

As in previous years, the other driver in the transport segment was the lift truck for logistic centers. In early 2017, Plug Power announced that it had supplied 4,000 fuel cell systems for these forklifts. All in all, more than 10,000 fuel cell versions are now roaming the halls of logistic providers. A new entrant to the market is Nuvera Fuel Cells, meanwhile bought up by Hyster-Yale, which should help increase sales even further this year.

Other types of vehicles such as buses, trains and trucks weren't that successful in making their mark on 2016's shipment statistics, but the number of fuel cell buses is expected to grow considerably in 2017. The signs had already been there last year, in the unpublished production figures for fuel cell modules and stacks (we only count end products, meaning the vehicle including the module, not the module on its own). Taking a second look at those numbers, we expect China to become the biggest market for fuel cell bus technology, with at least 300 new buses in 2017 alone.

*Fig. 2: Units shipped annually, by type of application from 2011 through 2016 (in thousands)*

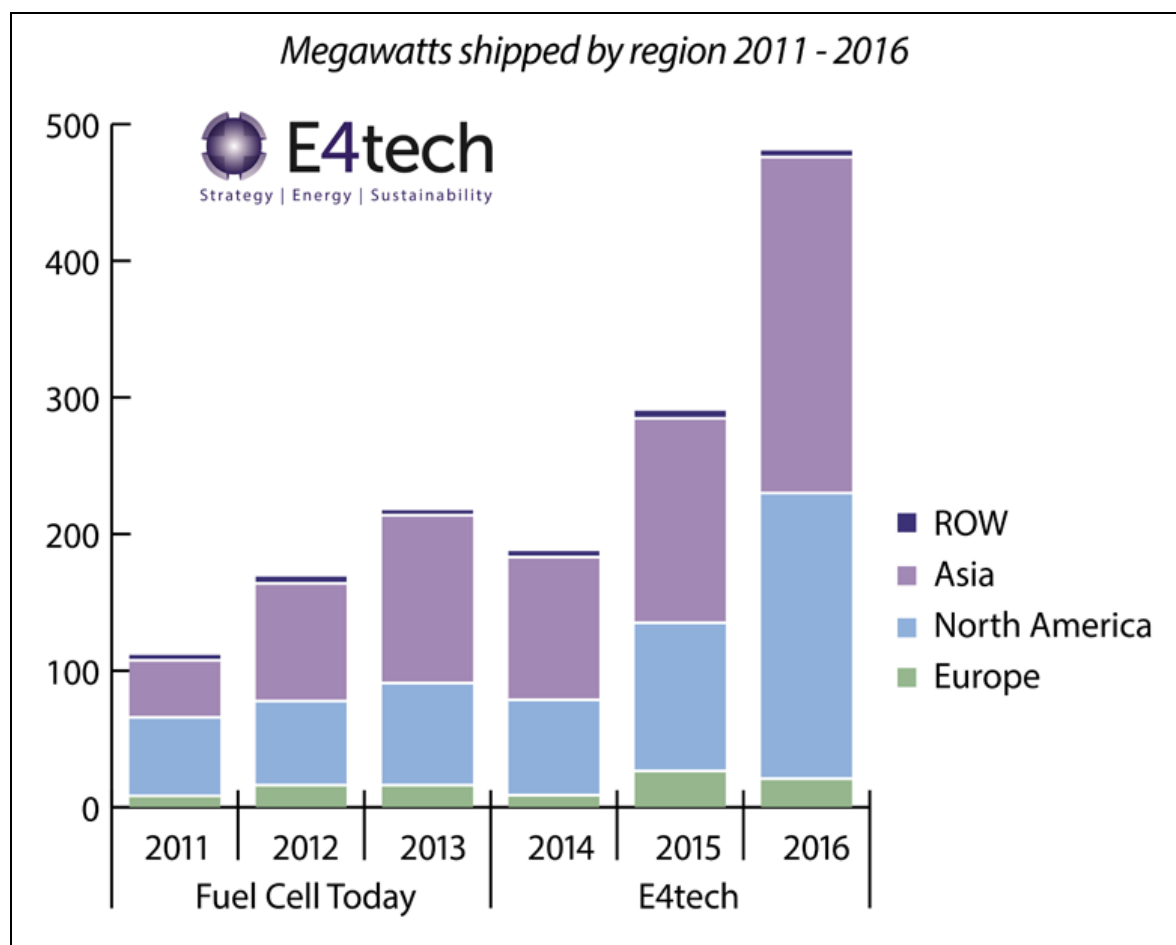


## Where China leads, others follow?

The attractive financial incentives offered by China's New Energy Vehicles program for fuel cell buses, cars and other vehicles triggered a gold rush-like boom in the Far East last year. Many renown and leading fuel cell businesses such as Ballard, Hydrogenics and Plug Power entered into delivery agreements with Chinese businesses. And even the country's domestic market actors are working tirelessly on accumulating fuel cell know-how, sometimes by hiring specialists from North America and Europe. It's a good bet that China will need only a few years to grow into one of the most important fuel cell markets worldwide.

The pressing issue of air quality and the country's efforts due to the Paris Climate Agreement will continue to push the market forward for a long time to come. The establishment of a domestic fuel cell industry has been officially sanctioned by the government when it created a national strategy, with a roadmap extending to 2030. The example of the local electric car industry, however, also illustrates the difficulties of trying to create an entire market basically overnight. In early 2017, the government made abrupt changes to the incentives for battery-electric vehicles to prevent fraud and force out disreputable suppliers. The measure may have been necessary, but did make observers feel uneasy about China's market development for a short while.

*Fig. 3: Capacity shipped per year, by region from 2011 through 2016 (in megawatts)*



## **New avenues for stationary fuel cells?**

Until a few years ago, the fuel cell market had been dominated by stationary applications. The preliminary November figures pointed to slight growth in the stationary segment, but after updating the 2016 figures, this growth seems to have evaporated. The big players on the large-scale system market (100 kilowatts to several megawatts) remain; they are FuelCell Energy, Bloom Energy, Doosan and Fuji Electric. Other manufacturers in this segment include Mitsubishi Hitachi, GE, LG and some less well-known businesses.

Stationary applications have had their highest concentration in South Korea and the United States. The latter still has its Renewable Portfolio Standard in place, a regulation that requires energy suppliers to add new and renewable energies to their portfolio, with power generation from fuel cells being credited at double the rate. The power market, however, is between a rock and a hard place right now and the willingness to invest in fuel cell projects is no longer as great as it had been some years ago.

The other main market for big stationary fuel cell systems, the United States, has had its own set of troubles: First, there was not enough political support for a timely extension of the fuel cell ITCs that ended in 2016. Second, California made changes to its Self-Generation Incentive Program, which had always provided more funds for energy storage units than for fuel cells. It will be interesting to see how fuel cell businesses will be able to cope with the new market environment in 2017. FuelCell Energy had to announce in late 2016 that the financing of some large projects in the States had failed. The setback had meant that staff was let go and production at the main factory was – quite abruptly – cut in half – from 50 to 25 MW per year.

Going into 2017, the ENE-FARM program in Japan remained as one of the main pillars of the fuel cell market. It has supported the installation of 200,000 micro-CHP systems to date, even though the original target of 1.4 million by 2020 seems almost out of reach. One particularly intriguing development in 2016 was the strong growth in SOFC installations. They have gained a considerable foothold in the market and are second only to the already well-established PEM units by Panasonic and Toshiba.

In Germany, the Technology Rollout Program for fuel cell heaters was launched last year under the auspices of the Energy Efficiency Incentive Program, or APEE for short. It subsidizes systems of 250 watts to 5 kilowatts of capacity. The program was launched too late to influence sales in 2016, but the new funding opportunities could finally turn Germany into a second important market besides Japan, after the country took such a long time preparing to go commercial.

## **Micro-sized fuel cells far from a success story**

Sales of portable fuel cells faced a severe decline in 2016 because of a drop in the number of small USB chargers for consumer electronics, typically with few watts of output. Most businesses have shut down or at least halted their activities. The only 2017 development worth mentioning in this segment seems to be myFC, which announced it would ship 1,000 units to China between 2017 and 2018. One portable technology still going strong, however, is UPS with units of, on average, 100 watts of

capacity. Designed for various off-grid applications, they are sold by SFC Energy in particular.

### **Few changes to preliminary figures**

The charts in this news article are based on the numbers published in the November 2016 edition of Fuel Cell Industry Review and show the preliminary figures from last year. The last months of 2016 were extrapolated based on the manufacturers' own estimates and the industry's business outlook. Typically, E4tech will ask manufacturers the following year whether their estimates squared with actual sales. From what we can tell so far, last year's megawatt total will be a bit above the 480 MW forecast from November, but slightly miss the 500 MW mark. Additionally, several megawatts may need to be shifted around across application categories, as sales of stationary systems were weaker than expected at the end of the year, but were more than made up for by vehicle sales. The number of units sold in 2016 may have to be lowered by a few thousand, as Japan did not reach the milestone of 50,000 ENE-FARM systems in 2016. The final figures for 2016 and the preliminary ones for this year will again be published in November as part of the next edition of Fuel Cell Industry Review.

You can download the entire report, including shipment numbers, data tables, analyses and comments, as a PDF at [www.FuelCellIndustryReview.com](http://www.FuelCellIndustryReview.com)

*Reference: D. Hart, F. Lehner, R. Rose, J. Lewis; The Fuel Cell Industry Review 2016. November 2016*

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## **Build-up of an H<sub>2</sub> Economy**

### **Global Market**

Japan remains fully committed to integrating hydrogen into its national energy mix, and is looking to Europe and to a lesser extent the U.S. for markets and research support. Developers of residential fuel cell systems have all found European partners to bid for FCH-JU funding. And Japan's Toyota has quietly led an international effort to engage corporations at the highest level in planning for a hydrogen transition. The result, The Hydrogen Council, announced at Davos in January, could be the most significant step towards hydrogen this year, if it can get organized to take advantage of the CEOs and Chairmen who were involved in the launch.

Companies include AngloAmerican, Air Liquide, Alstom, BMW GROUP, Daimler, ENGIE, Honda, Hyundai Motor, Kawasaki, Royal Dutch Shell, The Linde Group, Total and Toyota. The Council is led by two Co-Chairs, currently Air Liquide and Toyota. There are no US companies on the list yet, though recruiting is under way.

In Japan itself, implementation of the new hydrogen energy plan is well under way.

- Japan has issued a revised and more detailed hydrogen plan which includes some changes in numerical targets.
  - The new target numbers for fuel cell passenger cars are 40,000 by 2020, 200,000 by 2025 and 800,000 by 2030. There is a target of 100 buses, in time for the Tokyo Olympics in 2020, which Japan intends to utilize to showcase its progress on hydrogen. The plan also calls for commercialization of fuel cell trucks and forklifts, though no numerical targets have been established. In all cases, the government recognizes the need for marketplace subsidies.
  - There were about 78 open and 15 planned hydrogen fueling stations by late 2016. The target is 160 by 2020 and 320 by 2025, supported by capital and operating subsidies. (In a move rich with symbolism, Fukushima Prefecture will produce renewable hydrogen for use at the Tokyo Olympics.)
  - Residential and small commercial fuel cell power generation targets remained at 1.4 mil by 2020 5.3 mil by 2030 but additional development is under way or in the plan for larger commercial and utility scale systems, as well as telecom backup systems. Numerical targets were established only for the small residential (< 1 kw) systems.
  - There is also substantial new interest in renewably generated hydrogen, byproduct hydrogen, hydrogen energy storage, hydrogen storage and reconversion to grid electricity and Power to Gas.
- NEDO (New Energy and Industrial Technology Development Organization) is implementing R&D contemplated by the plan.
  - It has announced three R&D projects examining the use of hydrogen in combustion turbines, which is seen as a potentially significant source of demand for hydrogen post-2030. It has launched six renewable hydrogen / grid stability projects.
  - NEDO is also funding PEMFC and SOFC projects, and there seems to be a modest uptick in interest in SOFC for small commercial and industrial uses, with the first units to be deployed in 2017. The numbers pale in comparison with the robust market for PEM residential systems. The consultancy E4tech estimates the number of residential fuel cell systems to have reached 190,000.
- Japan's FY2017 fuel cell research budget is about JPY94.4 billion, including subsidies for residential units (JPY10.4 billion), hydrogen stations (JPY5.2 billion) and clean vehicle purchases (JPY14.0 billion). Other major budget segments are hydrogen supply chain (JPY 55 billion), vehicle R&D (JPY4.0

billion), fueling station R&D (JPY4.4 billion), and hydrogen production, transport and storage (JPY1.4 billion).

## Vehicles

Honda began offering its latest Fuel Cell Clarity vehicle about a year ago in small numbers, but appears to be aiming at 2020 for a more robust commercialization push, with a target of sales at an “affordable price” shortly thereafter. To this end Honda is partnering with General Motors on research and development. The two companies announced in January the formation of a joint manufacturing venture, Fuel Cell System Manufacturing, LLC, which will produce fuel cell systems in an existing GM facility about 20 miles southwest of downtown Detroit.



*Next Generation Fuel Cell Stack, Source: GM*

The companies will invest \$85 million, creating about 100 jobs. This is a modest investment by auto industry standards; it remains to be seen just how much volume the facility can produce.

Toyota, on the other hand, is manufacturing in Tokyo, at its Motomachi plant where it has committed to expanding the use of hydrogen. Toyota recently began operating two fuel cell forklifts there, and is developing technologies and strategies to use hydrogen in operating the plant and manufacturing vehicles, with an implementation target date of 2020. Expect the next generation of vehicle in 2020 as well, in time for the 2020 Tokyo Olympics.

Toyota says it expects to build about 3,000 Mirai fuel cell vehicles a year, which implies a slight increase in demand. About 2,850 have been put in customers' hands since late 2015. We know because Toyota in February recalled all of them to fix a

potential output voltage problem that could occur under certain unique driving conditions. Toyota has developed a software fix.

In the U.S. Toyota has teamed up with Shell to propose seven hydrogen fueling stations in California. The re-emergence of Shell as a hydrogen player in the U.S. is significant; it was very active a couple of decades ago before shutting down its US Shell Hydrogen subsidiary. Shell and Toyota are seeking \$16.4 million from the California Energy Commission for the stations. Hydrogen stations in California to date have been built mostly by local or regional developers. Having Shell back in the mix could entice other oil companies into the marketplace and certainly provides the credibility that only a deep-pocket household name can bring.

*Author: Robert "Bob" Rose*

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## IPHE Debates New Strategies

*27th Steering Committee Meeting in Hamburg*

Global Market



**International Partnership  
for Hydrogen and Fuel Cells  
in the Economy**

**The RD&D activities of the industry and the public sector have successfully established a global market for hydrogen and fuel cells. There is growing consensus about the importance of these clean energy carriers in transportation and several manufacturing segments. Countries such as Germany, Japan and the United States – and organizations such as the European Commission – have been spearheading efforts in research, development and demonstration technologically and politically to show how sustainable and reliable these resources really are. Others including China, South Korea and the United Kingdom are currently developing strategies and implementing initiatives needed for a significant impact on relevant**

**targets in the energy, environment and transportation sectors. All of them have joined IPHE, the International Partnership for Hydrogen and Fuel Cells in the Economy, a government-level project of 18 countries and the European Commission.**

At Hannover Messe, IPHE could be found on April 25, 2017 at the joint booth Hydrogen + Fuel Cells + Batteries. As part of the Public Forum program, it organized two discussion forums with representatives from governments and industry to debate political strategies, regulatory and market aspects and opportunities for an accelerated introduction of hydrogen and fuel cell technologies.

Both IPHE forums featured representatives who had been working to promote the integration of markets and the use of clean energy and transport infrastructures. The debates revolved around the most recent H<sub>2</sub> and fuel cell developments ready for commercialization and around the question of what actions were needed for broad market adoption.

The exposition in Hanover, Germany, was one of a series of IPHE activities between April 25 and 28. Another event had IPHE delegates meet with students from different fields of studies at Hamburg's University of Technology to discuss the current role of hydrogen and fuel cells and the plans for research and commercialization in several parts of the world. Together with the DWV, the German Hydrogen and Fuel Cell Association, IPHE presented awards to those who made an outstanding contribution at bachelor's or master's level. Another item on the agenda was touring facilities in Hamburg to stay informed about the current advancements and strategies of German businesses.

### **Hosted by BMVI and NOW**

The week of events closed with the 27th IPHE Steering Committee Meeting in Hamburg. During the meeting, the members of IPHE discussed what benefits and opportunities H<sub>2</sub> and fuel cells can offer when used for clean energy supply, transportation, industrial processes and buildings (the buzzwords were "sector integration" / "sector coupling" / "hydrogen at scale"). Host of the IPHE event in Hamburg was the German federal transport ministry BMVI and the National Organization for Hydrogen and Fuel Cell Technology, or NOW for short.

The objective of IPHE is to use H<sub>2</sub> and fuel cells to enable and accelerate the transition to clean and efficient energy and transport infrastructures, industrial processes and heating technologies. It provides a platform for exchanging information on political and technological advancements and initiatives, standards and regulations in order to speed up market deployment. IPHE also informs stakeholders and the public about the opportunities and challenges of introducing economically viable hydrogen and fuel cell systems.

The organization's members meet every half year in another partner country – one year ago, they came to Berkley, California, last fall to Gwangju, South Korea, and now to Hamburg.

[www.iphe.net](http://www.iphe.net)

*Author: Alexandra Huss*

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## **WHEC in Brazil**

### **News**

The 22nd World Hydrogen Energy Conference will take place next year in Brazil – with the help of a German business. Co-organizer of the WHEC 2018 held under the auspices of the International Association for Hydrogen Energy is reported to be Peter Sauber Agentur Messen und Kongresse. The hosts in Rio de Janeiro from June 17 through 22 will be the Laboratório de Hidrogênio, or Lab H<sub>2</sub> for short, and the Instituto

Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia, or COPPE UFRJ.



Peter Sauber Agentur has been organizing hydrogen and fuel cell events for twenty years, from Stuttgart's World of Energy Solutions, including f-cell symposium and trade show, to the German pavilion at the international FC Expo in Tokyo (see [FC Expo Now in Osaka Too](#)).

Silke Frank, division head of the Stuttgart-based business, confirmed to H2-international that the company's years-long global activities had led to strong business relationships in Brazil and that it greatly appreciated having been chosen to organize this important industry event.

WHEC's call for papers started in June 2017.

[www.whec2018.com](http://www.whec2018.com)

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## Toyota's Fuel Cell Bet

### *Mirai Test Drive*

#### Electric Transportation

**When the Mirai became available in late 2014, Toyota was convinced that the fuel cell would be the future of the automotive industry. Last year, however, the carmaker adjusted its strategy and explained that – previous statements notwithstanding – it would also start offering battery-driven vehicles. Did the then-number one carmaker get cold feet after previously announcing to rely on hybrid and fuel cells only? Or has demand for electric cars risen so dramatically in Asia that Toyota just wants its piece of the pie? H2-international has rented a Mirai for five days to put it to the test and see whether the forward-looking car is indeed ready for the mass market and has a realistic chance of becoming a household name.**

Unlike some European carmakers, Toyota Germany doesn't have any press cars available for test drives. Imagine how pleasantly surprised I was when Dirk Breuer, spokesperson for the German subsidiary, told me he had contacted a Toyota dealer in Berlin that would offer me its Mirai. After driving my LPG-run Mini to Ollenhauerstrasse in Reinickendorf, a Berlin suburb, I received a warm welcome by Mr. Hein, who immediately started explaining the technology to me.

However, there wasn't much to say about the fuel cell vehicle. Its design may take at least some time getting used to, but the keyless entry system is no different from other cars offered today. This system detects when the driver with the keys in his or her pants pocket approaches the car and will unlock the doors automatically. The interior is state of the art; the cockpit is a bit unconventional, but after a short learning curve, I knew where everything was.

Very little was happening following the push of the start button: not so much as a blip from the engine and no lengthy warm-up despite the low outside temperatures. The car only signaled that everything was ready, so I put my foot down on the accelerator pedal and started moving forward.

### **Amenities of a touring sedan**

I could hardly ever hear the car making a sound – there was no zooming and no annoying howling. I almost never heard the electric engine either. Even when driving at higher speeds on the freeway, it's an enjoyable and smooth ride. The only drawback I noticed was the limitation to four seats in an almost five-meter-long sedan (4.89 meters to be exact, or 16.04 feet). Dirk Breuer explained: "The components make the Mirai comparatively heavy; the total vehicle weight is 1,850 kilograms. Toyota decided to make it a four-seater, so that bringing along suitcases isn't out of the question. The middle console is there for added comfort; it doesn't contain special technology."



The car boasts many nice gadgets and functions; for example, the seat will automatically move a bit to the back when you unfasten the seat belt and move forward when you do the opposite. The innovative design of the heating controls in the middle lets passengers set temperatures with the stroke of a finger. When getting out, you only need to shut the door and lightly touch the two stripes on it to lock all doors and watch the side mirrors fold.

Despite easy operation of the car's controls, the five-day test drive revealed an important weakness, surprisingly one that was typically said to be a major benefit, but seems to have turned into a disadvantage. The Mirai is advertised as having a range of 500 kilometers (311 miles), but after I filled up the tank in the presence of Mr. Hein at the H<sub>2</sub> station on Jafféstrasse, the fuel gauge showed a mere 380 (236 miles). It

could have been the low ambient temperature or the not very powerful compressors of the station, but could also be a more fundamental problem, as other test drivers had reported similar issues.

### **Toyota Mirai**

Touring sedan

Five doors, four seats

Electric engine: 113 kW

Tanks: 2 x 60 liters

Range: 550 kilometers (341 miles; nominal)

Price: EUR 78,600 (leasing: EUR 1,200 per installment)

### **Fill-up instructions**

Closely related to the refueling issue is the fact that CEP fuel card holders are the only ones able to fill up hydrogen tanks in Germany. Since I don't have a card and there was none in the Mirai, I had to drive in economy mode most of the time, so that as promised, I could show several interested students at the end of the five-day period how it feels to ride in a car like this. I finally arrived safe and sound and on time at the Toyota dealership, so that the vehicle could still be prepared for the marketing campaign planned the following day.

In conclusion, the Mirai has only confirmed what others have said, namely that efforts should focus primarily on establishing an H<sub>2</sub> infrastructure; the technology itself is mature enough. In a 2015 interview with *Süddeutsche Zeitung*, Breuer had already lamented that "50 hydrogen stations had been announced for 2015 in Germany. In the end, only 19 were built. I know that there are a lot of reasons for why it's not going any faster. But I miss a clear strategy for expanding the infrastructure."

Accordingly, the number of cars sold in Germany in 2016, was at a low 27. Adding in previous test vehicles from other suppliers, the total number of fuel cell cars in Germany stood at 250 at the end of last year. It should come as no surprise that the *Süddeutsche Zeitung* called CEP's own positive evaluation of results in late 2016 (see [NIP to Continue Until 2026: "Unique Success Story"](#)) "cheering prose about Europe's biggest project in hydrogen transport," and remarked: "In reality, little has been accomplished under the leadership of the German transport ministry BMVI."

### **Electric-only future**

Toyota has been researching fuel cells since the mid-1990s; since 2010, it has also taken on the task of popularizing the technology. The first sign of that was the cooperation with BMW, as the Bavarian carmaker was afraid of being left behind on the development. In return, the Japanese business gained access to BMW's diesel technology. In 2014, Toyota made its around 5,680 patents on fuel cells and hydrogen available to everyone for free, in order to encourage other automotive suppliers to adopt fuel cells. But the head of Daimler, Dieter Zetsche, boasted that his corporation's advancement were "on par with Toyota's" and that Daimler did not need to use any of those patents.

Meanwhile, most competitors have shifted their attention to battery vehicles, prompting Toyota to pursue two competing strategies at once: At the International

Motor Show in Geneva, the Japanese corporation unveiled an electric concept study called i-TRIL Concept – a 2+1 seater that leans itself into turns automatically. After hybrid and fuel cells, Toyota now seems to be warming to the idea of selling battery-only vehicles.

It is not as if the company's previous single-focus strategy hasn't proven successful. This January, 20 years after the introduction of the first hybrid vehicle, Toyota reached the milestone of ten million hybrid cars sold worldwide. The new target set by Takeshi Uchiyamada, board chair of Toyota, is one million plug-in hybrids in fewer than ten years. And when the next generation of fuel cell cars hits the market in 2020, the aim is to reach annual sales of 30,000 fuel cell and 1.5 million hybrid vehicles.

In February 2017, the Japanese carmaker also delivered its first fuel cell bus. Developed in collaboration with Hino Motors, it had been tested since 2015 in Toyota City and Tokyo. The bus is equipped with two Mirai stacks, eight hydrogen tanks and two electric motors. About 100 units are soon expected to start running in Tokyo. They are thought to help cut the emissions of Toyota's fleet of new vehicles by on average 90 per cent until 2050 while combustion engines should be a thing of the past at that point.

*Fig. 2: After being taken out for a spin, the Mirai "blow-dries" its fuel cell stack to keep the car operable in spite of the prevailing frost.*



Right now, however, things are expected to move at a slower pace: Didier Leroy, president of business planning and operation at Toyota, had already told Austrian newspaper Kurier in 2015 that "market opportunities will remain very limited between today and 2020. At that point, we expect to see capacity increases until 2025 before we kick it into high gear, as we did with our hybrid cars." Kurier went on to quote Akio Toyoda, president of the Toyota, who reportedly said about fuel cell technology that it would be "the engine for the next 100 years of automotive development."

## “Total recall”

In early 2017, Toyota recalled all its previously sold Mirai cars (around 2,800) due to a software bug that caused the engine to shut down in certain situations.

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## Nissan Goes Symbio

Electric Transportation



Source: Symbio

Although Daimler, Ford and Nissan have been working together since 2013 to develop a fuel cell system, Symbio FCell has had its own collaboration project with Nissan to design an H<sub>2</sub> range extender. At the FC Expo in Tokyo this March (see [Japan Leads the Way](#)), Symbio – by its own account, the “European leader of hydrogen mobility solutions” – exhibited a system of this type for the e-NV200, a van with a powertrain based on Nissan’s Leaf engine.

Fabio Ferrari, CEO of Symbio, explained: “The integration of our system into Nissan’s five to seven seat EVs will have taxicabs contribute to improved air quality without any impact on day-to-day business.” He expects the vehicle – whose 3.8 kilograms of hydrogen boost the range to 500 kilometers (311 miles) – to make it to the European market in September next year. Symbio is supported by Michelin, which owns one-third of the company, Engie and Borit, the supplier of the metallic bipolar plates used for the stacks. It previously collaborated with Renault to equip the HYKangoo with a 300-kilometer (186-mile) range extender and has sold around 500 of these cars to date.

## Upscale Fuel Cell Market

Electric Transportation



Source: Lexus

The core market of Toyota's luxury brand Lexus has been Asia; in Europe, it sold merely 70,000 cars last year. Despite the headwinds, Lexus is increasingly becoming a serious alternative for many buyers, even though – or maybe precisely because – 98 per cent of its vehicles are hybrids. Alain Uyttenhoven, head of Lexus Europe, said: "When customers come in to pick up their Lexus, we have already preset their most favorite radio channels and connected their smartphone."

Part of Lexus's strategy is the hybrid engine, but without plug-in technology, as "very few customers in large cities will have comfortable access to a charging point," Uyttenhoven told motor-talk.de. Asked why the competition relied on battery vehicles, he replied: "They don't have any other way to meet the 2020 target of 95 grams of CO<sub>2</sub>. We do." Hydrogen is key to the carmaker's efforts. Lexus first presented a concept study of the Lexus Future – Flagship Car / Fuel Cell, or LF-FC for short (see image), last year. However, there are rumors that the LS sedan may also be equipped with a fuel cell starting in 2019.

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## Hyundai Unveils FE Fuel Cell

Electric Transportation

At the Geneva International Motor Show, Korean carmaker Hyundai unveiled its new fuel cell concept study, the FE Fuel Cell Concept. It offers a glimpse into the fourth vehicle generation boasting much higher output and an extended range. The fuel cell unit is said to be twenty per cent lighter and ten per cent more efficient than in previous models, which would raise energy density by thirty per cent. While the world's first commercially available fuel cell car, the ix35, reached the mass market in

2013 and offered 594 kilometers (369 miles) on one tank of 5.64 kilograms of H<sub>2</sub>, the FE or “Future Eco” will have an extended range of 800 (497 miles).



Source: Hyundai

The design of the new model is just as futuristic. “The FE Fuel Cell Concept’s flowing form is inspired by nature and water – the car’s only emission – with the clean and calm design emphasizing its non-polluting nature,” it says on Hyundai’s website. The steam produced by the fuel cell is not only blown out of the vehicle, but is likewise used to control the humidity level inside the car. Mass-market introduction is scheduled for 2018.

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## Lithium vs. Vanadium

### *Watchmaker Hayek to Design Electric Cars*

#### Electric Transportation

The head of Swatch, Nick Hayek, intends to use the company group’s subsidiaries Belenos and Renata to establish a second stream of income by developing electric cars with vanadium batteries. After many years of work, they are said to be tested soon in China. In summer 2015, Swatch had announced its decision to stop the development of fuel cell versions and transfer activities in this field to Groupe E based in Granges-Paccot, Switzerland. Hayek himself reportedly wanted to concentrate on electric vehicles instead.

In August 2007, his father, Nicolas G. Hayek – founder and then-board chair of Swatch – made public his intention to enter the car-making business. Known as the “Watch King” in his home country, he teamed up with Groupe E, a power company from western Switzerland, to build hydrogen cars (see [HZwei issue from October 2007](#)). This led to the creation of Belenos Clean Power based in the Swiss town of La Tène, with prominent people such as actor George Clooney and astronaut Claude Nicollier joining the ranks of the board of directors.

*Nick Hayek*



*Source: Swatch*

Hayek passed away in 2010 and it seemed as if Belenos would not survive. But this February, Hayek’s son said he was ready to start with the production of a growing number of battery cars in Itingen, Switzerland. “We will give electric transportation the big boost it needs,” he told Swiss business magazine Bilanz. His confidence stemmed from the company’s use of vanadium pentoxide, a material it had developed over the course of ten years. The business overseeing development and testing is Swatch’s Renata subsidiary.

The new vanadium battery seems to be a very promising advancement. It is reported to up power output by 30 per cent compared to currently available systems. Lifetime is said to double even and recharging was twice as fast as with conventional batteries, making for faster access to energy supply. The battery was also safer and did not require precious metals such as cobalt and nickel. Its main feature is the cathode, on which Belenos has 23 patents.

So far, so good – in theory. The first cars could be tested in day-to-day use this year in China, in collaboration with automotive supplier Geely, just as had been announced by Hayek during last year’s CeBIT. Only time will tell whether the system that Professor Reinhard Nesper from Swiss university ETH Zurich – which owns one-third of Belenos – designed when Hayek’s father asked him will turn out to be a success. Nesper, an emeritus professor of the Swiss university for the past three

years, said to Bilanz: “Hayek’s own idea was not very realistic. But I told him that I could imagine advancing development by a factor of ten, though it would take a long time and cost a lot of money.”

It did take a long time and was quite expensive (around EUR 25 million). The team of researchers went from lithium to vanadium and ultimately turned to nanotechnology. In the early days, hydrogen had still been floated around as an option. However, when the business started to focus on the “super battery” about two years ago, fuel cells were pushed to the sidelines.

Groupe E is no longer involved in the project. The energy supplier returned its shares in Belenos while gaining the former company location in La Tène and keeping about a dozen employees. They are said to develop hydrogen cars as well as a network of H<sub>2</sub> filling stations.

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## ***Hydrogen Economy as a Social Project***

### *HyTrustPlus Project Results*

#### Education & Training

**With passing the climate action plan, the German government has set clear, unequivocal targets: By 2050, the entire transportation sector is to produce zero CO<sub>2</sub> emissions, and a 40 per cent reduction compared to the baseline year of 1990 is to be achieved by as early as 2030. A hydrogen economy is one way to approach this social project, but it will require cooperation among all of society’s members – citizens, citizen advocacy groups, associations, businesses, politicians and researchers – to make it a success.**

Hydrogen and fuel cells could become key technologies in a post-fossil fuel, sector-integrated energy industry, whether they would be used to store renewable energies, supply low-emission heat or maintain sustainability in transportation. Establishing a hydrogen economy will ultimately rely on H<sub>2</sub> production from renewables to create a zero-emission energy infrastructure.

The HyTrustPlus project supported by the National Innovation Program Hydrogen and Fuel Cell Technology, or NIP for short, examined the options available for designing this kind of economy, the current environment for solutions in this field and the social acceptance of them. The analyses performed during the project run showed that the entire value chain of the new energy carrier, from production to storage and use in stationary and mobile applications, had not only been technically manageable already, but had been demonstrated with success during pilot projects, even if there has not been a final breakthrough yet.

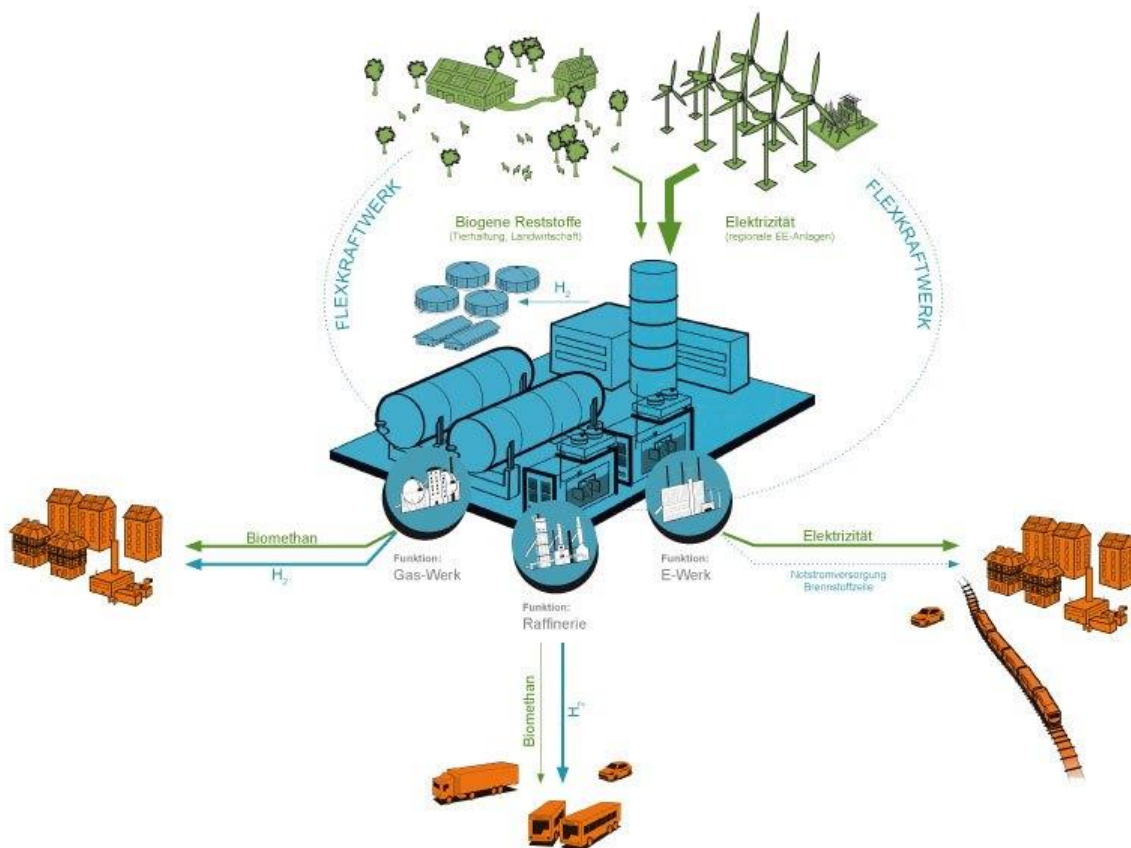
### **Enjoy broad support**

From 2014 through 2016, HyTrustPlus – Hydrogen Economy as a Social Project identified and analyzed plans, processes, ideas and opinions of many stakeholders that could contribute to the establishment of said economy. The study shows that

- Hydrogen produced from renewable sources can become a socially accepted and essential component of regional energy transformation.
- Designs of hydrogen economies based on renewable sources have the potential to persuade many in the debate about the energy supply of the future.

The recipe for success, however, is to use only renewably sourced hydrogen from the beginning and prevent the cost of energy from spinning out of control. Eighty-nine per cent of a sample group in a German-wide survey were in favor of public incentives to promote a “green” hydrogen industry. There is also consensus among stakeholders involved in building up a hydrogen economy that cooperation among people from different industries will be essential to sharing knowledge of technical, regulatory and economic issues and minimizing financial risks in the early stages of innovative usage concepts.

*Fig. 1: Steinfurt's flex power plants*



Source: [2]

### Instigate cooperation

The positive attitude towards (acceptance of) hydrogen use in transportation had already become clear during the previous HyTrust project and could be confirmed during HyTrustPlus for hydrogen and fuel cell use even if several industries are involved. This level of acceptance is perceived as a prerequisite for active support of innovation and the transformation process that comes with it.

Still, there would need to be more options to expose people to these technologies and see hydrogen used in day-to-day operations. Turning people who are sympathetic to the cause into full-fledged supporters will require that products and the related infrastructure become more visible to the public.

The number of cars running on hydrogen has not increased to a notable degree over the last years. German carmakers remain cautious. Only the launch of Linde's car-sharing offer BeeZero in Munich in summer 2016 and the planned utilization of fuel cell trains this year could be interpreted as important milestones toward popularizing hydrogen use. This is even more unfortunate considering hydrogen's role as a potential strategic resource of the energy and transport sector because of its zero-carbon properties.

The HyTrustPlus survey showed that more than 50 per cent of retail customers buying a new car could imagine purchasing their own H<sub>2</sub> vehicle and would be willing to pay more for it than for a conventional one. They expect, however, that either the industry itself or the government would help reduce the comparatively high cost at the start. It may be more beneficial to go the commercial route and support the use of H<sub>2</sub> vehicles as part of rental fleets.

Environmental organizations have been skeptical of the hydrogen infrastructure expansion, as the current lack of economic viability leads them to believe that green hydrogen will not be produced large scale. They are just as reluctant about using the technology in non-public transport because they fear that it will result in people not even considering mass transit options. Countering the skepticism about parts of the hydrogen economy will require an open and continuous dialog with NGOs about the opportunities and limitations of hydrogen in supporting the transformation of the energy market.

Another challenge that remains is the cooperation of stakeholders from different sectors. Experiences gathered during regional dialogs paint a first picture of how to incorporate hydrogen into local transformation projects.

### **Strengthen the regional H<sub>2</sub> economy**

One has yet to create a template for a successful business model of a hydrogen economy. There are indeed regions with a definite interest in integrating hydrogen into their renewable energy infrastructure, but they lack the knowledge and the professional support for implementing their ideas.

During the project, stakeholders from the Steinfurt district in North Rhine-Westphalia devised a plan to incorporate hydrogen into regional energy transformation projects. So-called "flex power plants" channel renewable energies in different markets (power, gas/heat and transportation) and avoid overloading the power grid and individual transmission lines temporarily or entirely by feeding in energy based on demand (see fig. 1). They are the primary driver of a post-fossil power and fuel production across this German region. The analyses showed the potential of regional hydrogen economies, but also the challenges given the current political and regulatory environment. In a representative survey of the population, Steinfurt's plan of a post-fossil fuel, localized energy market was welcomed throughout and deemed worthy of support.

The hydrogen economy could assume a key role particularly in energy and transportation if lobbying concentrated more on a compelling overarching storyline. As shown by the Steinfurt approach, the story would need to be about how challenges are solved and not stay focused on describing technical properties. The current debates must become more open to other interested parties and involve new stakeholders. From a user's point of view, expectations are that there will be more H<sub>2</sub> vehicle offerings to come, a sufficient number of German models among them. Stringent, obligatory CO<sub>2</sub> emission limits promise to increase the willingness to invest in sustainable products. Additionally, there needs to be an expansion of the hydrogen infrastructure in transportation.

### **Be clear about the benefits**

It would be advisable to involve regional stakeholders when creating a vision of how to transform the energy sector by relying on hydrogen as one of its future sources of energy. It would keep the value chain and the decision-making power over design choices in the region. A clear self-interest of stakeholders in introducing a hydrogen economy would prompt them to take on a more active role. For example, regions with many wind farms may have plant operators or taxpayers feeling personally affected by the limitations of excess wind energy to be fed into the grid. So far, the response has been to shut down wind farms temporarily. The flex power plants developed in Steinfurt could become an attractive solution for dealing with the surplus, as wind power is supplied based on demand and the renewable energy that is not utilized can be used to produce hydrogen. This would offer new opportunities for establishing sustainable transport and heat sectors.

Implementing a plan for the integration of hydrogen across sectors will require government risk sharing and political and legal planning security. So far, large investments in hydrogen technology have been hardly justifiable considering the unknown risks inherent in currently oft-insufficient output, a lack of value chains and continually changing regulations.

### **Grow visibility**

Many people in Germany have been made insufficiently aware of hydrogen and fuel cells and the activities of the hydrogen community. The current political, legal and regulatory environment and today's cost structures are perceived as barriers to the establishment of a hydrogen economy. At present, the revised renewable heating law does not include any incentives for energy producers to use hydrogen storage. On the contrary, electrolyzers are classified as end consumers, meaning that EEG surcharges, energy taxes and other fees must be paid to produce hydrogen and later convert it back into electricity. However, it will need all kinds of alternative technological and organizational options to create an integrated and renewable energy infrastructure and move Germany's energy transformation forward.

### **Reference(s)**

- [1] Zimmer, René (2013): HyTrust – Auf dem Weg in die Wasserstoffgesellschaft
- [2] Hölzinger, Nadine (2016): Die Steinfurter Flexkraftwerke. Positionspapier der regionalen Akteure aus dem Kreis Steinfurt, NOW

[3] Hölzinger, Nadine; Schmidt, Anke (2016): Die Steinfurter Flexkraftwerke. Eine Region realisiert die Energiewende, NOW

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## Training the Trade

*forumKWK – Osnabrück’s Center of Excellence for Building Engineering*

Residential Market



**The German chamber of crafts and trades of Osnabrück-Emsland-Grafschaft Bentheim has for about 15 years had a Berufsbildungs- und Technologiezentrum, a center of excellence for building engineering and CHP plants in particular. Several years ago, this center made fuel cell heaters part of its portfolio. After the new heating technology became technologically and commercially viable, the focus of activities was expanded while the center itself was renamed “forumKWK.”**

The reshuffling of priorities started with the FC CHP-Future project in 2014 when the center received its new name (see fig. 1). While forumKWK does cover every type of CHP design, the fuel cell has lately become its most prominent technology.

Courses mainly concentrate on the acquisition of expertise in life-like scenarios. At forumKWK, this hands-on experience translates into “skills” to distinguish them from theoretical content (“knowledge”). The classification is used for blended learning in training sessions (see box).

### Requirements for installers

Specialists must have profound knowledge of the functionality, technology and requirements for the use of fuel cell heaters, prerequisites for their economic feasibility, etc. In response to requests and queries about CHP plants, these specialists need to provide clear, understandable and convincing explanations and present customers with detailed offers that cover items such as

- Cost of investment;
- Registration and approval;
- Disassembly and disposal;
- Assembly and start of operations;
- Incentives.

If fuel cell heaters always provide both heat and power, tradesmen need to have added certifications to provide proof of having been trained in heating and electrical device installations.

After a customer places an order for installing and operating a fuel cell heater, the specialist needs a plan to

- Determine the basic load;
- Size additional equipment and storage;
- Choose where to install the unit;
- Specify hydraulic and electrical integration, hookups for the gas and exhaust, and the connections to instrumentation and control;
- Deal with registration and approval;
- Select materials;
- Hire subcontractors;
- Disassemble redundant devices and parts;
- Create a work breakdown structure, including a section on logistic services.

Consequently, the installation of a fuel cell heater will require some knowledge outside of the scope of one's own line of work. Installation begins with setting up and connecting the units and continues with hydraulic and electrical integration, remote monitoring, leak testing, etc. A special situation is the commissioning of a unit, where the tradesman needs to pay as much attention to general procedures marked down on check lists, to installation and to the instruction manual as to the device-specific start-up of operations. Individual areas of functionality (gas, exhaust, power, water) need to be tested too.

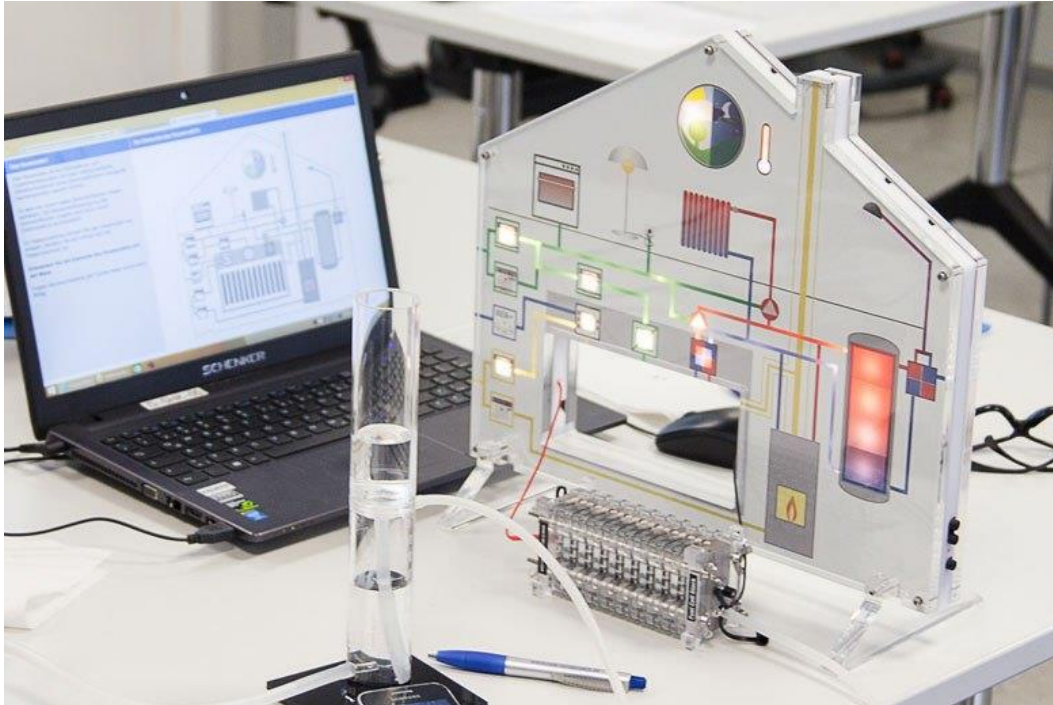
Naturally, customers expect to be eligible for government incentives and profit from grid feed-in after purchasing and installing a CHP plant. The fact that the eligibility criteria for these incentives may undergo continual and rapid changes means that customers may ask for advice and support from tradesmen or suppliers/utilities. To facilitate the market deployment of fuel cell heaters, specialists need to have some marketing skills as well.

### **Center of excellence equipment**

The offline seminars at forumKWK provide fuel cell devices for assembly, measurement and functionality testing in teams of two. There is one residential fuel

cell unit available per group of four (see fig. 2) to simulate and explain residential power and heat systems.

*Fig. 2: Use of a residential unit during class*



At present, forumKWK has two residential fuel cell heaters that supply both power and heat and identical units that are no longer operational. The, however, are used to identify device components (see fig. 3), install and remove them, explain their function or demonstrate maintenance and service. The defective units were set up in close vicinity to the operational ones to allow participants to compare components and draw conclusions regarding the differences in heating curves, weak or strong vibrations, and pressure and temperature gauges.

As the defective devices were put on wheels to make them mobile, they can be moved to the seminar room, for example, to enable trainees to carefully observe and study them.

The experiments with fuel cells and stacks include taking various measurements to determine electric voltage or output, first without voltage and later with loads added. The results will be captured and analyzed in a table. It is during those experiments that natural gas and hydrogen will be discussed regarding their viability as energy carriers. The demonstration and subsequent exercises will show which measuring units are required during installation, how to measure and what else to look out for.

*"In 2016, we conducted a good dozen – usually, one-day – seminars on fuel cell heaters at forumKWK in Osnabrück, eight of them with apprentices only. Our experience has been that fuel cell heaters were an abstract idea to the apprentices, who could not relate to the concept until the seminar started and made them more open to and curious about the idea. After it was over, their views had changed."*

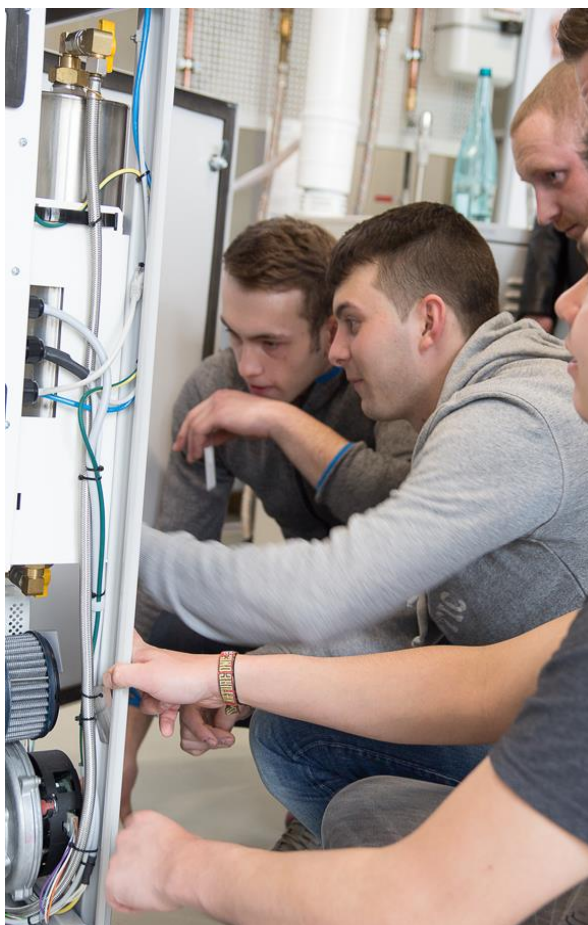
### **Not only somewhere, but all over Germany**

Anyone participating in the training courses can draw up their own learning schedule to complete the online module. Module 1 communicates the basics. A test offered by forumKWK after completion will show trainees whether they learned enough about the issues to proceed. Module 2 starts with detailed preparations for the hands-on seminar at forumKWK. Another knowledge quiz will signal participants when the time is right to attend it.

The one-day events provide practical experience and are always grounded in activities that participants were prepared for by the online modules. Examples of such activities include

- How to assemble a fuel cell;
- How to measure and calculate stack properties based on performance specifications;
- How to illustrate energy supply based on the residential unit;
- How to identify fuel cell components and their functionality;
- How to add/remove components such as filters, fans, etc.

*Fig. 3: Component identification*



Source: forumKWK

A network has been established to support the hands-on seminars by having organizations specialized in job training collaborate at regional level, assist each other and respond to differing demand for information on fuel cell heaters.

One main benefit of this strategy is that while all partners of the network provide identical e-learning content throughout Germany, they can offer the seminars close to participants' homes. In addition to cutting down on travel back and forth and avoiding the cost of overnight stays, this will make it possible to join another group seminar in a bigger city in the region.

The following organizations are members of the network:

- forumKWK of the Handwerkskammer Osnabrück
- Elektro Technologie Zentrum Stuttgart (etz)
- SHK Ausbildungszentrum Berlin
- Energie-Effizienz-Zentrum of HWK Dresden

### Blended Learning

Blended Learning is a kind of hybrid, integrated approach that combines two methods. First, there is the online offer of content, which students can access anytime from anywhere. Second, there is the joint seminar to enable trainees to apply and communicate the expertise and skills they gained. Blended Learning uses the opportunities of digital media and traditional teaching methods and materials to teach, inform, exchange ideas and experiences.

Based on blended learning, forumKWK offers seminars that consist of two modules, one for online learning and one for gaining practical experience (see figure). This approach combines the freedom of choosing when and where to complete the e-learning stage with the opportunity to attend an event for which all participants are equally well prepared. The positive feedback to forumKWK's offerings prove its usefulness in "training the trade."

[www.fuelcellknowhow.com](http://www.fuelcellknowhow.com)

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## Stakeholder Know-How of H<sub>2</sub> and Fuel Cells

*KnowHy – EU-wide Offer of H<sub>2</sub> Training*

Training & Education

The success of marketing a new technology hinges on the number of people who know how to install, maintain and repair it properly. In 2014, the Fuel Cells and Hydrogen Joint Undertaking launched the KnowHy project to disseminate knowledge of fuel cell technologies that had reached near-market maturity. Supported by the European Commission's 7th Framework Program, the project

**became more detailed as the years passed. Now fully developed, it will continue until 2020.**



The aim of KnowHy has been to combat the current lack of industry specialists by helping to train technicians early on, so that there will be enough people experienced in systems and components when the time has

come for new fuel cell technologies to hit the market. Until 2020, KnowHy will offer training sessions to interested tradesmen and anyone else employed in the H<sub>2</sub> and fuel cell industry in the EU.

### **Online and offline training**

Between 2014 and 2016, the partners of the project developed hands-on training modules for a total of six courses: one core module of around 40 hours and five on specialization with around 60 hours each to cover fuel cell generators, CHP, hydrogen production and handling, micro-sized fuel cells, and H<sub>2</sub> fuel cells in transportation. The courses are being offered in seven languages – Dutch, English, French, German, Italian, Portuguese and Spanish – and have already been taught in many European countries.

Training begins online with an e-learning section, the content of which trainees will learn on their own (see also “blended learning” on p. 37). Course participants acquire the relevant expertise in four to six chapters with the help of videos, explanations and figures. A test at the end of each chapter will, if passed, unlock the next. Only after passing the final test on all chapters will a trainee be admitted to the one-day hands-on seminar to apply the knowledge to real-life examples and attend tutoring classes. Whoever succeeds in completing all tasks will be rewarded with a KnowHy certificate.

### **Europe-wide offerings**

The creators of the KnowHy concept intend to make it relatively easy for technicians to take part in the course in addition to working normal hours. Thanks to a comparatively high amount of online material, they can decide on their own when and where they intend to learn. The course was also designed with low fees in mind – in Germany, the sessions have even been offered at no cost at all.

Another objective of the KnowHy project has been to test and develop the concept toward a point at which offerings no longer need to be subsidized, for example, by prompting project partners to create spin-offs or external organizations to adopt the curriculum.

KnowHy has partnered with universities, e.g., Delft University of Technology, and businesses, such as McPhy, to make laboratories and demonstration systems available to trainees or supply them with know-how and contacts. The Technical University of Munich is involved as well – as recently as Jan. 30, 2017, it hosted the training session on CHP.

Michael Geis from the Institute for Energy Systems, a department of TU Munich, told H2-international: “After a short time refreshing what we had been taught in the online

module, we got down to business. Participants gained hands-on experience through an Elcore fuel cell heater. The unit was perfect for explaining the individual components of a fuel cell system and because it was identical in design to others sold by Elcore, we could deliver the same kind of maintenance experience as in the real world. The day – and with it, the module – ended with passing a written exam, for which you had an hour.”

*Fig. 2: Experimenting with the device during seminar hours*



Source: TU München

### **Munich options**

The kickoff workshop of KnowHy took place on May 25, 2016, during the Fuel Cell & Hydrogen Technical Conference in Birmingham, UK. From September 2016, courses were also held in the Netherlands, Italy, Spain and the UK; overall, 140 students registered. Since last November, there have been additional offerings at TU Munich in Germany and in Belgium, France and Portugal.

The most recent opportunity to take part in a course was the base module offered on April 18, 2017, at TU Munich, which ended with the one-day hands-on seminar on May 18. The training on Hydrogen Production and Handling will likewise consist of an online section and a day to gain practical experience. To register, please visit [www.knowhy.eu/registration/](http://www.knowhy.eu/registration/) – or contact Michael Geis ([michael.geis@tum.de](mailto:michael.geis@tum.de)).

[www.knowhy.eu](http://www.knowhy.eu)

## Changes at WBZU

### Education & Training



These are indeed trying times for the Education and Training Center for Innovative Energy Technologies, or WBZU, in Ulm, Germany. The institute, which had become part of the local chamber of industry and commerce in January 2014 (see [HZwei issue from April 2014](#)), had seen a steadily declining interest in its educational offerings in the months before the end of last year, evidenced by a much lower number of seminars held during that period. Subsequently, Sirko Nell – formerly, managing director of the institute – left WBZU prior to the beginning of 2017. His responsibilities were handed over to Rolf Schäfer, vice president of Ulm's chamber of commerce. Tina Betz, who had taken on the job of long-time employee Manuela Egger, the “kind soul” of WBZU, has left the company as well. All in all, Schäfer will have to make due with three employees for the time

being.

*R. Schäfer, ©: Handwerkskammer Ulm*

WBZU was founded in 2002 with the support of the German state of Baden-Württemberg and the federal government and used to be called Fuel Cell Education Center Ulm. Despite losing its independence, nothing was supposed to change “regarding the organization’s primary objectives,” Tobias Mehlich, president of Ulm’s chamber, said at the time. In reality, however, attempts were made to attract more tradesmen to the seminars. These attempts failed, presumably because the several hundred euros charged for a single course were just too much to pay, not least considering that the institute mainly provides educational resources for academics and scientists.

Only time will tell whether this year’s ten seminar options will be enough to guarantee the organization’s survival.

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## Events

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- **European PEFC & Electrolyser-Forum**, July 4th to 7th, 2017, in Lucerne, Switzerland, [www.efcf.com](http://www.efcf.com)
- **China International Hydrogen and Fuel Cell Exhibition (CHFCE 2017)**, August 28th to 30th, 2017, in Beijing, China, <http://en.chfce.com>
- **Hydrogen + Fuel Cells NORTH AMERICA**, September 10th to 13th, 2017, in Las Vegas, USA, [www.h2fc-fair.com/usa](http://www.h2fc-fair.com/usa)
- **New Mobility World**, September 14th to 17th, 2017, in Frankfurt a.M., Germany, [www.newmobility.world](http://www.newmobility.world)
- **European Summer School on Hydrogen Safety (ESSHS)**, September 18th to 22th, 2017, in Athens, Greece, [www.jes-school.eu](http://www.jes-school.eu)
- **2nd FC EXPO Osaka**, September 20th to 22th, 2017, Osaka, Japan, [www.fcexpo-kansai.jp](http://www.fcexpo-kansai.jp)
- **f-cell and Battery+Storage**, October 9th to 11th, 2017, on the Stuttgart Fair Ground, [www.f-cell.de](http://www.f-cell.de)
- **EVS30**, October 9th to 11th, 2017, on the Stuttgart Fair Ground, [www.evs30.org](http://www.evs30.org)

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## Social Media

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**Facebook** 67 Follower, 69 Likes



**Twitter** 772 Follower



**Facebook** 152 Group Members



**Xing** 722 Followers



**Google+** 48 Follower



**Xing** 1056 Group-Members



**LinkedIn** 1094 Follower

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## Companies

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### Electrolyzers

#### **AREVA H<sub>2</sub>Gen**

- **AREVA H2Gen GmbH**, Maarweg 137, 50825 Cologne, Germany, Phone +49-(0)221-888244-88, Fax -67, [www.arevah2gen.com](http://www.arevah2gen.com)



#### **Diamond Lite SA**

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



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

#### **GREENHYDROGEN.DK**

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

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



- **Proton OnSite**, 10 Technology Dr, 06492 Wallingford CT, USA, Phone +1-(0)203-678-2000, [info@protononsite.com](mailto:info@protononsite.com), [www.protononsite.com](http://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](http://www.gkn.com/sintermetals)
- **HPS Home Power Solutions GmbH**, Carl-Scheele-Str. 16, 12489 Berlin, Germany, Phone +49-(0)30-5169-5810, [mail@homepowersolutions.de](mailto:mail@homepowersolutions.de), [www.homepowersolutions.de](http://www.homepowersolutions.de)



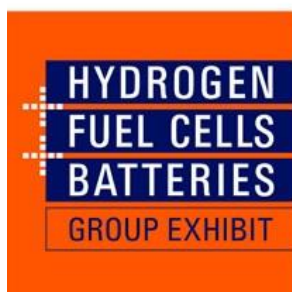
- **Hydrogenious Technologies GmbH**, Weidenweg 13, 91058 Erlangen, Germany, Phone +49-(0)9131-12640-220, Fax -29, [www.hydrogenious.net](http://www.hydrogenious.net)



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

## Event Organizers

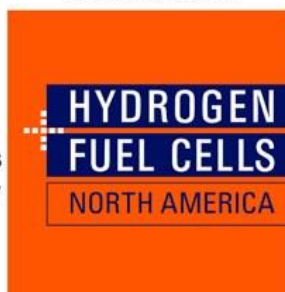
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**September 10-13  
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Mandalay Bay  
Convention Center  
Las Vegas, NV, USA

- **24rd Group Exhibit Hydrogen + Fuel Cells + Batteries**, HANNOVER MESSE 2018, April 23 – 27, Tobias Renz FAIR, Tobias Renz, [tobias@h2fc-fair.com](mailto:tobias@h2fc-fair.com), [www.h2fc-fair.com](http://www.h2fc-fair.com)



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

## Fittings, Regulators, Valves



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



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



**[www.ptec.eu](http://www.ptec.eu)**

- PTEC – Pressure Technology GmbH, pipelines, screw connections, filters, valves, regulators, TPRD, Linde 11, 51399 Burscheid, Germany, Phone +49-2174-748-722, [mail@ptec.eu](mailto:mail@ptec.eu), [www.ptec.eu](http://www.ptec.eu)

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- **Busch Clean Air S.A.**, Chemin des Grandes-Vies 54, 2900 Porrentruy, Switzerland,  
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## Gas Diffusion Layers (GDL)



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

## Hydrogen Distribution



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



- **Wystrach GmbH**, Industriestrasse 60, Germany – 47652 Weeze, Phone +49-(0)2837-9135-0, Fax -30, [www.wystrach-gmbh.de](http://www.wystrach-gmbh.de)

## Membrane and Separator



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

## Organization



- **Deutscher Wasserstoff- und Brennstoffzellen-Verband**  
**German Hydrogen and Fuel Cell Association**, Deutscher Wasserstoff- und Brennstoffzellen-Verband e.V. (DWV), Moltkestr. 42, 12203 Berlin, Germany, Phone +49-(0)30-398209946-0, Fax -9, [www.dwv-info.de](http://www.dwv-info.de)
- **hySOLUTIONS GmbH**, Steinstrasse 25, 20095 Hamburg, Germany, Phone +49-(0)40-3288353-2, Fax -8, [hysolutions-hamburg.de](http://hysolutions-hamburg.de)



- **Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie**  
**National Organisation Hydrogen and Fuel Cell Technology (NOW GmbH)**, Fasanenstr. 5, 10623 Berlin, Germany, Phone +49-(0)30-3116116-15, Fax -99, [www.now-gmbh.de](http://www.now-gmbh.de)

## Reformers

- **WS Reformer GmbH**, Dornierstrasse 14, 71272 Renningen, Germany, Phone +49-(0)7159-163242, Fax -2738, [www.wsreformer.com](http://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](mailto:info@imm.fraunhofer.de), [www.imm.fraunhofer.de](http://www.imm.fraunhofer.de)

**ISE**

- **Fraunhofer ISE**, Heidenhofstrasse 2, 79110 Freiburg, Germany, Phone +49-(0)761-4588-5208, Fax -9202, [www.h2-ise.de](http://www.h2-ise.de)

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- **Borit NV**, Bipolar plates and interconnects, Lammerdries 18e, 2440 Geel, Belgium, Phone +32-(0)14-25090-0, Fax -9, [contact@borit.be](mailto:contact@borit.be), [www.borit.be](http://www.borit.be)



- **ElectroChem Inc.**, 400 W Cummings Park, Woburn, MA 01801, USA, Phone +1-781-9385300, [www.fuelcell.com](http://www.fuelcell.com)



- **HIAT gGmbH**, Schwerin, Germany, CCMs / MEAs / GDEs for PEFC, DMFC & PEM-Electrolysis, [www.hiat.de](http://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](http://www.kerafol.com/sofc)



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## System Integration



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- **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](http://www.dlr.de/tt), [www.dlr.de/tt](http://www.dlr.de/tt)

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

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